

Agriculture and Allied Science

Restructured and Revised Syllabi of Post-graduate Programmes

Volume 12 - Food Science Technology

- * Food Processing Technology
- * Food Process Engineering
- * Food Safety and Quality

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Compiled By

**Dean & Director of Instruction
Co-Ordination Committee
of SAU's 2022-23**



Restructured and Revised Syllabus

**M.Tech. & Ph. D. (Food Science and
Technology)**

In

**Food Processing Technology,
Food Safety and Quality
Food Process Engineering**

Submitted by

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Preamble

Food Process Engineering” is a relatively young discipline covering not only factories, equipment and processes but also understanding the product and developing innovative products and packages to satisfy the consumer’s needs and wishes. Over the years Food Process Engineering studies emerged as a scientific and industrial discipline describing equipment and means for proper plant operations and environment control considering engineering properties of materials, transport phenomenon, computer aided design, simulation, project engineering and management, post-harvest engineering, storage engineering, additives and preservatives, reaction kinetics, and so on, in ways that preserve value of food and prevent any illness.

Food Process Engineering has been an area of priority for the food industries, processing plants, plant designers, equipment and plant manufacturers, bulk material handling systems, cold storage, supply chain systems and manufacturers, mega kitchen equipment, analytical instruments, ingredient/chemical producers, consumers, retailers, manufacturers, national and international agencies and regulators. Further, need for mechanization of selected indigenous food products and automation has been felt. Simulation and modeling constitute an essential step in food process research and development. “Virtualization” becomes a legitimate approach in food engineering research for equipment, mechanization, integrated processing system and hygienic plant design. Further, recent technologies such as Internet of Things, Artificial Intelligence, Nanomaterials, 3D printing, 3D scanning, soft gripping, nondestructive and online/quick analyzing have been found useful for suitable equipment and machineries manufacturing for sustainable food production.


To meet the compliances for efficient use of resources, related equipment, instrumentation, plant and building design, establishment and operation for sustainable food manufacturing; competent human resources at various levels such as process engineers, plant engineers, equipment engineers, service engineers, service in-charges, plant in-charge, auditors, designated officers, equipment and instrument handlers, safety officers etc. Development of trained human resource in this scientific and industrial sector is essential for the future growth of food processing and national – international trade from it. This motivated the ICAR-BSMA Broad Subject committee framed by DICC and MCAER, Pune for Food Science and Technology to strive hard to enrich the content and

syllabus in the area of new stream of M.Tech. and Ph.D. programme in the area Food Process Engineering.

Thus, the restricted M.Tech. programme is intended to offer the industry ready professionals for food processing sector on one hand while they would be given training so that they can ponder upon the industry problems to offer solution either through deep scientific research or problem-solving approach for quick industry solution and immediate response. While PhD programme is envisaged to begin a new era of food process engineering research. While proposing this programme it is believed that this programme will also cover research gap in the area and will provide primary data from the country to be used in best quality indigenous equipment and production system manufacturing with compliance to applicable international/ reputed standards and codes which has been lacking in the past.

BSMA Degree and Discipline Coordinators

Broad Subject Coordinator and Chairman

| | Name | Designation |
|---|-----------------------|--|
|  | Dr.R.B. Kshirsagar | Professor &Head Dept. of FoodEngineering, College of Food Technology, Vasantrya Naik Marathwada Krishi Vidyappeth, Parbhani |

Discipline Coordinators

| | Name | Designation | Discipline |
|---|----------------------------|--|----------------------------------|
|  | Dr.U.D. Chavan | Head, Dept. Food Science and Technology Mahtma Phule Krishi VidyappethRahuri | Food Processing Technology |
|  | Dr. (Mrs.)V.S. Pawar | Associate Professor & Head, Dept.of Food Process Technology College of Food Technology, Vasantrya Naik Marathwada Krishi Vidyappeth, Parbhani | Food Processing Technology |
|  | Dr.S.P. Sonawane | Professor & Head, Agriculture Engineering Section, College of Agriculture, MPKV,Dhule | Food Process Engineering |
|  | Prof. H. W. Deshpande | Associate Professor & Head Dept. of Food Microbiology and Safety Vasantrya Naik Marathwada Krishi Vidyappeth, Parbhani | Food Safety and Quality |

Foreword

The processing of agro commodities has immense potential to mitigate the shortage in food and nutritional requirements of the ever increasing population of our country. Furthermore, for food security of our populace, appropriate processing technologies, value addition, enhanced economic returns and employment generation are essential. The main causes of the expansion of the processed food industry include changes in lifestyle, eating habits, organised food retail, and urbanisation. However, the food processing sector in our nation is still in its infancy and is severely fragmented, despite having enormous potential to become the highest-yielding industry and become the world's foremost food supplier. In addition, emerging and advance food processing technologies can reduce postharvest losses, promote food safety practices, induce demand-driven production, enable value addition and facilitate exports. Food processing sector is considered a "Sun Rise Industry" as far as India is concerned.

Further, as per the ICAR Vth Dean Committee, the new syllabus of PG and Ph.D. has been revised and restructured by constituted Broad Subject Matter Area (BSMA) committee with assigned Broad Subject Coordinator and Discipline Coordinator for M.Tech and Ph.D (Food Technology) degree programme in Food Processing Technology, in Food Safety and Quality and in Food Process Engineering based on ICAR BSMA norms under the new education policy.

I avail this opportunity to acknowledge my sincere, humble and whole hearted sense of gratitude to **Dr. Arvind Kumar**, Chairman of National Core Group-ICAR and its member **Dr. N.S. Rathore**, former DDG, **Dr. R.C. Agrawal** DDG and **Dr. G. Venkateshwarlu** former ADG (EQR), and **Dr. V.B. Singh**, Chairman, former Dean, CDFST and Vice chancellor of MPUAT, Udaipur, Rajasthan and all BSMA Committee member of Food Technology for providing adequate guidance and encouragement through developed restructured and revised syllabi for course of PG and Ph.D. degree programme in the subject of Food Technology which led to the successful formulation and compilation of the syllabus.

I owe high esteemed respect and whole hearted thanks to **Dr. S. S. Narkhede** (DI and Dean and Chairman of DICC Committee, Dr.BSKKV, Dapoli), **Dr. D. N. Gokhale** (DI and Dean, VNMKV, Parbhani), **Dr. U. M. Khodke** (Associate Dean and Principal, CFT, VNMKV, Parbhani) and **Dr. Amol Dethe** (Controller Exam, MAUEB, MCAER, Pune) for


their support, proper coordination and valuable guidance during the process of syllabus designing.

I express my unequivocal sincere thanks to all Discipline coordinators, **Dr. U. D. Chavan** (Professor and Head, Department of Food Science and Technology, MPKV, Rahuri), **Prof. H. W. Deshpande** (Head, Department of Food Microbiology and Safety, CFT, VNMKV, Parbhani), **Dr. V. S. Pawar** (Head, Department of Food Process Technology, CFT, VNMKV, Parbhani) and **Dr. S. P. Sonawane** (Professor and Head, Agriculture Engineering Section, College of Agriculture, MPKV, Dhule) for their feedbacks and contribution in completing the task of revising and finalizing the syllabus of PG and Ph.D. degree programme in the subject of Food Technology as per ICAR Vth Dean Committee BSMA recommendations which is to be implemented in the Maharashtra State Agricultural Universities (SAU's) from Academic year 2022-23.

I acknowledge the valuable contributions made by all Head, academic staff of my institution for their contribution in typography, editing and compilation in an efficient manner.

The proposed revised and restructured new syllabus of M.Tech and Ph.D degree programmes in the area of Food Technology should render as an intellectually and more stimulating skill oriented discipline and an economically rewarding profession to shape the career of Food Technology graduate to serve for the betterment of country through their acquired knowledge and skill development.

I hope the new syllabus will serve as an important channel in creation of employment in terms of food technocrats, scientists, entrepreneurs, skilled human resource to serve in the national task of food safety and security management, entrepreneurship development, nutritional and economical security.



Dr. R. B. Kshirsagar
Professor and Head,
Department of Food Engineering, CFT,
VNMKV, Parbhani and
Broad Subject Coordinator
(Chairman of all Discipline sub Committee)

Implementation of New Curriculum

The universities offering PG and Ph. D. degree programmes in Food Technology need to be supported for establishing specialized laboratories equipped with State-of-the Art Equipments for conducting hands on practical classes especially, Processing Technology, Safety and Quality instrumentation lab, Process Engineering pilot scale units.

One time catch up grant should be awarded to each SAU, offering PG programmes in Food Technology for meeting expenditure for upgrading the course requirements.

Faculty training and retraining should be an integral component. For imparting total quality management, a minimum of two faculty in each department under an SAU should be given on job training in reputed national and international institutes. To execute the new PG and Ph.D. programmes in different discipline of Food Technology in effective manner, special funds from ICAR & MOFPI would be required for outsourcing of faculty from Indian/Foreign Universities for some initial years.

The already existing M.Tech. and Ph.D. Programmes in Food Technology will be considered at par with the recommended M.Tech. & Ph.D. programme by V Deans Committee for admission and employment.

Expected Outcome

- Revamping of post graduate programme in whole of Food Technology through out the country.
- Imparting in-depth and comprehensive knowledge of the food technology and also arming the students with management skills and professional attitude.
- Development of human resource to cater the need of food processing Industries, governments, corporate sector and research organization in India and abroad.
- Exposure to the faculty to emphasize the need of innovation and mechanism to ensure the quality and excellence in the mandatory activity i.e. teaching research and extension.

Organization of Course Contents & Credit Requirements

Minimum Residential Requirement:

M. Tech : 4 Semesters

Ph. D : 6 Semesters

Name of the Departments/ Disciplines

- Food Processing Technology
- Food Process Engineering
- Food Safety and Quality

Nomenclature of Degree Programme

(a) M.Tech. Programmes

- M.Tech (Food Science and Technology) in Food Processing Technology
- M.Tech (Food Science and Technology) in Food Process Engineering
- M.Tech (Food Science and Technology) in Food Safety and Quality

(b) Ph.D.Programmes

- Ph.D (Food Science and Technology) in Food Processing Technology
- Ph.D (Food Science and Technology) in Food Process Engineering
- Ph.D (Food Science and Technology) in Food Safety and Quality

Eligibility for Admission

• **Master’s Degree Programme**

- i. B. Tech (Food Technology) / B.Tech. (Food Science)/B.Tech. (Food Science and Technology) or equivalent degree with four years duration of agriculture related Universities (SAUs) and having the Common Entrance Test in Food Technology faculty conducted by MAUEB, Pune.
- ii. The candidate must have scored Overall Grade Point Average (OGPA) of at least 5.50/10.00 in ten-point scale.

• **Doctoral Degree Programme**

- i. The candidate must have passed 4 years B. Tech (Food Technology)/ B. Tech Food Science or Equivalent degree with four years duration of agricultural related universities (SAUs).
- ii. Master’s degree in the concerned Discipline of Food Technology and having appearing the Common Entrance Test of Food Technology subject conducted by MAUEB, Pune.
- iii. The candidate must have scored Overall Grade Point Average (OGPA) of at least 6.5/10.00 in ten-point scale.

| | | |
|-----------------------------|----------------------------|---|
| Food Science and Technology | Food Technology | M.Tech. (Food Technology) |
| | Food Processing Technology | M.Tech. (Food Technology) in Food Processing Technology |
| | Food Process Engineering | M.Tech. (Food Technology) in Food Process Engineering |
| | Food Safety and Quality | M.Tech. (Food Technology) in Food Safety and Quality |

Minimum Course and Credit Requirements

| CourseDetails | Master's Degree | Doctoral Degree |
|----------------------|------------------------|------------------------|
| Major Courses | 20 | 12 |
| Minor Courses | 08 | 06 |
| Supporting/ Optional | 06 | 05 |
| Common PGS Courses | 05 | - |
| Seminar | 01 | 02 |
| Research | 30 | 75 |
| Total | 70 | 100 |

Course Layout and Structure of Masters Degree in Food Processing Technology

| Course Code | Semester | Course Title | Credit Hrs. |
|---|----------|--|------------------|
| FPT 501* | I | Emerging Technologies in Food Processing | 3 (2+1) |
| FPT 502* | II | Emerging Technologies in Food Packaging | 3 (2+1) |
| FPT 503* | III | Industrial Manufacturing of Food and Beverages | 3 (2+1) |
| FPT 508 | I | Nutraceuticals and Specialty Foods | 3 (2+1) |
| FPT 511 | I | Traditional Foods | 3 (2+1) |
| FPT 514 | II | Food Ingredients and Additives | 3 (2+1) |
| FPT 517 | II | Enzymes in Food Processing | 3 (2+1) |
| | | Total | 21 (14+7) |
| Note: Optional Major Subjects: The said courses are subjected to availability of infrastructure and facilities and to be decided by SAC committee | | | |
| FPT 504 | | Food Material and Product Properties | 3 (2+1) |
| FPT 505 | | Cocoa and Chocolate Processing Technologies | 3 (2+1) |
| FPT 506 | | Spices, Herbs and Condiments | 2 (2+0) |
| FPT 507 | | Meat, Poultry, Fish and Egg Processing | 3 (2+1) |
| FPT 509 | | Frozen and Concentrated Foods | 2 (1+1) |
| FPT 510 | | Aseptic Processing and Packaging | 3 (2+1) |
| FPT 512 | | Technologies of Convenience Foods | 3 (2+1) |
| FPT 513 | | Food Powders and Premixes | 3 (2+1) |
| FPT 515 | | Flavour Chemistry and Technology | 3 (2+1) |
| FPT 516 | | Bioprocessing and Separation Technology | 3 (2+1) |
| FPT 518 | | Food Process Automation and Modelling | 2 (2+0) |
| FPT 519 | | Zero Waste Processing | 2 (2+0) |
| FPT 520 | | Special Problem/ Summer Internship | 2 (0+2) |

Minor and Supporting Courses

Minor Disciplines / Divisions

1. Food Processing Technology
2. Food Safety and Quality
3. Post Harvest Management
4. Basic Sciences
5. Post Harvest Technology
6. Food Chemistry and Nutrition
7. Food Microbiology and Safety
8. Food Business Management
9. Food Plant Operations

Suggestive Minor Courses

| Minor courses | | Course Title | Credits |
|---------------|----|-------------------------------------|----------------|
| FPE 508 | I | Food Safety and Storage Engineering | 3 (2+1) |
| FSQ 503 | I | Advanced Food Chemistry | 3 (2+1) |
| FSQ 504 | II | Global Food Laws and Regulations | 2 (2+0) |
| Total | | | 8 (6+2) |

Note: Optional Minor Subjects: The said courses are subjected to availability of infrastructure and facilities and to be decided by SAC committee
 Minor courses from discipline of Food Process Engineering, Food Safety and Quality and Processing and Food Process Engineering

| | | | |
|---------|--|---|---------|
| FPE 502 | | Engineering Properties of Food Materials | 3 (2+1) |
| FPE 504 | | Bioprocessing and Down Stream Engineering | 3 (2+1) |
| FPE 506 | | Numerical Technique and Simulation | 2 (1+1) |
| FSQ 506 | | Process and Products Monitoring for Quality Assurance | 2 (2+0) |
| FSQ 508 | | Management of Food By-products and Waste | 3 (2+1) |

Supporting Disciplines

1. Food Processing Technology
2. Food Safety and Quality
3. Post Harvest Management
4. Food Chemistry and Nutrition
5. Food Microbiology and Safety
6. Food Business Management
7. Food Plant Operations

Suggestive Supporting Courses

| Supporting courses | | Title | Credits |
|--------------------|-----|--|----------------|
| FBM 501 | I | Post-Harvest Management | 3 (2+1) |
| FBM 503 | III | Food Processing Entrepreneurship and Start up | 1 (1+1) |
| FSQ 505 | II | Food Safety Management Systems and Certification | 2 (2+0) |
| Total | | | 7 (5+2) |

Note: Optional Supporting Subjects: The said courses are subjected to availability of infrastructure and facilities and to be decided by SAC committee

Supporting courses from discipline of Basic sciences, Food business management Food Process Engineering and Food Safety and Quality

| | | | |
|---------|--|---|---------|
| FBM 502 | | Food Business Management | 2 (2+0) |
| FSQ 507 | | Quality Concepts and Chain Traceability | 2 (2+0) |
| FPE 505 | | Energy Management and Auditing in Food Industry | 3 (2+1) |
| FPE 510 | | Operation Research | 3 (2+1) |
| BSH 501 | | Research Methodology | 2 (2+0) |
| BSH 502 | | Food Informatics | 2 (1+1) |

Master Seminar

| | | | |
|---------|----|-----------------|---------|
| FPT 591 | IV | Masters Seminar | 1 (0+1) |
|---------|----|-----------------|---------|

FOOD PROCESSING TECHNOLOGY

| Masters Research | | | |
|------------------|-----|---------------|-----------|
| FPT 599 | III | Research Work | 10 (0+10) |
| | IV | Research Work | 20 (0+20) |

*Compulsory Courses

Compulsory Common PGS Courses (5 credits Non Credit):

| Course code | Semester | Course Title | Credits |
|-------------|----------|---|---------|
| PGS 501 | I | Library and Information Services | 0+1 |
| PGS 502 | I | Technical Writing and Communications Skills | 0+1 |
| PGS 503 | II | Intellectual Property and its management in Agriculture | 1+0 |
| PGS 504 | II | Basic Concepts in Laboratory Techniques | 0+1 |
| PGS 505 | II | Agricultural Research, Research Ethics and Rural Development Programmes | 1+0 |
| PGS 506 | III | Disaster Management | 1+0 |

Compulsory Non credit Deficiency Courses:

Students from non Food Science and Technology stream will be required to complete non credit deficiency courses (6 to 10 credits) from the below courses related to the discipline in which admitted and as decided by the Student Advisory Committee.

| Course Number | Course Name | Credits |
|---------------|-----------------------------------|---------|
| FPT-111 | Principles of Food Processing | 3 (2+1) |
| FPT-124 | Food Packaging Technology | 2 (1+1) |
| FPT-2410 | Fruits and Vegetables Processing | 3 (2+1) |
| FCN-235 | Food Chemistry and Micronutrients | 3 (2+1) |
| FMS-122 | Food Microbiology | 3 (2+1) |
| FBM-243 | ICT Application in Food Industry | 3 (1+2) |

Semester wise course layout

| First Semester | | | |
|------------------------|-----|---|------------------|
| FPT 501 | I | Emerging Technologies in Food Processing* | 3 (2+1) |
| FPT 508 | I | Nutraceuticals and Specialty Foods | 3 (2+1) |
| FPT 511 | I | Traditional Foods | 3 (2+1) |
| FSQ 503 | I | Advanced Food Chemistry | 3 (2+1) |
| FPE 508 | I | Food Safety and Storage Engineering | 3 (2+1) |
| FBM 501 | I | Post-Harvest Management | 3 (2+1) |
| PGS 501 | I | Library and Information Services | 1+0 |
| PGS 502 | I | Technical Writing and Communications Skills | 1+0 |
| | | Grand Total | 20 (14+6) |
| Second Semester | | | |
| FPT 502 | II | Emerging Technologies in Food Packaging* | 3 (2+1) |
| FPT 514 | II | Food Ingredients and Additives | 3 (2+1) |
| FPT 517 | II | Enzymes in Food Processing | 3 (2+1) |
| FSQ 504 | II | Global Food Laws and Regulations | 2 (2+0) |
| FSQ 505 | II | Food Safety Management Systems and Certification | 2 (2+0) |
| PGS 503 | II | Intellectual Property and its management in Agriculture | 1 (1+0) |
| PGS 504 | II | Basic Concepts in Laboratory Techniques | 1 (0+1) |
| | | Grand Total | 15 (11+4) |
| Third Semester | | | |
| FPT 503 | III | Industrial Manufacturing of Food and Beverages* | 3 (2+1) |
| FBM 503 | III | Food Processing Entrepreneurship and Start up | 1 (0+1) |
| PGS 505 | III | Agricultural Research, Research Ethics and Rural Development Programs | 1 (1+0) |
| FPT 599 | | Masters Research | 10 (0+10) |
| | | Grand Total | 15 (3+12) |
| Fourth Semester | | | |
| FPT 591 | | Seminar | 1 (1+0) |
| FPT 599 | | Research work | 20 (0+20) |
| | | Grand Total | 21 (1+20) |

ABSRTACT OF SEMESTER WISE COURSE DISTRIBUTION

| Course Credits | | | | | | | |
|----------------|-----------|----------|------------|----------|----------|---------------|-----------|
| Semester | Major | Minor | Supporting | Seminar | PGS | Research Work | Total |
| I | 9 | 6 | 3 | - | 2 | - | 20 |
| II | 9 | 2 | 2 | - | 2 | - | 15 |
| III | 3 | - | 1 | - | 1 | 10 | 15 |
| IV | - | - | - | 1 | - | 20 | 21 |
| Total | 21 | 8 | 6 | 1 | 5 | 30 | 71 |

**Course Layout and Structure of Doctoral Degree in
Food Processing Technology**

| Course Code | Semester | Course Title | Credit Hrs. |
|---|----------|---|------------------|
| FPT 601* | I | Novel Technologies for Food Processing and Shelf-Life Extension | 3 (3+0) |
| FPT 602 | I | Food Packaging | 3 (3+0) |
| FPT 604* | II | Plant Food Products | 3 (3+0) |
| FPT 606 | III | Animal Food Products | 3 (3+0) |
| | | Total | 12 (12+0) |
| Note: Optional Major Subjects: The said courses are subjected to availability of infrastructure and facilities and to be decided by SAC committee | | | |
| FPT 603 | | Food Manufacturing Technology | 3 (3+0) |
| FPT 605 | | Food Process Modeling and Scale up | 3 (3+0) |
| FPT 607 | | Special Problem | 2 (0+2) |
| FPE 602 | I | Concentration and Drying Engineering | 3 (3+0) |
| FSQ 603 | II | Quality Assurance in Food Supply Chain | 3 (3+0) |
| | | Total | (6+0) |

*Compulsory Courses

Minor and Supporting Courses

Minor Disciplines / Divisions

1. Food Processing Technology
2. Food Safety and Quality
3. Post Harvest Management
4. Basic Sciences
5. Post Harvest Technology
6. Food Chemistry and Nutrition
7. Food Microbiology and Safety
8. Food Business Management
9. Food Plant Operations

Suggestive Minor Courses

| Minor courses from discipline of Food Process Engineering or Food Safety and Quality | | | |
|--|--|---|---------|
| FPE 606 | | Food Handling and Storage Engineering | 3 (3+0) |
| FSQ 604 | | Formulation of Standards of Food Products, Packaging and Labeling | 2 (2+0) |

Note: Optional Minor Subjects: The said courses are subjected to availability of infrastructure and facilities and as decided by SAC committee

Supporting Disciplines

1. Food Processing Technology
2. Food Safety and Quality
3. Post Harvest Management
4. Food Chemistry and Nutrition

5. Food Microbiology and Safety
6. Food Business Management
7. Food Plant Operations

Suggestive Supporting Courses

| | | | |
|---------|-----|-----------------------------|----------------|
| FPE 605 | II | Food Analytical Techniques | 3 (1+2) |
| FSQ 607 | I | Sensory Evaluation of Foods | 2 (2+0) |
| | | Total | 5 (3+2) |
| FPT 691 | III | Doctoral Seminar I | 1 (1+0) |
| FPT 692 | IV | Doctoral Seminar II | 1 (1+0) |
| FPT 699 | | Doctoral Research | 75 (75+0) |

Semester wise Course Layout

| Course Code | Semester | Course Title | Credit Hrs. |
|---------------------|----------|---|------------------|
| Semester I | | | |
| FPT 601 | I | Novel Technologies for Food Processing and Shelf-Life Extension | 3 (3+0) |
| FPT 602 | I | Food Packaging | 3 (3+0) |
| FPE 602 | I | Concentration and Drying Engineering | 3 (3+0) |
| FSQ 607 | I | Sensory Evaluation of Foods | 2 (2+0) |
| | | Grand Total | 11 (11+0) |
| Semester II | | | |
| FPT 604 | II | Plant Food Products | 3 (3+0) |
| FSQ 603 | II | Quality Assurance in Food Supply Chain | 3 (3+0) |
| FPE 605 | II | Food Analytical Techniques | 3 (1+2) |
| | | Grand Total | 9 (7+2) |
| Semester III | | | |
| FPT 606 | III | Animal Food Products | 3 (3+0) |
| FPT 691 | III | Doctoral Seminar I | 1 (0+1) |
| | | Grand Total | 4 (4+0) |
| Semester IV | | | |
| FPT 692 | IV | Doctoral Seminar II | 1 (0+1) |
| FPT 699 | IV | Doctoral Research Work | 25 (0+25) |
| | | Grand Total | 26 (1+25) |
| Semester V | | | |
| FPT 699 | V | Doctoral Research Work | 25 (0+25) |
| | | Grand Total | 25 (0+25) |
| Semester VI | | | |
| FPT 699 | VI | Doctoral Research Work | 25 (0+25) |
| | | Grand Total | 25 (0+25) |

ABSRTACT

| Course Credits | | | | | | |
|----------------|-----------|----------|------------|----------|---------------|------------|
| Semester | Major | Minor | Supporting | Seminar | Research Work | Total |
| I | 6 | 3 | 2 | - | - | 11 |
| II | 3 | 3 | 3 | - | - | 09 |
| III | 3 | - | - | 1 | - | 04 |
| IV | - | - | - | 1 | 25 | 26 |
| V | - | - | - | - | 25 | 25 |
| VI | - | - | - | - | 25 | 25 |
| Total | 12 | 6 | 5 | 2 | 75 | 100 |

Course Syllabus and Content of Masters Degree in Food Processing Technology**FPT 501****Emerging Technologies in Food Processing****3 (2+1)****Theory****Unit I:**

Membrane Technology: Pressure activated membrane processes: MF, UF, NF and RO and their industrial application. Membrane distillation; Supercritical fluid extraction: Concept, property of super critical fluids SCF, extraction methods, application in food processing

Unit II:

Microwave and radio frequency processing: Advantages, mechanism of heat generation, application in food processing: microwave blanching, sterilization and finish drying Hurdle technology: Concept and Principle, Preservation techniques as hurdles and their principles, hurdle tech foods.

Unit III:

High Pressure processing: Concept, equipment for HPP treatment, mechanism of microbial and enzyme inactivation and its application in food processing, effect on food constituents. Ultrasonic processing: Properties of ultrasonic, types of equipment, application of ultrasonic as processing technique.

Unit IV:

Newer techniques in food processing: principle and application of High intensity light, pulse electric field, ohmic heating, IR heating, inductive heating, cold plasma, and pulsed X- rays in food processing and preservation, Cryo-processing of foods Nanotechnology: Principles and applications in foods.

Practical

- To evaluate the characteristics of treated water using RO system
- To study production and characteristics of treated water using, microfiltration, UF, NF and RO system
- To study the effect of ultrafiltration process on fruit juices quality
- To study suitability and production of fruit juices using ultrafiltration
- To study the effect of microfiltration process on milk quality
- To study super critical fluid extraction system and to carry out extraction of bioactive compound from selected samples
- To carry out extraction of lycopene from tomato using SCFE system
- To study microwave system and to evaluate the effect of different power on drying characteristics of selected vegetable products
- To study microwave blanching of vegetable and determination of blanching efficacy
- To study the ultrasonicator and evaluate the effect of ultrasonication on micro- organism in sample
- To study the ultrasonicator and to evaluate the effect of ultrasonication on extracted juice yield from fruit pomace
- To evaluate the different pre-treatment on oil yield from oil seed cake
- To prepare nano emulsion and study of their characteristics
- To study ohmic heating system and to study the processing of fruit pup using ohmic heating system

- To visit food industries utilizing advance food processing techniques
- To study the effect of different drying techniques/ hybrid drying techniques on fruits and vegetables.

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|---|---------------|
| 1-4 | Membrane Technology: Pressure activated membrane processes: MF, UF, NF and RO and their industrial application. | 25% |
| 5-9 | Membrane distillation; Supercritical fluid extraction: Concept, property of super critical fluids SCF, extraction methods, application in food processing. | |
| 10-12 | Microwave and radio frequency processing: Advantages, mechanism of heat generation, application in food processing: microwave blanching, sterilization and finish drying. | 25% |
| 13-18 | Hurdle technology: Concept and Principle, Preservation techniques as hurdles and their principles, hurdle tech foods. | |
| 19-23 | High Pressure processing: Concept, equipment for HPP treatment, mechanism of microbial and enzyme inactivation and its application in food processing, effect on food constituents. | 25% |
| 24-29 | Ultrasonic processing: Properties of ultrasonic, types of equipment, application of ultrasonic as processing technique. | |
| 30-34 | Newer techniques in food processing: principle and application of High intensity light, pulse electric field, ohmic heating, IR heating, inductive heating. | 25% |
| 35-36 | Cold plasma and pulsed X-rays in food processing and preservation, Cryo-processing of foods Nanotechnology: Principles and applications in foods. | |
| | Total | 100 |

Practical

| Practical No | Topic |
|--------------|--|
| 1 | To evaluate the characteristics of treated water using RO system |
| 2 | To study production and characteristics of treated water using, microfiltration, UF, NF and RO system |
| 3 | To study the effect of ultrafiltration process on fruit juices quality |
| 4 | To study suitability and production of fruit juices using ultrafiltration |
| 5 | To study the effect of microfiltration process on milk quality |
| 6 | To study super critical fluid extraction system and to carry out extraction of bioactive compound from selected samples |
| 7 | To carry out extraction of lycopene from tomato using SCFE system |
| 8 | To study microwave system and to evaluate the effect of different power on drying characteristics of selected vegetable products |
| 9 | To study microwave blanching of vegetable and determination of blanching efficacy |

| | |
|-------|--|
| 10 | To study the ultrasonicator and evaluate the effect of ultrasonication on micro-organism in sample |
| 11 | To study the ultrasonicator and to evaluate the effect of ultrasonication on extracted juice yield from fruit pomace |
| 12 | To evaluate the different pre-treatment on oil yield from oil seed cake |
| 13 | To prepare nano emulsion and study of their characteristics |
| 14 | To study ohmic heating system and to study the processing of fruit pup using ohmic heating system |
| 15 | To visit food industries utilizing advance food processing techniques |
| 16-18 | To study the effect of different drying techniques/ hybrid drying techniques on fruits and vegetables |

Suggested Readings

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

Theory**UNIT I**

Active and intelligent packaging: Active Packaging Techniques and intelligent Packaging Techniques, current use of novel Packaging Techniques, consumers and novel Packaging Oxygen, ethylene and other scavengers: Oxygen scavenging technology, selecting right types of oxygen scavenger, ethylene scavenging technology, carbon dioxide and other scavengers. Antimicrobial food packaging: Antimicrobial agents, constructing antimicrobial packaging systems, factors affecting the effectiveness of antimicrobial packaging.

UNIT II

Non-migratory bioactive polymers (NMBP): Advantages of NMBP, Inherently bioactive synthetic polymers: types and application, Polymers with immobilized bioactive compounds and their applications. Time Temperature labels and indicators (TTIs): Defining and classifying TTIs, Requirements for TTIs, development of TTIs, Maximizing the effectiveness of TTIs, Application of TTIs- to monitor shelf-life, and optimization of distribution and stock rotation, leakage indicators, oxygen indicators, micro indicators etc. Freshness indicator in packaging: Compounds indicating the quality of packaged food products, freshness indicators, pathogen indicators, other methods for spoilage detection. Self- heating /rehydrating packages.

UNIT III

Packaging-flavour interaction: Factors affecting flavor absorption, role of food matrix, role of differing packaging materials, flavour modification and sensory quality, Study of packaging materials compatibility with foods. Developments in modified atmosphere packaging (MAP): Permeability properties of polymer packaging, measurement of permeability – water and gases. Selection criteria of packaging films, Novel MAP gas, testing novel MAP applications, applying high oxygen MAP. Recycling packaging materials: Recyclability of packaging plastics, improving the recyclability of plastics packaging, testing safety and quality of recycled materials, uses of recycled plastics in packaging.

UNIT IV

Green plastics for food packaging: Problems of plastic packaging wastes, range of biopolymers, developing novel biodegradable materials. Edible Films and Coatings: Properties, types, sources, applications, advantages, disadvantages, theories of plasticization, challenges and opportunities.

PFS machine, seal and closures. Safety and legislative aspects of packaging: Regulatory considerations, plastic, metal, paper and glass packaging.

Practical

- Determination of WVTR in different packaging materials
- Determination of GTR in different packaging materials.
- Study of different ethylene scavengers and their analysis
- Study of different oxygen scavengers systems and their analysis
- Application of anti-microbial packaging for moisture sensitive foods
- Evaluation of chemical residue migration from package to food
- Application of MAP packaging in selected foods

- Study of TTI label, leakage indicators etc.
- Determination of oxidative changes in packaged foods
- Comparative evaluation of flexible and rigid packages for fragile foods
- Packaging of foods under inert atmosphere.
- To study textural characteristics of selected fruit/ vegetable under MAP storage
- Shelf life evaluation and mode up of packaged food product.
- Determination of oil and grease resistant test for packaging films
- Determination of respiration rate in fresh fruits and vegetables
- Determination of shelf life of fresh fruits and vegetables by using edible coating and films.
- Effect of edible coating and films on respiration behaviour, chemical, physical and sensory characteristics of fresh fruits and vegetables.
- Visit to food packaging material manufacturing industry

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|---|---------------|
| 1-4 | Active and intelligent packaging: Active Packaging Techniques and intelligent Packaging Techniques, current use of novel Packaging Techniques, consumers and novel Packaging. | 20% |
| 5-8 | Oxygen, ethylene and other scavengers: Oxygen scavenging technology, selecting right types of oxygen scavenger, ethylene scavenging technology, carbon dioxide and other scavengers. | |
| 9-12 | Antimicrobial food packaging: Antimicrobial agents, constructing antimicrobial packaging systems, factors affecting the effectiveness of antimicrobial packaging. | |
| 13-15 | Non-migratory bioactive polymers (NMBP): Advantages of NMBP, Inherently bioactive synthetic polymers: types and application, Polymers with immobilized bioactive compounds and their applications. | 30% |
| 16-18 | Time Temperature labels and indicators (TTIs): Defining and classifying TTIs, Requirements for TTIs, development of TTIs, Maximizing the effectiveness of TTIs, Application of TTIs- to monitor shelf-life, and optimization of distribution and stock rotation, leakage indicators, oxygen indicators, micro indicators etc. | |
| 19-20 | Freshness indicator in packaging: Compounds indicating the quality of packaged food products, freshness indicators, pathogen indicators, other methods for spoilage detection. Self-heating /rehydrating packages. | |
| 21-22 | Packaging-flavour interaction: Factors affecting flavor absorption, role of food matrix, role of differing packaging materials, flavour modification and sensory quality. | |

| | | |
|-------|--|------------|
| 23-24 | Study of packaging materials compatibility with foods. Developments in modified atmosphere packaging (MAP): Permeability properties of polymer packaging, measurement of permeability – water and gases. | 30% |
| 25-26 | Selection criteria of packaging films, Novel MAP gas, testing novel MAP applications, applying high oxygen MAP. | |
| 27-32 | Recycling packaging materials: Recyclability of packaging plastics, improving the recyclability of plastics packaging, testing safety and quality of recycled materials, uses of recycled plastics in packaging. | |
| | Recycling packaging materials: Recyclability of packaging plastics, improving the recyclability of plastics packaging, testing safety and quality of recycled materials, uses of recycled plastics in packaging. | |
| 33-34 | Green plastics for food packaging: Problems of plastic packaging wastes, range of biopolymers, developing novel biodegradable materials. | 20% |
| 35-36 | Edible Films and Coatings: Properties, types, sources, applications, advantages, disadvantages, theories of plasticization, challenges and opportunities. | |
| 37-38 | PFS machine, seal and closures. Safety and legislative aspects of packaging: Regulatory considerations, plastic, metal, paper and glass packaging. | |
| | Total | 100 |

Practical

| Practical No | Topic |
|--------------|---|
| 1 | Determination of WVTR in different packaging materials |
| 2 | Determination of GTR in different packaging materials. |
| 3 | Study of different ethylene scavengers and their analysis |
| 4 | Study of different oxygen scavengers systems and their analysis |
| 5 | Application of anti-microbial packaging for moisture sensitive foods |
| 6 | Evaluation of chemical residue migration from package to food |
| 7 | Application of MAP packaging in selected foods |
| 8 | Study of TTI label, leakage indicators etc. |
| 9 | Determination of oxidative changes in packaged foods |
| 10 | Comparative evaluation of flexible and rigid packages for fragile foods |
| 11 | Packaging of foods under inert atmosphere. |
| 12 | To study textural characteristics of selected fruit/ vegetable under MAP storage |
| 13 | Shelf life evaluation and mode up of packaged food product. |
| 14 | Determination of oil and grease resistant test for packaging films |
| 15 | Determination of respiration rate in fresh fruits and vegetables |
| 16 | Determination of shelf life of fresh fruits and vegetables by using edible coating and films. |
| 17 | Effect of edible coating and films on respiration behaviour, chemical, physical and sensory characteristics of fresh fruits and vegetables. |
| 18 | Visit to food packaging material manufacturing industry |

Suggested Readings

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

Theory**UNIT I**

Grain products: Industrial manufacturing of grain based products: formulation, processes, machinery and material balance of baked, rolled, shredded, puffed, flaked, roasted products. Extrusion technology: Importance and applications of extrusion in food processing; Pre and post extrusion treatments; Manufacturing process of extruded products; Change of functional properties of food components during extrusion. Breakfast cereals, RTE/RTC foods, instant premixes, functional foods.

UNIT II

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

UNIT III

Chocolates and candies: Coating or enrobing of chocolate (including pan-coating); Maintenance, safety and hygiene of bakery plants. Fats and oils processing: Technology of refined oil, winterized oil, hydrogenated fat, Texturized fat, by-products of fat/oil processing industries – oil seed protein isolates; Quality standards of fats and fatty foods; Antioxidants and its mechanism of application.

UNIT IV

Beverages: Production technology of beer and wine; Non – alcoholic beverages: Carbonated beverages: carbonation equipment, - ingredients preparation of syrups- Filling system-packaging-containers and closures. Non-carbonated beverage: Coffee bean preparation-processing-brewing-decaffeination- instant coffee, Tea types black, green, Fruit juices and beverages, Flash pasteurization, Aseptic Packaging of beverages Tea/coffee and cocoa beverages, Grain based and malted beverages. Packaged drinking water: types, manufacturing processes, quality evaluation and raw and processed water, methods of water treatment, BIS quality standards of bottled water; mineral water, natural spring water, flavoured water, carbonated water.

Practical

- Preparation of cereals based fried snack foods
- Preparation of cereal, pulses based ready-to-eat snack food by extrusion cooking their quality evaluation
- Preparation of cereal grain based puffed products
- Development of instant food premixes
- Preparation of cereal and legume based roasted snack
- Preparation of flaked rice product
- To study the effect of roasting time and temperature on quality of pop-corn
- Determination of shelf-life and packaging requirements of snack food products
- Preparation of fruits/vegetable based ready to serve beverages and quality evaluation
- Heat classification of milk powders.
- Determination of degree of browning-chemical/physical methods.

- Determination of quality of packaged drinking water.
- Preparation of wine and beer
- Preparation of soy milk.
- Determination of quality of canned food.

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|--|---------------|
| 1-2 | Grain products: Industrial manufacturing of grain based products: formulation, processes, machinery and material balance of baked, rolled, shredded, puffed, flaked, roasted products. | 20% |
| 3 | Extrusion technology: Importance and applications of extrusion in food processing; Pre and post extrusion treatments. | |
| 4-5 | Manufacturing process of extruded products; Change of functional properties of food components during extrusion. | |
| 6 | Breakfast cereals, RTE/RTC foods, instant premixes, functional foods. | 20% |
| 7-9 | Fruit and vegetable products: Industrial manufacturing of fruit and vegetable based products: formulation, processes, machinery and material balance of minimally processed. | |
| 10-11 | Retorted products, IMF, high moisture stable foods, IQF. | |
| 12-14 | Machines and equipment for batch and continuous processing of fruit and vegetable products. | 30% |
| 15 | Chocolates and candies: Coating or enrobing of chocolate (including pan-coating). | |
| 16-17 | Maintenance, safety and hygiene of bakery plants. | |
| 18-20 | Fats and oils processing: Technology of refined oil, winterized oil, hydrogenated fat, Texturized fat, by-products of fat/oil processing industries. | 30% |
| 21-24 | Oil seed protein isolates; Quality standards of fats and fatty foods; Antioxidants and its mechanism of application. | |
| 25-27 | Beverages: Production technology of beer and wine; Non – alcoholic beverages: Carbonated beverages: carbonation equipment, - ingredients preparation of syrups-Filling system-packaging-containers and closures. | |
| 28-32 | Non-carbonated beverage: Coffee bean preparation-processing-brewing-decaffeination- instant coffee, Tea types black, green, Fruit juices and beverages, Flash pasteurization, Aseptic Packaging of beverages. | 30% |
| 33-35 | Tea/coffee and cocoa beverages, Grain based and malted beverages. Packaged drinking water: types, manufacturing processes, quality evaluation and raw and processed water, methods of water treatment. | |
| 36-38 | BIS quality standards of bottled water; mineral water, natural spring water, flavoured water, carbonated water. | |

Practical

| Practical No | Topic |
|--------------|---|
| 1 | Preparation of cereals based fried snack foods |
| 2-4 | Preparation of cereal, pulses based ready-to-eat snack food by extrusion cooking their quality evaluation |
| 5 | Preparation of cereal grain based puffed products |
| 6 | Development of instant food premixes |
| 7 | Preparation of cereal and legume based roasted snack |
| 8 | Preparation of flaked rice product |
| 9 | To study the effect of roasting time and temperature on quality of pop-corn |
| 10 | Determination of shelf-life and packaging requirements of snack food products |
| 11-12 | Preparation of fruits/vegetable based ready to serve beverages and quality evaluation |
| 13 | Heat classification of milk powders. |
| 14 | Determination of degree of browning-chemical/physical methods. |
| 15 | Determination of quality of packaged drinking water. |
| 16 | Preparation of wine and beer |
| 17 | Preparation of soy milk. |
| 18 | Determination of quality of canned food. |

Suggested Readings

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

Theory**UNIT I**

Introduction: Defining nutraceuticals and functional foods. Nature, type and scope of nutraceutical and functional foods. Nutraceutical and functional food applications and their health benefits. Nutraceutical compounds and their classification based on chemical and biochemical nature, Innovations in Functional Food Industry for Health and Wellness, Development of biomarkers to indicate efficacy of functional ingredients. Nutraceuticals and Functional foods: Nutraceuticals / food components for specific disease such as cancer, heart disease, diabetes, obesity, anti-aging, arthritis, Prebiotics and probiotics; Omega and omega 6 fatty acids, Isoflavones, phenolic compounds, catechins, lycopene, glucosinolates.

UNIT II

Specialty Foods: Design of food for infants, children and old age. Functional Beverage: Selection of ingredients, health benefits and production. Extraction and delivery system: Non-thermal techniques, bioprocessing techniques, dehydration techniques, effect on bioactive ingredients. Delivery system and controlled release of nutraceuticals

UNIT III

Packaging, Storage, labelling: Packaging requirements, storage and storage kinetics on quality of nutraceuticals, interactions of various environmental factors. Marketing and safety aspects: Marketing and safety and regulatory issues for functional foods and nutraceuticals.

UNIT IV

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

Practical

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

- To study the storage kinetics of nutraceutical.
- Estimation of soluble/insoluble fibres of given food sample.

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|--|---------------|
| 1-2 | Introduction: Defining nutraceuticals and functional foods. Nature, type and scope of nutraceutical and functional foods. | 40% |
| 3-4 | Nutraceutical and functional food applications and their health benefits. | |
| 5-6 | Nutraceutical compounds and their classification based on chemical and biochemical nature, Innovations in Functional Food Industry for Health and Wellness. | |
| 7-8 | Developmen of Biomarke to indicate efficacy of Functional ingredients. | |
| 9-10 | Nutraceuticals and Functional foods: Nutraceuticals / food components for specific disease such as cancer, heart disease, diabetes, obesity, anti- aging, arthritis. | |
| 11-12 | Prebiotics and probiotics; Omega and omega 6 fatty acids, Isoflavones, phenolic compounds, catechins, lycopene, glucosinolates. | |
| 13-14 | Specialty Foods: Design of food for infants, children and old age. | 20% |
| 15-16 | Functional Beverage: Selection of ingredients, health benefits and production. | |
| 17-18 | Extraction and delivery system: Non-thermal techniques, bioprocessing techniques, dehydration techniques, effect on bioactive ingredients. | |
| 19 | Delivery system and controlled release of nutraceuticals. | 20% |
| 20-22 | Packaging, Storage, labelling: Packaging requirements, storage and storage kinetics on quality of nutraceuticals, interactions of various environmental factors. | |
| 23-26 | Marketing and safety aspects: Marketing and safety and regulatory issues for functional foods and nutraceuticals. | |
| 27-28 | Nutrigenomics: concept of personalized medicine. | 20% |
| 29-30 | Use of nanotechnology in functional food industry. | |
| 31-32 | Biological functionality of cruciferous vegetables, tropical, subtropical and temperate fruits, herbs and spices. | |
| | Total | 100 |

Practical

| Practical No | Topic |
|--------------|---|
| 1-3 | Determination of antioxidant activity of given food sample by different techniques viz DPPH, FRAP, ABTS, FRAP. |
| 4 | Determination of total phenolic content of given food sample. |

| | |
|----|---|
| 5 | Estimation of dietary fibres of given food sample. |
| 6 | Estimation of lycopene in tomato. |
| 7 | Estimation of carotenoids of given food sample. |
| 8 | Determination of total flavonoid content of given food sample |
| 9 | Effect of heat processing on ascorbic acid |
| 10 | Determination of vitamins A. |
| 11 | Estimation of pectic substances in plant sample |
| 12 | Determination of beta carotene of given food sample. |
| 13 | To determine gas chromatography for bioactive components analysis. |
| 14 | To study the effect of drying on bioactive components of food sample |
| 15 | To study the packaging requirement of functional foods. |
| 16 | Determination and qualifications of some nutraceutical and functional food compounds by HPLC. |
| 17 | Estimation of β - glucan |
| 18 | To study the storage kinetics of nutraceutical. |
| 19 | Estimation of soluble/insoluble fibres of given food sample. |

Suggested Readings

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

Theory**UNIT I**

Present status of traditional food products, Globalization of traditional food products; Plans and policies of the Government and developmental agencies. Overview of heat- desiccated, coagulated, fried, fermented traditional food products Process technology for Indian bread (chapatti), paratha, stuffed paratha, panipoori Process technology for Indian fried foods- poori, samosa, sev, fafda, chorafali, Jalebi Process technology for fermented traditional food and its improvement- pickle, idli, khaman, nan, dahi, dhokla, Spiced buttermilk etc. Process improvement in production of Indian sweets (Halwasan, kajukatli, carrothalwa, Rabdi, chocolate burfi, Chikki etc). Process improvement in production of puffed cereals and grains by microwave technique

UNIT II

New products based on fruits, vegetables and cereals Application of membrane technology; microwave heating, steaming, extrusion for industrial production of traditional food products (Shrikhand, Dhokla, wadi, murukku/chakri, Patra, Khandvi) Utilization and scope of legumes and grains in India for novel food products development like flour, ready to eat products, flour mixes etc (puranpoli, Idlimix, Wada mix, Gotamix) Process technology for convenience traditional food products (ready to eat and serve –Curried vegetables, pulses and legumes), chutneys, paste Use of natural and permitted synthetic preservatives and new packaging systems for traditional food products

UNIT III

Techno-economic aspects for establishing commercial units for traditional products. Introduction to traditional foods of India, composition and nutritive values, microbial and biochemical diversity, quality and food safety challenges Processing & Preservation methods of Sweets & Desserts: Kulfi, Falooda, Kheer, khurchan, khoa/mawa, Rabri, jalebi, imarti, Gulab jamun, Peda, petha, rewdi, gajak, milk cake, balushahi, bal mithai, singoni, Ras- malayi, Gulqand, ghevar, rasgolla, chamcham, son halwa, son papri, several varieties of halwa, laddu, barfi & rasgolla.

UNIT IV

Traditional fermented foods: Idli, dosa, Vada, khamman dhokla, Dahi (Curd), Srikhand. Processing & Preservation methods of Snacks: Gujiya, kachauri, samosa, mirchibada, kofta, potato chips, banana-chips, mathri, bhujiya, fried dhals, bhujia, shakarpara, pakora, vada.

Processing & Preservation methods of Baked Products: Biscuits, Toast, Candies, Cookies, Breads, Roti, Naan, Tandoori Roti, parantha, kulcha, puri, bhatura. Processing & Preservation methods of Preserves & Beverages: Murabba, sharbat, pana, aam papad, sharbat, Coconut water, milk (khas, rose), Alcoholic Beverages Industrialization, Socioeconomic Conditions and Sustainability of Traditional Foods.

Practical

- To study the effect of different combination of salt and oil in quality of traditional fermented food product (pickle)

- To study the effect of different starter culture on taste and texture of idli
- To evaluate the shelf life of stuffed paratha under different storage conditions
- To study the effect of time and temperature on quality of fried food products (poori/ panipoori etc.
- To study effect of sugar and Artificial sweeteners in the preparation of kajukatli
- To study the microwave heating in drying of khaman/ dhokla
- To study the effect of cold extrusion on mixing of vermicelli
- To prepare instant carrot halwa mix
- To study the effect of different packaging material on shelf life of traditional Indian food products
- To study the effect of different natural food preservatives in traditional sweets
- Preparation of spiced buttermilk
- Preparation of puffed cereals and grains
- Preparation and quality evaluation of Instant Premixes (Puranmix)
- Preparation and quality evaluation of dried malted moth bean powder
- Preparation of Indian traditional confections (chikki)
- Visit to ethnic food industry (Instant mixes/Pickle making)

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|---|---------------|
| 1-2 | Present status of traditional food products, Globalization of traditional food products; Plans and policies of the Government and developmental agencies. | 30% |
| 3-4 | Overview of heat-desiccated, coagulated, fried, fermented traditional food products Process technology for Indian bread (chapatti), paratha, stuffed paratha, panipoori. | |
| 5-8 | Process technology for Indian fried foods- poori, samosa, sev, fafda, chorafali, Jalebi Process technology for fermented traditional food and its improvement- pickle, idli, khaman, nan, dahi, dhokla, Spiced buttermilk etc. | |
| 9-10 | Process improvement in production of Indian sweets (Halwasan, kajukatli, carrothalwa, Rabdi, chocolate burfi, Chikki etc). | |
| 11-12 | Process improvement in production of puffed cereals and grains by microwave technique. | |
| 13-15 | New products based on fruits, vegetables and cereals Application of membrane technology; microwave heating, steaming, extrusion for industrial production of traditional food products (Shrikhand, Dhokla, wadi, murukku/chakri, Patra, Khandvi). | 20% |
| 16-18 | Utilization and scope of legumes and grains in India for novel food products development like flour, ready to eat products, flour mixes etc (puranpoli, Idlimix, Wada mix, Gotamix). | |
| 19-21 | Process technology for convenience traditional food products (ready to eat and serve –Curried vegetables, pulses and legumes), chutneys, paste. | |

| | | |
|-------|--|------------|
| 22-23 | Use of natural and permitted synthetic preservatives and new packaging systems for traditional food products. | |
| 24-26 | Techno-economic aspects for establishing commercial units for traditional products. Introduction to traditional foods of India, composition and nutritive values, microbial and biochemical diversity, quality and food safety challenges. | 20% |
| 27-30 | Processing & Preservation methods of Sweets & Desserts: Kulfi, Falooda, Kheer, khurchan, khoa/mawa, Rabri, jalebi, imarti, Gulab jamun, Pedas, petha, rewdi, gajak, milk cake, balushahi, bal mithai, singoni, Ras-malayi, Gulqand, ghevar, rasgolla, chamcham, son halwa, son papri, several varieties of halwa, laddu, barfi & rasgolla. | |
| 31-33 | Traditional fermented foods: Idli, dosa, Vada, khamman dhokla, Dahi (Curd), Srikhand. | 30 % |
| 34-35 | Processing & Preservation methods of Snacks: Gujiya, kachauri, samosa, mirchibada, kofta, potato chips, banana-chips, mathri, bhujia, fried dhals, bhujia, shakarpara, pakora, vada. | |
| 36-37 | Processing & Preservation methods of Baked Products: Biscuits, Toast, Candies, Cookies, Breads, Roti, Naan, Tandoori Roti, parantha, kulcha, puri, bhatura. | |
| 38-39 | Processing & Preservation methods of Preserves & Beverages: Murabba, sharbat, pana, aam papad, sharbat, Coconut water, milk (khas, rose). | |
| 40 | Alcoholic Beverages Industrialization, Socioeconomic Conditions and Sustainability of Traditional Foods. | |
| | Total | 100 |

Practical

| Practical No | Topic |
|--------------|--|
| 1 | To study the effect of different combination of salt and oil in quality of traditional fermented food product (pickle) |
| 2 | To study the effect of different starter culture on taste and texture of idli. |
| 3 | To evaluate the shelf life of stuffed paratha under different storage conditions. |
| 4 | To study the effect of time and temperature on quality of fried food products (poori/ panipoori etc. |
| 5 | To study effect of sugar and Artificial sweeteners in the preparation of kajukatli. |
| 6 | To study the microwave heating in drying of khaman/ dhokla. |
| 7 | To study the effect of cold extrusion on mixing of vermicelli. |
| 8 | To prepare instant carrot halwa mix. |
| 9-11 | To study the effect of different packaging material on shelf life of traditional Indian food products. |
| 12 | To study the effect of different natural food preservatives in traditional sweets. |
| 13 | Preparation of spiced buttermilk. |
| 14 | Preparation of puffed cereals and grains. |
| 15 | Preparation and quality evaluation of Instant Premixes (Puranmix). |
| 16 | Preparation of quality evaluation of dried malted moth bean powder. |
| 17 | Preparation of Indian traditional confections (chikki). |

Suggested Readings

1. K.H. Steinkrus. (1995) Handbook of Indigenous Fermented Foods. CRC Press
2. P. Wickramasinghe. (2007). The Food of India OM Book Service
3. R. P. Aneja, B.N. Mathur, R.C. Chandan, and A.K Banerjee (2002)
Technology of Indian Milk Products, India Year Book Publications
4. Rakesh Mangal. (2013) Fundamentals of Indian Cooking: Theory and Practice.

Theory**UNIT I**

Introduction: Role of food ingredients and additives in food processing, functions, classification, intentional and unintentional food additives, toxicology and safety evaluation of food additives, beneficial effects of food additives, food additives generally recognized as safe (GRAS), tolerance levels and toxic levels in foods-LD 50 values of food additives. Preservatives: General mechanism of action; basis of selection; classes; Chemical preservatives: characteristics, antimicrobial spectrum, mechanism of action, toxicology, regulations, application in food.

UNIT II

Antioxidants: Characteristics, types/classes/groups, mechanism of action/ working of antioxidants, functions, sources, application in food, limits and toxic effects of synthetic antioxidants, synergistic effects of antioxidants, role of free radicals in human body, Natural antioxidants. Flavouring agents: Flavour functions, selection; forms; sources; process of flavour creation; natural and synthetic flavouring; extractions methods; production process; application in food. Emulsifiers and Stabilizers: Characteristics/ functional properties; functions; basis of selection; types; mechanism of emulsion formation; mechanisms of emulsion stabilization and destabilization; application in food

UNIT III

Hydrocolloids: Definition: function and functional properties: sources; application in food. Sweeteners: Characteristics; classification/types; applications in food; Limits and toxicology of non-nutritive sweeteners. Colouring agents: Properties; functions; classification; sources of natural and synthetic colours: extraction; applications in food, levels of use, misbranded colours, colour stabilization.

UNIT IV

Starch, protein, and lipids, fibres and fructo-oligosaccharides: As functional ingredients; their isolation, modification, specifications, functional properties and applications in foods. Humectants, clarifying agents, Stabilizers and thickeners, Bleaching and maturing agents, Humectants, Sequestrants / chelating agents, Anti-caking agents, Buffering agents, Acidulants: definition; characteristics; sources; functions and their application in food processing.

Practical

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

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

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|--|---------------|
| 1-4 | Introduction: Role of food ingredients and additives in food processing, functions, classification, intentional and unintentional food additives, toxicology and safety evaluation of food additives. | 30% |
| 4-7 | Beneficial effects of food additives, food additives generally recognized as safe (GRAS), tolerance levels and toxic levels in foods-LD 50 values of food additives. | |
| 8-10 | Preservatives: General mechanism of action; basis of selection; classes; Chemical preservatives: characteristics, antimicrobial spectrum, mechanism of action, toxicology, regulations, application in food. | |
| 11-13 | Antioxidants: Characteristics, types/classes/groups, mechanism of action/ working of antioxidants, functions, sources, application in food, limits and toxic effects of synthetic antioxidants, synergistic effects of antioxidants. | 30% |
| 13-15 | Role of free radicals in human body, Natural antioxidants. Flavouring agents: Flavour functions, selection; forms; sources; process of flavour creation; natural and synthetic flavouring; extractions methods; production process; application in food. | |
| 16-20 | Emulsifiers and Stabilizers: Characteristics/ functional properties; functions; basis of selection; types; mechanism of emulsion formation; mechanisms of emulsion stabilization and destabilization; application in food. | |
| 21 | Hydrocolloids: Definition: function and functional properties: sources; application in food. | 20% |
| 22-24 | Sweeteners: Characteristics; classification/types; applications in food; Limits and toxicology of non-nutritive sweeteners. | |
| 25-27 | Colouring agents: Properties; functions; classification; sources of natural and synthetic colours: extraction; applications in food, levels of use, misbranded colours, colour stabilization. | |
| 28-30 | Starch, protein, and lipids, fibres and fructo-oligosaccharides: As functional ingredients; their isolation, modification, specifications, functional properties and applications in foods. | 20% |
| 33-35 | Humectants, clarifying agents, Stabilizers and thickeners, Bleaching and maturing agents, Humectants, Sequestrants / chelating agents, Anti- caking agents, Buffering agents. | |

| | | |
|-------|---|-----|
| 36-38 | Acidulants: definition; characteristics; sources; functions and their application in food processing. | |
| | Total | 100 |

Practical

| Practical No | Topic |
|--------------|---|
| 1 | Determination of benzoic acid in food samples |
| 2 | Estimation of sulphur dioxide in food samples |
| 3 | Estimation of sorbic acid in cheese and yoghurt |
| 4 | Determination of nitrate and nitrites in foods |
| 5 | Detection and determination of aspartame by thin layer chromatography |
| 6-7 | Liquid chromatographic determination of caffeine, benzoate and saccharin in soda beverage |
| 8 | Identification of natural colours |
| 9-10 | Isolation, identification and estimation of synthetic food colours |
| 11 | TLC detection of antioxidants in fats and oils |
| 12 | TLC detection of emulsifiers |
| 13-15 | Detection of alginates in foods (chocolate, ice cream) |
| 16-17 | GC determination of menthol in mentholated pan masala |
| 18-19 | Isolation and modifications of protein, starch, lipids, fibres from the raw and processed food samples. |
| 20 | Estimation of various additives mentioned in unit IV |

Suggested Readings

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

Theory**UNIT I**

Introduction: General Characteristics of Enzymes, Classes and Nomenclature of Enzymes, Enzymatic Reactions, Factors affecting enzyme activity, Enzyme Kinetic, Enzyme Inhibition Enzyme Production: Selection and sources of commercial Enzymes, Advantages of microbial enzymes, rDNA in enzyme engineering, Problems of scale up, Enzyme extraction and purification.

UNIT II

Immobilization: Techniques, Advantages and disadvantages, use of immobilized biocatalysts in food processing Enzymes for protein modification (hydrolysates and bioactive peptides), Enzymes for Lipid modification Enzymes in cereal processing: Application of enzymes in process of malting, brewing, milling, baking (fungal – amylase for bread making; maltogenic – amylases for anti-staling xylansandpentosanes as dough conditioners; lipases or dough conditioning; oxidases as replacers of chemical oxidants; synergistic effect of enzymes), production of high fructose corn syrup, glucose syrups.

UNIT III

Enzymes in fruit processing: Applications of enzyme in fruit juice clarification, removal of haziness and bitterness, Uses of enzymes in wine production Enzymes in meat, fish and milk processing: Meat tenderization and flavour development, fish processing (De- skinning, collagen extraction etc.,) Egg processing, Cheese processing.

UNIT IV

Flavour production: Role of enzymes (enzyme-aided extraction of plant materials for production of flavours, production of flavour enhancers such as nucleotides, MSG; flavours from hydrolysed vegetable/animal protein) Enzymes in the processing of fats and oils: specificity, stability and application of lipases and related enzymes Role of enzymes in hydrolysis of triglycerides, interesterification and randomization. Enzyme allergy.

Practical

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

- To carry out protease fermentation
- To carry out lipase fermentation

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|---|---------------|
| 1-5 | Introduction: General Characteristics of Enzymes, Classes and Nomenclature of Enzymes, Enzymatic Reactions, Factors affecting enzyme activity, Enzyme Kinetic, Enzyme Inhibition | 20% |
| 6-10 | Enzyme Production: Selection and sources of commercial Enzymes, Advantages of microbial enzymes, rDNA in enzyme engineering, Problems of scale up, Enzyme extraction and purification | |
| 10-14 | Immobilization: Techniques, Advantages and disadvantages, use of immobilized biocatalysts in food processing. Enzymes for protein modification (hydrolysates and bioactive peptides). | 30% |
| 15-18 | Enzymes for Lipid modification Enzymes in cereal processing: Application of enzymes in process of malting, brewing, milling, baking (fungal –amylase for bread making; maltogenic – amylases for anti- staling xylansandpentosanes as dough conditioners. | |
| 19-21 | lipases or dough conditioning; oxidases as replacers of chemical oxidants; synergistic effect of enzymes), production of high fructose corn syrup, glucose syrups. | |
| 22-25 | Enzymes in fruit processing: Applications of enzyme in fruit juice clarification, removal of haziness and bitterness. | 20% |
| 26-28 | Uses of enzymes in wine production Enzymes in meat, fish and milk processing. | |
| 29-30 | Meat tenderization and flavour development, fish processing (De- skinning, collagen extraction etc..) Egg processing, Cheese processing. | |
| 31-34 | Flavour production: Role of enzymes (enzyme-aided extraction of plant materials for production of flavours, production of flavour enhancers such as nucleotides, MSG; flavours from hydrolysed vegetable/animal protein) | 30% |
| 35-38 | Enzymes in the processing of fats and oils: specificity, stability and application of lipases and related enzymes Role of enzymes in hydrolysis of triglycerides, interesterification and randomization. Enzyme allergy. | |
| | Total | 100 |

Practical

| Practical No | Topic |
|--------------|--|
| 1 | To investigate some of the kinetic properties of invertase |
| 2 | To study time course of the reaction catalysed by alkaline phosphatase. |
| 3 | To investigate the thermal stability of horseradish peroxidase |
| 4 | Quantitative estimation of endoglucanase |
| 5 | Quantitative estimation of exoglucanase |
| 6 | Quantitative estimation of β galactosidase |
| 7 | Quantitative estimation of Pectinase |
| 8 | Quantitative estimation of Protease |
| 9 | Quantitative estimation of Lipase |
| 10-12 | Immobilization of amylase by sodium alginate and comparative evaluation with native enzyme |
| 13-14 | To immobilize yeast cells and demonstrate its biological activity by invertase assay |
| 15-16 | To carry out amylase fermentation |
| 17-18 | To carry out protease fermentation |
| 19-20 | To carry out lipase fermentation |

Suggested Readings

1. Trevor Palmer (2008) Enzymes: Biochemistry, Biotechnology and Clinical Chemistry East West
1. 2.Allen I. Laskin (2007) Enzymes and Immobilized Cells in Biotechnology Benjamin/Cummings Pub. Co
2. 3.Mansi El-Mansi & Charlie Bryce (2011) Fermentation Microbiology and Biotechnology CRC Press
3. 4.Nicholes C. Price and Lewis Stevens 2000 Fundamentals of Enzymology Oxford University Press
4. 5.Gerald Reed (2007) Enzymes in Food Processing Academic Press
5. Whitehurst RJ & Oort MV (2010) Enzymes in Food Technology Blackwell Publ
6. Bayindirli A (2010) Enzymes in Fruit and Vegetable Processing: chemistry and engineering applications CRC Press.

Theory**UNIT I**

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

UNIT II

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

UNIT III

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

UNIT IV

Predictive microbial modelling: classification of models: Kinetic & probability, Empirical & mechanistic models, Primary, secondary & tertiary models, Deterministic & stochastic models; Description of main models, Modelling growth curves, Modelling inactivation/survival curves, Secondary models, Probability models; Applications of predictive microbial modelling: Hazard analysis critical control point (HACCP) & quantitative risk assessment (QRA), Microbial shelflife studies, Temperature function integration and temperature monitors, Product research and development, Design of experiments; Predictive microbial modelling and quantitative risk assessment.

UNIT V

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

UNIT VI

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

Practical

- Rapid methods and automation in microbiology: trends and predictions
- Study on phage-based detection of foodborne pathogens
- Study on real-time PCR
- Study on DNA Array

- Study on immunoassay
- Offline and online assessments for food safety for industry
- Storage pest, insects and rodent control
- Study on storage systems and structures, Shelf life evaluation of packaged food products
- Recent advancements in storage and handling systems
- Hygienic design standards and codes for food processing equipment / system
- Case studies on food safety engineering, guidelines, regulations.

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|---|---------------|
| 1-4 | Overview of food microbiology: Foodborne illness, food spoilage, food fermentation, microbiological physiology and food preservation, microbiological analysis, safety management systems. | 20% |
| 5-8 | Overview of food-borne pathogens: Bacterial pathogens, food borne viruses and parasites. | |
| 9-10 | Chemical safety of foods: nature of chemical hazards in foods, food safety engineering and control of chemical hazards, food allergen control. | 10% |
| 11-12 | Intrinsic and extrinsic parameters for microbial growth and heat inactivation: Intrinsic and extrinsic factors affecting microbial growth, factors affecting heat resistance, combining traditional peroration techniques. | |
| 13-15 | Kinetics of microbial inactivation: Microbial inactivation kinetics based on food processing methods: thermal, pressure, pulsed electric field, microwave and radio frequency, ohmic and inductive heating etc. | 20% |
| 16-18 | Kinetic parameter for the inactivation of pathogens: Salmonella, Listeria monocytogenes, Staphylococcus aureus, Escherichia coli, Bacillus cereus, Clostridium, Vibrio, other pathogens. | |
| 19-20 | Predictive microbial modelling: classification of models: Kinetic & probability, Empirical & mechanistic models, Primary, secondary & tertiary models, Deterministic & stochastic models; Description of main models. | 20% |
| 21-23 | Modelling growth curves, Modelling inactivation/survival curves, Secondary models, Probability models; Applications of predictive microbial modelling: Hazard analysis critical control point (HACCP) & quantitative risk assessment (QRA). | |
| 24-26 | Microbial shelflife studies, Temperature function integration and temperature monitors, Product research and development, Design of experiments; Predictive microbial modelling and quantitative risk assessment. | |
| 27-28 | Process-dependent microbial modeling: Predictive microbial | |

| | | |
|-------|--|-----|
| | kinetic models, Temperature dependent microbial growth kinetic models. | 10% |
| 29 | Irradiation-dependent microbial growth model. | |
| 30-32 | Pulsed electric field-dependent microbial growth model, High-pressure-dependent microbial growth model. | |
| 33 | Process modeling; Integration of process and microbial growth kinetic models. | |
| 34 | Storage and handling systems for grains, horticultural and animal based produces. | |
| 35-36 | Post-harvest physiology of fruits and vegetables; post-harvest physiology of fruits and vegetables. | |
| 37-38 | biochemical changes during storage, production, distribution; storage capacity estimate models, ecology, storage factors affecting losses, storage requirements. | |
| | Total | 100 |

Practical

| Practical No | Topic |
|--------------|--|
| 1-2 | Rapid methods and automation in microbiology: trends and predictions |
| 3-4 | Study on phage-based detection of foodborne pathogens |
| 5 | Study on real-time PCR |
| 6-7 | Study on DNA Array |
| 8-9 | Study on immunoassay |
| 10-11 | Offline and online assessments for food safety for industry |
| 12-13 | Storage pest, insects and rodent control |
| 14-15 | Study on storage systems and structures, Shelf life evaluation of packaged food products |
| 16-17 | Recent advancements in storage and handling systems |
| 18-19 | Hygienic design standards and codes for food processing equipment / system |
| 20-21 | Case studies on food safety engineering, guidelines, regulations. |

Suggested Readings

1. Sun, D. W. (2015). Handbook of food safety engineering. Wiley Black Well Academic Press, Elsevier Ltd
2. International Organization for Standardization. (2018). Food Safety Management Systems: Requirements for Any Organization in the Food Chain. ISO.
3. Shejbal J (1980). Controlled Atmosphere Storage of Grains. Elsevier, Vijayaraghavan
4. S. (1993). Grain Storage Engineering and Technology. Batra Book Service
4. Chakraverty A. & Singh R.P. (2014). Postharvest technology and food process engineering. CRC Press
5. Chakraverty A., Mujumdar A.S. & Ramaswamy H.S. (2002). Handbook of Postharvest Technology: Cereals, Fruits, Vegetables, Tea, and Spices. CRC Press
6. ISO 22000 Food safety management systems - Requirements for any organization in the food chain. Technical Committee ISO/TC 34, Food products and updates
7. Case Studies & Field Reports - Food Safety Engineering.

Theory**UNIT I**

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

UNIT II

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

UNIT III

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

UNIT IV

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

Practical

- Estimation of protein content in food samples using spectroscopic methods
- Study of effect of heat on protein denaturation using enzymes
- Study of effect of various salt solutions on solubility of proteins
- Separation of milk proteins by salting out method
- Separation of proteins using chromatographic methods
- Fractionation of proteins
- Extraction and purification of essential oil/ flavouring compound of a natural source
- Study the process of starch retrogradation, gelatinization and modification
- Estimation of crude and dietary fibres in given food sample
- Analysis of resistant starches
- Estimation of various antioxidants, polar compounds and free fatty acids in frying oils
- Extraction and purification of natural plant pigment
- Functional properties and isoelectric point of proteins

- Qualitative and quantitative evaluation of processing and packaging induced chemicals
- Qualitative identification of different flavouring compounds

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|---|---------------|
| 1-4 | Composition, nutritional and functional value of food. | 25% |
| 5-6 | Water activity and sorption phenomenon, Engineered foods and influencing water activity and shelf-life. | |
| 7-10 | Chemical reactions of carbohydrates—oxidation, reduction, with acid & alkali. | |
| 9-11 | Maillard reaction, Caramelization, Ascorbic acid oxidation. | |
| 12-15 | Resistant Starch, Soluble and Insoluble fibre, Pigments and approaches to minimize the impact of food processing, Molecular Mobility. | |
| 16-18 | Structure and Properties of proteins; electrophoresis, sedimentation, amphoterism, denaturation, viscosity, gelation, texturization, emulsification, foaming, protein-protein and other interactions in food matrix. | 25% |
| 19-21 | Lipids: melting point, softening point, smoke, flash and fire point, turbidity point, polymorphism and polytypism; Lipids: melting point, softening point, smoke, flash and fire point, turbidity point, polymorphism and polytypism; | |
| 22-24 | Polymerization and polymorphism, flavor reversion, autooxidation and its prevention, fat in food matrix like fat globule in milk. | |
| 25-28 | PUFA, MUFA, CLA, ω - fatty acids, trans fatty acids, phytosterol, etc. | |
| 29-30 | Description of food flavours; Flavour enhancers, Food acids their tastes and flavours. | |
| 31-33 | Principles and techniques of flavour encapsulation, types of encapsulation; Factors affecting stabilization of encapsulated flavor and their applications in food industry. | 25% |
| 34-35 | Processing and packaging induced chemicals and their control – acrylamide, nitrosamines, carcinogenic and genotoxic chloropropanols such as 3-monochloropropane-1,2diol (3-MCPD). | 25% |
| 36-38 | PAHs (in grilled and smoked products), dioxine, histamine, ethyl carbamate, furan, bisphenol A or phthalates from plastic materials, microplastics, 4-methylbenzophenone and 2-isopropylthioxanthone from inks, mineral oil from recycled fibers or semicarbazide from a foaming agent in the plastic gasket. | |
| | Total | 100 |

Practical

| Practical No | Topic |
|--------------|---|
| 1 | Estimation of protein content in food samples using spectroscopic methods |
| 2 | Study of effect of heat on protein denaturation using enzymes |
| 3 | Study of effect of various salt solutions on solubility of proteins |
| 4 | Separation of milk proteins by salting out method |
| 5 | Separation of proteins using chromatographic methods |
| 6 | Fractionation of proteins |
| 7 | Extraction and purification of essential oil/ flavouring compound of a natural source |
| 8-10 | Study the process of starch retrogradation, gelatinization and modification |
| 11 | Estimation of crude and dietary fibres in given food sample |
| 12 | Analysis of resistant starches |
| 13 | Estimation of various antioxidants, polar compounds and free fatty acids in frying oils |
| 14-15 | Extraction and purification of natural plant pigment |
| 16 | Functional properties and isoelectric point of proteins |
| 17 | Qualitative and quantitative evaluation of processing and packaging induced chemicals |
| 18 | Qualitative identification of different flavouring compounds |

Suggested Readings

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|---|---------------|
| 1-2 | International Plant Protection Convention, world organization for animal health (OIE), sanitary and phytosanitary measures (SPS). | 25% |
| 3-5 | Codex Alimentarius, FAOLEX, OECD Agriculture and Fisheries, International Trade Centre's Standards Map. | |
| 6-9 | FAO Food safety and quality emergency Prevention, JFSCA, Fundamental Principles of food safety governance. | |
| 10-12 | Risk Analysis as a Method to Determine the Regulatory Outcome, Increasing Responsibility of Businesses (Private) Risk Assessors. | |

| | | |
|-------|--|-------|
| 13-14 | Concept of harmonization of global food laws. Concept of harmonization of global food laws. | |
| 15-16 | EU Food Safety Standards - Regulation 178 of 2002, The European food safety authority (EFSA), A critical overview of the EU food safety policy and standards. | |
| 17-18 | COMESA Food Safety Standards - An overview, Case Studies in Food Safety Standards in EU-COMESA Trade, Private voluntary standards (PVS) and EU food safety standards. | 25% |
| 19-20 | FDA Food safety modernization Act (FSMA), FSPCA Preventive Controls for Human Food, Foreign Supplier Verification Programs (FSVP). | |
| 21-22 | Food Facility Registration, FDA - Current Good Manufacturing Practices (CGMPs). Food Facility Registration, FDA - Current Good Manufacturing Practices (CGMPs). | |
| 23-24 | Hazard Analysis & Critical Control Points (HACCP) guidelines. | 25% |
| 25-26 | Foreign Food Facility Inspection Program, International and Interagency Coordination, Registration of Food Facilities, Seafood Imports and Exports, Regulation on GM Foods. | |
| 27-30 | Regulations on Irradiated foods, Global Regulations on Health Foods, International Law on Adequacy of thermal processing. | |
| 31-33 | Grain Fumigation for Export, Law of trading horticultural Products, Safety Frame Applied to Food Applications of Nanotechnology. | 25% |
| 34-35 | Review of Indian Regulatory Scenario in Food and Food Products. | |
| 36-37 | Food Safety and Standards (FSS) Act, 2006, FSS Rules and Regulations, Agricultural Produce Act, 1937 (Grading and Marketing). | |
| 38-40 | Export (Quality Control & Inspection), Act, 1963 and Rules, Bureau of Indian Standards relevant to food safety, Legal Metrology Act, International Food Control Systems/ Laws. | |
| | Total | 100 % |

Suggested Readings

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

Theory**UNIT I**

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

UNIT II

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

UNIT III

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

UNIT IV

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

Practical

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

- Visit to local processing units.
- Visit to local market yards and cold storage units.
- Visit to local market and packing industries.

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|--------------|---|---------------|
| 1-2 | Post-harvest handling of F&V. Maturity indices, harvesting and post-harvest handling of fruits and vegetables. | 30% |
| 3-6 | Respiration and ripening process. Factors affecting respiration and ripening. Pre and post-harvest factors affecting quality on post-harvest shelf life. | |
| 7-9 | Chemicals used for hastening and delaying ripening of fruits and vegetables. Methods of storage – precooling, prestorage treatments, low temperature storage, controlled atmospheric storage, hypobaric storage, irradiation and low cost storage structures. | |
| 10 | Cleaning & Washing machinery and methods for grading. | |
| 11-16 | Packing technology for export. Fabrication of types of containers, cushioning material, vacuum packing, poly shrink packing, specific packing for export of mango, banana, grapes kinnow, sweet orange and mandarin etc. | 20% |
| 17-19 | Principles of preservation by heat, low temperature, chemicals and fermentation. Cut fruits and vegetables. | |
| 20-23 | Post-harvest practices for safe storage of food grains. Preparation of threshing, threshers for different crops, parts, terminology, care and maintenance. | 30% |
| 24-27 | Winnowing, manual and power operated winnowers. Groundnut decorticators- hand and power operated principles of working. | |
| 28-31 | Maize shellers & castor shellers. Drying- grain drying method and equipment. Grain storage and practices. | |
| 32-35 | Post-harvest technology for major spices (black pepper, cardamom, coriander, cinnamon, ginger, onion and garlic, paprika, saffron, turmeric), their post-harvest diseases and storage pests and their management. | 20% |
| 36-38 | Packaging and storage of spices and spice powders. | |
| Total | | 100 |

Practical

| Practical No | Topic |
|--------------|--|
| 1 | Macro quality analysis, grading, packaging. |
| 2 | Harvesting indices of different vegetable crops. |
| 3 | Grading and packing of vegetables. |
| 4 | Practice in judging the maturity of various fruits and vegetables. |
| 5 | Conservation of zero energy cool chambers for on farm storage. |

| | |
|-------|---|
| 6-10 | Determination of physiological loss in weight (PLW), total soluble solids (TSS), total sugars, acidity and ascorbic and content in fruits and vegetables. Packing methods and types of packing and importance of ventilation. |
| 11 | Pre cooling packing methods for export or international trade. Methods of prolonging storage life. |
| 12 | Effect of ethylene on ripening of banana, sapota, mango, sapota. |
| 13-14 | Identification of equipment and machinery used is preservation of fruits and vegetables. |
| 15 | Preservation by drying and dehydration. |
| 16 | Visit to local processing units. |
| 17 | Visit to local market yards and cold storage units. |
| 18 | Visit to local market and packing industries. |

Suggested Readings

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

Theory

Unit I

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

Unit II

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

Unit III

SWOT analysis, Generation, incubation and commercialization of ideas and innovations. Government schemes and incentives for promotion of entrepreneurship. Government policy on Small and Medium Enterprises (SMEs)/ SSIs. Export and Import Policies relevant to food sector. Venture capital. Contract farming and joint ventures, public-private partnerships. Overview of horti inputs industry. Characteristics of Indian food processing and export industry. Communication Skills: Structural and functional grammar; meaning and process of communication, verbal and non-verbal communication; listening and note taking, writing skills, oral presentation skills; field diary and lab record; indexing, footnote and bibliographic procedures. Reading and comprehension of general and technical articles, précis writing, summarizing, abstracting; individual and group presentations, impromptu presentation, public speaking; Group discussion. Organizing seminars and conferences.

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|---|---------------|
| 1-2 | Assessing overall business environment in the Indian economy. | 20% |
| 3-4 | Overview of Indian social, political and economic systems and their implications for decision making by individual entrepreneurs. | |
| 5-6 | Globalization and the emerging business/entrepreneurial environment. | |
| 7-8 | Concept of entrepreneurship; entrepreneurial and managerial characteristics; managing an enterprise; motivation and entrepreneurship development. | 20% |
| 9-10 | Importance of planning, monitoring, evaluation and follow up; importance of planning, monitoring, evaluation and follow up. | |
| 11-12 | Managing competition; entrepreneurship development programs; Social Responsibility of Business. Managing competition; entrepreneurship development programs; Social Responsibility of Business. | |

| | | |
|--------------|---|------------|
| 13-14 | SWOT analysis, Generation, incubation and commercialization of ideas and innovations. Government schemes and incentives for promotion of entrepreneurship. | |
| 15-16 | Government policy on Small and Medium Enterprises (SMEs)/ SSIs. Export and Import Policies relevant to food sector. Venture capital. Contract farming and joint ventures, public-private partnerships. Overview of Horti. inputs industry. | |
| 17-18 | Characteristics of Indian food processing and export industry. Communication Skills: Structural and functional grammar; meaning and process of communication, verbal and non-verbal communication; listening and note taking, writing skills, oral presentation skills; field diary and lab record. | 60% |
| 19-20 | Indexing, footnote and bibliographic procedures. Reading and comprehension of general and technical articles, précis writing, summarizing, abstracting; individual and group presentations. Impromptu presentation, public speaking; Group discussion. Organizing seminars and conferences. | |
| Total | | 100 |

Practical/Assignments/Case studies

- Study of a regulated market,
- Study of a fruit and vegetable market,
- Study of State and Central Warehousing Corporation
- Study of functioning of a regional rural bank and commercial bank for loan.
- Study of food processing enterprise,
- Formulation of project reports for financing food Industry,
- Working out repayment plans,
- Legal Issues in Product Development, Marketing and Market Segments
- Case studies: Innovations in Dairy industry, Bakery industry, fats and oils industry, fruit and vegetable industry, primary and secondary processing of cereals, brewing industry.

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

Suggested Readings

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|---|---------------|
| 1-2 | Food safety management systems and its requirements for any organization in the food chain. | 25% |
| 3-6 | Block chain concept, Global food safety initiative (GFSI), PAS 220, Prerequisite programs on food safety for food manufacturing. | |
| 7-9 | Audits: Introduction, objectives, documentation, responsibilities. | |
| 10-12 | Food safety plan overview, Good manufacturing practices and other prerequisite programs, GAP and GMP. | 25% |
| 13-15 | Preliminary Steps in Developing a food safety plan, Resources for food safety plans, HACCP, TACCP and VACCP. | |
| 16-20 | Biological/ Chemical/ Physical and Economically motivated food safety hazards. | 25% |
| 21-26 | Process preventive controls, Food allergen preventive controls, Sanitation preventive controls, supply chain preventive controls. | |
| 27-32 | Verification and validation Procedures, Record Keeping Procedures, Recall Plan. | |
| 33-35 | FSMS and FSSC 22000. ISO 22003, ISO 20005 and traceability in food chain, ISO 14000 series - certification and its importance. | 25% |

| | | |
|-------|--|-----|
| 36-38 | ISO 17025 - General requirements for the competence of testing and calibration laboratories, BRC Standard, BRC Storage and Distribution, SQF. Southern RocklobsterSeafood, Retailer programs like Woolworths, Coles, Costco and ALDI, Concept of Auditing. | |
| | Total | 100 |

Suggested Readings

1. Erasmo Salazar, 2013, Understanding Food Safety Management Systems: A Practical Approach to the Application of ISO-22000:2005, Create Space Independent Publishing Platform.
2. ISO 22000 Standard Procedures for Food Safety Management Systems, 2008, Bizmanualz, Inc.
3. Mike Dillon and Chris Griffith (ed), 2001 Auditing in the food industry - From safety and quality to environmental and other audits, CRC Press
4. Alli, Inteaz, 2003, Food Quality Assurance: Principles and Practices, CRC Press
5. Respective certification documents.

Theory**Unit I**

Introduction: Biomaterials and their properties in relation to processing and product development. Physico-chemical characteristics: Shape, sphericity, size, volume, microstructure, density, porosity, surface area, coefficients of friction and angle of repose and influence of constituents on processing.

Unit II

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

Unit III

Thermal, electrical and optical properties: Specific heat, thermal conductivity, phase transition, thermodynamics-basic principles and laws, Thermodynamic properties of moist air, kinetics of water absorption, heat capacity, thermal diffusivity, electrical resistance and conductance, dielectric constant, reflectivity, transmittivity and absorptivity of incident rays. Food microstructure: Methods and systems for food microstructure, determination of light microscopy, transmission electron microscopy, scanning electron microscopy, other instrumentation and techniques, image analysis: image acquisition, image processing, measurement analysis.

Unit IV

Functional properties: Dextrinization, Gelatinisation, Crystallisation, gelation, foaming, coagulation, denaturation and syneresis, foaming, emulsification. Sensory attributes: Sensory properties and correlation with objective indices, microstructure and its relation to texture from their mechanical models and its examination. Sorption behaviour of food: sorption isotherm, modelling.

Practical

- To determine physical dimension and shape for suitability of processing and packaging of food materials
- To determine bulk, true density and porosity of samples
- To determine the angle of repose using rough and smooth surface
- Analysis of powder characteristics using powder flow analyser.
- To determine the mixing and strength characteristics of wheat flour using farinograph/ mixograph/ mixolab
- To determine the amyolytic activity using falling number of wheat flour
- Development of stress and strain curve and to study viscosity of Newtonian and non-Newtonian fluid
- Effect of temperature on viscosity profile of a food sample
- Texture profile analysis of foods samples.
- Effect of temperature on textural profile of food
- Determination of thermal properties of foods using DSC.
- To estimate dielectric constant of foods

- Organoleptic evaluation of food materials
- TEM and SEM, image analysis and image processing techniques
- To determine water activity of food
- To determine colour value of food, viz. Lab, whiteness index, yellow index, browning index

Suggested Reading

- Rao MA and Rizvi SSH, 1986. Engineering Properties of Foods, Marcel Dekker.
- Aguilera JM & Stanley DW, 1999. Microstructural Principles of Food Processing and Engineering, Springer.
- Mohsenin NN, 1986. Physical Properties of Plant and Animal Materials, Gordon & Breach Science.
- Bourne MC, 1981. Food Texture and Viscosity; Concept and Measurement, Academic Press. Steffe JF, 1992. Rheological Methods in Food Process Engineering, Freeman Press. Aguilera JM, 1999. Microstructure: Principles of Food Processing Engineering, Springer.
- Rahman MS, 2009. Food Properties Handbook, CRC Press.
- Serpil S & Sumnu SG, 2006. Physical Properties of Foods, Springer-Verlag.
- Pomeranz Y, 1991. Functional Properties of Food Components, Academic Press

Theory**Unit I**

Introduction: Cocoa, Occurrence, chemistry of the cocoa bean, analysis of cocoa beans, processing of raw bean, changes taking place during fermentation of cocoa bean
Cocoa processing: processing of cocoa bean- Cleaning, roasting, alkalization, cracking and fanning; Nib grinding for cocoa liquor, cocoa butter and cocoa powder; processing of roast bean; chemical changes during various stages of processing

Unit II

Chocolates: Types, ingredients, chemistry of chocolate manufacture, Mixing, Refining, Conching, Tempering, moulding etc. to obtain chocolate slabs, chocolate bars. Dark, milk and white chocolate and their manufacturing processes

Unit III

Enrobed and other confectionary products: Compound Coatings & Candy Bars, Tempering technology, Chocolate hollow figures, Chocolate shells, Enrobing technology, Manufacture of candy bars, Presentation and application of vegetable fats. Production of chocolate mass

Unit IV

Packaging, quality and storage of chocolates.

Practical

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

Suggested Reading

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

Theory**Unit I**

Introduction: Status and scope of spice processing industries in India; Spices, Herbs and seasonings: sources, production, selection criteria, classification on the basis of origin, physical characteristic. Major spices: Post-Harvest Technology composition, processed products of following spices (1) Ginger (2) Chilli (3) Turmeric (4) Onion and garlic (5) Pepper (6) Cardamom.

Unit II

Minor spices, herbs and leafy vegetables: All spice, Annie seed, sweet Basil, Caraway seed, Cassia, Cinnamon, Clove, Coriander, cumin, Dill seed, nutmeg, mint, Rose merry, saffron,sage Processing technology of Spices: Chemical composition, processing methods, equipment's used; recent developments in processing.

Unit III

Processing effect on spice quality: Effect of processing on spice quality, contamination of spices with microorganisms and insects.

Unit IV

Spice Essential Oils: methods of extraction, isolation, and encapsulation, Spice Oleoresins: method of extraction, isolation, separation equipment Spices quality evaluation: Criteria for assessment of spice quality.

Suggested Reading

- Reineccius G. 2005. *Flavour Chemistry and Technology*. CRC Press.
- Heath HB, 1986. *Flavour chemistry and Technology*. AVIPubl.
- Piggott JR, Paterson A. 1994. *Understanding Natural Flavours*. Springer US

Theory**Unit I**

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

Unit II

Cattle and beef, sheep and mutton, pig and pork and their fabrication: Breeds, Preslaughter care, ante and post-mortem, slaughter, handling of offal (edible and inedible). Cuts of beef, pork and mutton. Meat inspection and grading: Application and Enforcement of inspection laws, elements of inspection (sanitation, antemortem inspection, post-mortem inspection, condemnation, product inspection, laboratory inspection, labelling). Identification of inspected products, product inspection, types of grades, factors used to establish quality grades, conformation, fleshing and finish.

Unit III

Properties of fresh meat: Perception of tenderness, Factors effecting tenderness, connective tissue, collagen, sarcomere contractile state, Myofibrillar tenderness, marbling. Methods to improve tenderness (Electrical stimulation, aging, Meat colour, Pigments associated with colour, Chemical state of pigments, methods to improve meat colour. Water holding capacity (Net charge effect and stearic effect) Molecular Techniques in meat products, cultured meat etc. Poultry meat: Kind of poultry, processing of poultry. Special poultry products, Breaded poultry, Smoked turkey, packagedprecooked chicken, Freeze dried poultry meat. Egg and eggprocessing: Egg quality, egg preservation, egg powder production

Unit IV

Meat analogues and restructured meat products: Textured plant proteins, processes forpreparation of meat analogues and restructured meat products. Fish processing and fish products: Chemical/Nutritional composition of Fish, Fish in human diet: protein, carbohydrates, lipids, vitamins etc. Selection of raw material for processing of streaking and filleting of fish; production of fish paste, fish oils, sauce, fish protein concentrates. Irradiation of fish and fisheries products, packaging of fish products, quality control and quality assurance. Allergens, toxins and infectious diseases from meat, poultry and fish products.

Practical

- To study the effect of low and high oxygen atmosphere on meat colour.
- To study the chemistry of myoglobin as it relates to the colour of the molecule.
- To understand and compare the action of two meat tenderizing

enzymes by applying the technique of electrophoresis.

- To study the structure of the muscle under compound microscope.
- Perform the slaughtering of the poultry birds.
- Identification of different internal organs of poultry birds and their utilization for product preparation.
- Dressing of Fish.
- Determination of total volatile acids in fish,
- Determination of buffering capacity of fish muscle.
- Rapid estimation of hypoxanthine concentration in chill stored fish.
- Determination of glycine in fish muscle.
- Determination of protein fractions in fresh fish.
- Cut out test for canned fishery products.
- Determination of glycogen in fish muscle.
- Industrial visit to meat industry.

Suggested Reading

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

Theory**Unit I**

Freezing: Glass transitions in frozen foods and biomaterials, Microbiology of frozen foods, Thermo-physical properties of frozen foods, Freezing loads and Freezing time calculation, Innovations in freezing process, freezing methods and equipment. Facilities for the Cold Chain: Cold store design and maintenance, Transportation and storage of frozen foods, Retail display equipment and management.

Unit II

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

Unit III

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

Unit IV

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

Practical

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

Suggested Reading

- Erickson MC & Hung YC, 1997. *Quality in Frozen Foods*, Springer.
- Hui YH, Legarretta IG, Lim, MH, Murrell KD & Nip WK, 2004. *Handbook of FrozenFoods*, CRC Press.
- Kennedy C J, 2000. *Managing Frozen Foods*, Elsevier.

Theory**Unit I**

Introduction: present and future of aseptic processing, Advantages and disadvantages, processing of semi-solid and fluid and particulate foods. Aseptic processing operations: pre- sterilization, loss of sterility, water-to-product and product-to-water separation, cleaning, control, CIP.

Unit II

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

Unit III

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

Unit IV

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

Practical

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

Suggested Reading

- Robertson GL, 2012. *Food Packaging: Principles and Practices*, CRC Press.
- David JRD, Graves RH and Szemplenski T, 2016. *Handbook of Aseptic Processing and Packaging*, CRC Press.
- Reuter H, 1993. *Aseptic Processing of Foods*, CRC Press.
- Willhoft EM, 1993. *Aseptic Processing and Packaging of Particulate Foods*, Springer.

Theory**Unit I**

Overview of grain-based snacks: whole grains – roasted, toasted, puffed, popped and flakes Coated grains- salted, spiced and sweetened Flour based snack– batter and dough-based products; *savoury* and *farsans*; formulated chips and wafers, papads. Fruit and vegetable-based snacks: chips, wafers, papads etc. Coated nuts – salted, spiced and sweetened products- *chikkis*, *fried groundnut pakora*,

Unit II

Technology of ready- to- eat baked food products, drying, toasting, roasting and flaking, coating, chipping Extruded snack foods: Formulation and processing technology, flavouring and packaging

Unit III

Ready-to-cook food products- different puddings and curried, Vegetables, meat and meat food products etc. Technology of instant cooked rice, carrot and other cereals-based food products Technology of ready to eat instant premixes based on cereals, pulses etc. Technology for RTE puffed snack- sand puffing, hot air puffing, explosion puffing, gunpuffing etc.

Unit IV

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

Practical

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

Suggested Reading

- Edmund WL 2001. *Snack Foods Processing*. CRC Press
- Frame ND 1994. *Technology of Extrusion Cooking*, Blackie Academic.
- Gordon BR 1997. *Snack Food* AVIPubl.
- Samuel AM. 1976. *Snack Food Technology*. AVIPubl.
- Manley D. 2000. *Technology of Biscuits, Crackers and Cookies* CRC Press

- Deny AV and Dobraszczyk BJ. 2001. *Cereals and Cereal Products*, Aspen Publishers
- Ram S and Mishra B. 2010. *Cereals: Processing and Nutritional Quality*, New India Publishers

Theory**Unit I**

Food powder properties: Particle size, shape, particle size distribution, density, Crystalline and amorphous microstructure of powders, cohesive forces in powders, adhesive forces and surface energies, stickiness of powders, surface structure of powders, fluidity of powders, compressibility of powders, mixing property of powders, segregation of powder particles, flow and packing properties Handling of food powders: Basic flow patterns in storage vessels, storage vessel design, mass-flow operation, the Jenike silo design method, the flow-no flow criterion, Powder conveying: Belt, screw, chain, pneumatic

Unit II

Size reduction and enlargement: Principles, equipment, criteria for selecting comminution process, aggregation and agglomeration, instantization Encapsulation: Principles, methods of encapsulation, viz. spray drying, coacervation, extrusion, co-crystallization

Unit III

Powder Production: Spray, drum and freeze-drying process and equipments Undesirable properties: Attrition, segregation, caking, dust explosion hazards, laboratory testing to assess explosion characteristics of dust clouds, safety from dust cloud explosion hazards Food powder rehydration: Principles of powder rehydration- wettability and sink ability, dispersibility, solubility, improvement of rehydration properties Surface composition of food powders: Microscopy and spectroscopy techniques for analysing the surface of food powder, factors affecting food powder surface composition, impact of powder surface composition on powder functionality.

Unit IV

Packaging and Storage: Packaging requirements, design of package, effect of environmental factors on quality of food powders, shelf life test and prediction Food Premix: Formulation, processing and packaging of Vitamin premix, mineral premix, fibres premix for food supplements.

Practical

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

- Packaging of food powders
- Effect of storage on quality of food powders
- Production of various vitamin premix and its application
- Production of various mineral premix and its application

Suggested Reading

- Hong Yan. 2005. *Food Powders: Physical Properties, Processing, and Functionality*/Springer US.
- Bhandari BS, Bansal N, Zang M, Schuck P. 2013. *Handbook of Food Powders-Process and Properties*/ Woodhead Publishing
- Yasuo Arai. 1996. *Chemistry of Powder Production* Springer Netherlands
- Masuda H, Higashitani K and Yoshida H. 2006. *Powder Technology: Fundamentals of Particles, Powder beds, and Particle Generation*/ CRC press

Theory**Unit I**

Introduction: classification of food flavour, chemical compounds responsible for flavours, difficulties of flavour chemistry research. Anatomy of chemical senses. Chemical compounds classes and their flavour response. Flavour intensifiers: Flavour intensifiers and their effects, Chemistry and technology of various flavour intensifiers. Flavour Extraction: Methods of flavour extraction, isolation, separation and equipments.

Unit II

Flavour development during biogenesis: Flavour Compounds from Carbohydrates and Proteins, Lipid oxidation. Flavour formulation: Creating and formulating flavour, Synthetic flavours, Blended flavouring, flavour, creation for new products, Delivery of flavours from food matrices. Flavouring compounds during food processing: Volatile and non-volatile flavouring compounds, non-enzymatic browning reactions.

Unit III

Flavour analysis: Sensory evaluation, discrimination analysis, descriptive analysis, Instrumental analysis (Absorption Spectroscopy (W/VIS), chromatography, mass spectrometry) Food Flavours in different food products: Principal components and properties, baked products, cheese, milk, meat, fish, wine, coffee, tea, chocolate, fruit and vegetable products and fermented foods

Unit IV

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

Practical

- Qualitative identification of different flavouring compounds
- Extraction of essential oil/ flavouring compound of basil leave by hydro distillation
- Extraction of essential oil/ flavouring compound of basil leave by SCFE
- Comparison of the quality of flavouring component obtained by hydro distillation and SCFE
- Extraction of essential oil/ flavouring compound of ginger by SCFE
- Effect of storage conditions on flavouring compound of ginger

- Preparation of flavour emulsions and their stability
- To study effects of staling on food flavours and its adverse effects
- Separation, purification and identification of some flavouring compounds by GC/ MS.
- Sensory evaluation of different flavours
- To check effect of cooking on flavour of food sample
- To check effect of fermentation on food flavour
- To study sugar caramelization reaction for flavour development
- Development of blended food flavour-based products
- To study effects of storage conditions on food flavour
- Encapsulation of flavouring compounds
- To study effects of overdoses of flavours
- To study flavour development on roasting/ baking

Suggested Reading

- Reineccius G. 2005. *Flavour Chemistry and Technology*/ CRC Press
- Heath HB. 1986. *Flavour Chemistry and Technology*/ AVIPubl.
- Piggott JR, Paterson A. 1994/ *Understanding Natural Flavours*. Springer US
- Morton ID, Macleod AJ. 1990. *Food Flavour* Elsevier Science
- Ashurst PR. 1994. *Food Flavourings* Blackie
- Taylor AJ and Linfoth RST. 2010. *Food Flavour Technology*/ Blackwell Publishing Ltd
- Hui YH. 2010. *Handbook of Fruit and Vegetable Flavours* Wiley & Sons, Inc
- Bruckner B and Wyllie SG. 2008. *Fruit and vegetable flavour: Recent advances and future prospectus* CRC Press.
- Ferreira V and Lopez R. 2013. *Flavour Science* Academic Press

Theory**Unit I**

Introduction to various separation processes, Gas-Liquid, Gas-Solid, Liquid-Liquid, Liquid- Solid separation; Concept of phase equilibrium, Stage equilibrium, Stage efficiency, Equilibrium concentration; Single stage contact equilibrium, counter current multiple contact stages, Concept of equilibrium line and operating line, Determination of optimum number of contact stages by analytical and graphical method; Rate of extraction, Rate of gas absorption, Individual and over all mass transfer coefficient; Calculation of tower height for gas absorption for both dilute and concentrated solution. Construction and working mechanism of different extraction equipments like single stage extraction, Multiple stage static bed system, Bollmann extractor, Hildebrandt extractor, Rotocell extractor.

Unit II

Various separation processes Solid Separation Process, Introduction, Concept of size, Shape, Cut-size, Sieving, Magnetic separation, Eddy-current separation, Wet separation, Ballistic separation, Colour separation, Wet Separation Process, liquid solid and liquid- liquid separation by hydro cyclones, Surface velocity classifier, Elutriators, Impingement separator, Electrostatic precipitation, Distillation: Introduction, boiling point diagram, differential or simple distillation, Flash or equilibrium distillation, Continuous rectification with and without reflux, Reflux ratio, Optimum reflux ratio, Batch distillation, Application of distillation in food processing.

Unit III

Membrane Separation Technology: Introduction to micro-filtration, Ultrafiltration, Reverse osmosis, Electro dialyses, dialyses, physical characteristics of membrane separation, Factors affecting reverse osmosis process, Concentration polarization, Design of reverse osmosis and ultra-filtration systems, Operation layout of the modules, Electrodialysis, per vaporization, Fabrication of membranes, Application of membrane technology in food industry.

Unit IV

Powder Technology: Classification of powder, Separation of powder, Sieving, Air classification, Factors affecting air classification, Cyclone application, Air separation, Particle size distribution, Supercritical Fluid Extraction: Introduction, Properties of SCF, Food application, Application of SCFE in analytical technique, Pharmaceutical application.

Practical

- Determination of contact equilibrium in counter current and multiple contact model systems.
- Determination of rate of extraction in gas-liquid, gas-solid, liquid-liquid and liquid solid systems.
- Study of working mechanisms of different extraction equipments.
- Evaluation of physical separation techniques based on size, shape and

- densities, magnetic, eddy current, ballistic and colour separation,
- Use of air classification, hydrocyclones, electrostatic and distillation techniques for fractionation and separation, application studies on Microfiltration,
 - Ultrafiltration, reverse osmosis and dialysis.

Suggested Reading

- Saravacos GD and Maroulis ZB. 2011. *Food Process Engineering Operations* CRC Press
- Smith PG. 2011. *Introduction to Food Process Engineering* Springer

Theory**Unit I**

Principles of modelling: Linear programming-concepts, graphical and algebraic solution; Simplex method; Duality theory; post-optimality analysis; Sensitivity analysis; Transportation and assignment models; Computer applications to LP, queuing theory; Project scheduling and management by PERT-CPM; Integer programming; Non-linear programming; Simulation; Goal programming; Decision theory; Markov chains; Sequencing problem. Food process modelling: The principles of modelling, kinetic modelling, the modelling of heat and mass transfer; introduction diffusion equation, the Navier- stokes equations, heat and mass transfer in porous media Luikov's equation. Modelling thermal processes: cooling and freezing, modelling product heat load during cooling & freezing. Modelling foods with complex shapes, numerical solution of the heat conduction equation with phase change. Modelling thermal processes: heating, introduction, processing of packed and solid foods, continuous heating and cooling processes, Modelling food quality and microbiological safety. Case Studies in Modelling, Control in Food Processes.

Unit II

Food process equipment design: Design considerations of agricultural and food processing equipment. Design of food processing equipment, Dryers, design of dryers. Determination of heat and air requirement for drying grains. Types of heat exchanger. Design of heat exchangers and evaporators. Design of material handling equipment like belt conveyor, screw conveyor, bucket elevator and pneumatic conveyors. Digital image processing: digital representation of image, morphological image processing – dilation, erosion, opening and closing, line and edge detection, thresholding, segmentation, techniques for finding length, breadth, perimeter, surface area, eccentricity and surface roughness of solids. Machine Vision-Based Measurement Systems for Fruit and Vegetable Quality Control in Postharvest. Genetic algorithm optimization: traditional optimization techniques and their limitations, non-traditional method, fitness function in biological evolution, computational procedure for optimization of independent parameters using Genetic algorithm. Artificial neural network modelling: Developing predictive model between independent and dependent parameters by using Artificial neural network – Neural network architecture, weights and bias values of neurons, least square method for NN parameters optimization, matrix representation and computation of the values of NN parameters.

Unit III

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

Suggested Reading

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

Theory**Unit I**

Introduction: Food processing waste and by-product, ISO 14000 for environmental management system, biochemical and nutritional aspects of food processing byproducts. Waste minimization: Chain management issues and good housekeeping Procedures, minimise energy use in food Processing, minimise water use in food processing.

Unit II

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

Unit III

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

Unit IV

Waste management and co-product recovery: Meat, cereal, dairy, fish, fruit and vegetable, vegetable oil, plantation crops processing, waste management of food packaging. Food processing wastewater treatment and gas production from solid food processing

Suggested Reading

- Waldron K. 2009. *Handbook of Waste Management and Co-product Recovery in Food Processing* Woodhead Publishing
- Arvanitoyannis IS. 2007. *Waste Management for the Food Industries* Academic Press
- Nout MJR and Sarkar PK. 2013. *Valorisation of Food Processing By- Products* CRC Press

Theory**Unit I**

Physical characteristics of different food grains, fruits and vegetables; shape and size, volume and density, porosity, surface area, water activity. Thermal properties: Specific heat, thermal conductivity, thermal diffusivity, phase transition, methods of determination, steady state, transient heat flow. Electrical properties; Dielectric loss factor, loss tangent, temperature dependent electrical conductivity and dielectric constant, method of determination, energy absorption from high-frequency electric field.

Unit II

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

Unit III

Contact stresses between bodies, hertz problems, firmness and hardness, mechanical damage, dead load and impact damage, vibration damage, friction, effect of load, sliding velocity and surface roughness. Friction in agricultural materials, rolling resistance, angle of internal friction, angle of repose, flow of bulk granular materials, aero dynamics of agricultural products, drag coefficients, terminal velocity.

Unit IV

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

Unit V

Rheology of semi-solid and solid food; Rheological characterization of foods in terms of stress-strain relationship; Viscoelasticity; Transient tests - Creep Compliance and Stress Relaxation; Mechanical models for viscoelastic foods: Maxwell, Kelvin, Burgers and generalized models and their application; Dynamic measurement of viscoelasticity.

Unit VI

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

Unit VII

Food structuring: traditional food structuring and texture improvement, approaches to food structuring, extrusion and spinning, structuring fat products, structure and

stability, gels, gelation mechanisms, mixed gels, the microstructure of gels, structure property relations angels.

Unit VIII

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

Practical

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

Suggested Reading

- Rao MA, Rizvi SS, Datta AK and Ahmed J. 2014. *Engineering Properties of Foods*.CRC
- Figura OL. and Teixeira AA. 2007. *Food Physics: Physical Properties – Measurement and Applications*. Springer Science & Business Media.
- Sahin S and Sumnu SG. 2006. *Physical Properties of Foods*. Springer Science and BusinessMedia.
- Mohsenin NN. 1980. *Thermal properties of foods and agricultural materials*. NewYork. USA.
- Mohsenin NN. 1986. *Physical properties of plant and animal materials*. Gordon and Breach Science Publishers.
- Peleg M and Bagley EB. 1983. *Physical Properties of Foods*. In *IFT basic symposium series (USA)*. AVI Pub. Co.
- Ronal J, Felix E, Bengt H, Hans F, Meffert Th., Walter EC and Gilbert V. 1983. *Physical Properties of Foods*. Applied Science Publishers.
- Bourne M. 2002. *Food texture and viscosity: concept and measurement*. Elsevier.
- Norton IT, Spyropoulos F and Cox P. 2010. *Practical food rheology: an interpretive approach*. John Wiley & Sons.

Theory**Unit I**

Introduction: Interaction of biochemical engineering, biochemistry and microbiology, Reaction kinetics, kinetics of batch and continuous cultures, process variables, biocatalyst and enzyme kinetics, scope and present status in India in relation to food industry.

Unit II

Fermenter and bioreactors: Transport phenomenon in microbial systems, types of reactor, working principles, aeration and agitation, sterilization and sanitation, advances in continuous fermentation, developments in solid-state fermentation for food applications.

Unit III

Alcoholic beverages: Production of alcoholic beverages: raw materials, culture fermentation technology of non-distilled beverages (beer and wine) and distilled alcoholic beverages (brandy, whiskey, vodka, rum, gin).

Unit IV

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

Unit V

Organic acids/acidulants: Raw materials, Starters and fermentation conditions, recovery and applications, Case studies production of acetic acid (vinegar), citric acid, lactic acid and gluconic acid.

Unit VI

Biocatalysts in food processing: Sources of enzymes, advantages of microbial enzymes, mechanism of enzyme function, Production and purification of enzymes, immobilization and applications of biocatalysts in food processing, enzyme biosensors.

Unit VII

Down-stream processing: Handling of materials in microbial systems, filtration, centrifugation, sedimentation, chromatography, membrane separation (UF and NF) and electrophoresis, separation and disintegration of cells for product recovery operations. Biological waste treatment and in-plant sanitation.

Unit VIII

Modeling, simulation and scale-up: Bioprocess modeling and simulation and its application in industrial fermentation, scale-up of fermentation processes, design and analysis of biological fermenter and bioreactors.

Practical

- Studying biochemical changes during handling of important food items
- Study of fermenter and fermentation process
- Study of bioprocess instrumentation and control system

- Study of bacterial growth in batch culture
- Production and maintenance of starter culture
- Production of enzyme, extraction and purification
- Production of SCP; Production of microbial pigments
- Production of amino acids
- Production of alcohol and alcoholic beverages
- Visit to brewery
- Visit to effluent treatment plant
- Bioprocess modeling and simulation
- Case Studies & Reports.

Suggested Reading

- Schügerl K and Zeng AP. 2010. *Advances in Biochemical Engineering Biotechnology: Tools and Applications of Biochemical Engineering Science*. Springer
- Scheper Th.(Ed). *Advances in Biochemical Engineering and Biotechnology Series*. Springer
- Ghose TK and Fiechter A. 1971. *Advances in Biochemical Engineering-I. Indian Journal of Physics*, 47, 189-192.
- James EB and David FO. 1986. *Biochemical Engineering Fundamentals*. McGraw- Hill Book Co. Inc., New York
- Scheper T, Bajpai P, Bajpai PK, Dochain D, Dutta NN, Ghosh AC, Mathur RK, Mukhopadhyay A, Perrier M, Rogers PL, Shin HS, Wang B. 1996. *Biotreatment, downstream processing and modelling*. Springer
- Doran PM. 1995. *Bioprocess engineering principles*. Elsevier
- Perry JH. 2007. *Chemical engineers' handbook*, 8e. McGraw-Hill Professional
- Stumbo CR. 2013. *Thermo bacteriology in food processing*. Elsevier
- Stanbury PF, Whitaker A and Hall SJ. 2013. *Principles of fermentation technology*. Elsevier
- Hitzmann B 2017. *Measurement, modeling and automation in advanced food processing*. Springer

Theory**Unit I**

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

Unit II

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

Unit III

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

Unit VI

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

Unit V

Computational fluid dynamics (CFD) applications in food processing.

Practical

- Introduction to various features in different spreadsheet softwares
- Solving problems using functions and/or add-Ins and/or Analysis Tool pack in spreadsheets
- Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data
- Testing linearity and normality assumption, Testing the goodness of fit of different models
- Testing the hypothesis for one sample t-test, two sample t-test, paired t-test, test for large samples - Chi-squares test, F test, Analysis of variance
- Practice on modelling and simulation softwares i.e. MATLAB, FLUENT, GAMBIT, EDEM, Solid works, ANSYS
- Practice on process optimization softwares i.e. SAS, SPSS, Origin Pro, Design Expert(DX), Minitab, Matlab
- Practice on design optimization softwares i.e. Solid works, ANSYS.

Suggested Reading

- Das H. 2005. *Food Processing Operations Analysis*. Asian Books Private Limited
- Denn MM. 1986. *Process Modeling*. Longman
- Holland CD. 1975. *Fundamentals and Modeling of Separation Processes*.

Prentice Hall.

- Luyben WL. 1990. *Process Modeling Simulation and Control for Chemical Engineers* 2ed. McGraw Hill.
- Najim K. 1990. *Process Modeling and Control in Chemical Engineering*. CRC
- Aris R. 1999. *Mathematical Modeling, Vol. 1: A Chemical Engineering Perspective (Process System Engineering)*. Academic Press.
- Kreyszig E. 2005. *Advanced Engineering Mathematics*. John Wiley & Sons publication Granato D and Ares G. 2014. *Mathematical and statistical methods in food science and technology*. IFT Press, Wiley Blackwell
- Standard software for modelling, analysis and simulations

Theory**Unit I**

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

Unit II

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

Unit III

Machine vision for the food industry, Ultrasonic methods, Sampling procedures for online quality.

Unit IV

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

Suggested Reading

- Rodríguez MEP. 2018. *Process Monitoring and Improvement Handbook*, Second Edition 2018 by ISBN: 978-0-87389-974-1
Food Process Monitoring Systems 1993, Springer

Theory**Unit I**

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

Unit II

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

Unit III

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

Unit IV

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

Practical

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

Suggested Reading

- Wastewater treatment and use in agriculture - FAO irrigation and drainage paper 47, <http://www.fao.org/docrep/t0551e/t0551e00.htm#Contents>
- Waste Biomass Valor (2017) 8:2209–2227 DOI: 10.1007/s12649-016-9720-0

Theory**UNIT I**

Business management; introduction, theories and functions, food industry management; marketing management and human resource development, personal management. Sectors in food industry and scale of operations in India. Human resource management, study the basics about HR and related policies and capacity mapping approach for better management. Consumer Behavior towards food consumption, consumer surveys by various institutes and agencies, Various journals on consumer behaviour and market research, Internet based data search.

UNIT II

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

UNIT III

International trade; basics, classical theory, theory of absolute advantage. theory of comparative, modern theory, free trade- protection, methods of protection, quotas, bounties, exchange control, devaluation, commercial treaties, terms of trade, balance of payments, EXIM policy, foreign exchange, mechanics of foreign exchange, GATT, WTO, role of WTO, International Trade in agriculture. World trade agreements related with food business, export trends and prospectsof food products in India.

UNIT IV

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

Suggested Reading

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

Theory**Unit I**

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Suggested Reading

- Montgomery, Jennings and Pfund. 2010. *Managing, Controlling and Improving Quality*, Wiley
- Arora KC. 2016 (4th Edition). *Total Quality Management*, S K Kataria & Sons Pub

Theory**Unit I**

General Aspects of Energy Management & Energy Audit: Energy scenario, basics of energy and its various forms, material and energy balance, monitoring and targeting and financial management.

Unit II

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

Unit III

Energy Accounting and Analysis: Energy Accounting and Analysis, The energy use index, Conditioned area, electricity costs, Thermal energy costs, Energy-using systems, Commercial energy use profiles, Identifying potential measures, Industrial audit Opportunities, Industrial Energy Use Profiles.

Unit IV

Energy economics: Simple payback, time value of money, job simulation experience, making decisions for alternate investments, depreciation, taxes and the tax credit, impact of fuel inflation on life cycle costing.

Unit V

Measurements, Survey instrumentation, and data Collection: General audit instrumentation; CO₂, temperature, pressure, fluid and fuel flow, combustion gas composition, electrical and light measurement, measuring building losses, application of IR thermograph, infrared radiation and its measurement, measuring electrical system performance.

Unit VI

Energy and Water Conservation Technologies Applied to Food Processing Facilities: Conservation in steam generation and consumption system, energy conservation in heat exchangers, conservation in compressed air system, conservation in power and electrical systems, waste-heat recovery and thermal energy storage in food processing facilities, building envelope audit, energy consumption and saving opportunities.

Practical

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

- Conservation possibilities in bakery processing facilities
- Conservation possibilities in meat processing facilities
- Case studies & field reports.

Suggested Reading

- Wang L. 2009. *Energy Efficiency and Management in Food Processing Facilities*. CRC Press Thumann A, Niehus T and Younger WJ. 2013. *Handbook of Energy Audits 9e*. Fairmont Press
- Klemes J, Smith R and Kim JK. 2008. *Handbook of water and energy management in food processing*. Elsevier.
- Christopher CS. 2007. *Electric Water: The Emerging Revolution in Water and Energy*. New Society Publishers
- BEE-NPC Cases studies

Theory**Unit I**

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

Unit II

Linear programming problem: Mathematical formulation of the linear programming problem and its graphical solution, Simplex method.

Unit III

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

Unit IV

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

Unit V

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

Unit VI

Queuing theory: Introduction and classification of queues, Solution of queuing models.

Unit VII

Project planning and network analysis: Introduction and basic definitions in Network Analysis, Rules for drawing network analysis, Critical path method (CPM), Project evaluation and review technique (PERT).

Practical

- Studies on application of Linear Programming on food product standardization
Studies on use of Transportation and Assignment Problems in food plant operations
Studies on Economic Order Quantity and Replacement Model
- Studies on Sequencing of food plant operations; Studies on Queuing Model
Network Analysis using CPM and PERT.

Suggested Reading

- Ackoff RK and Sassiioni MW. 1978. *Fundamentals of Operations Research*. Wiley Eastern, New Delhi
- Wagner HM. 1978. *Principles of Operations Research, with Applications to Management Decisions*. Prentice Hall of India, New Delhi
- Taha HA. 2007. *Operations Research: An Introduction*. Pearson Prentice Hall, New Jersey
Goel BS and Mittal SK. 1985. *Operations Research*. Pragati Prakashan, Meerut

- Panneerselvam R. 2012. *Operations Research*. PHI Learning Pvt. Ltd.
- Prasanna C. 2009. *Projects*. Tata McGraw-Hill Publication, New Delhi.
- Nicolas JM. 2003. *Project Management for Business and Technology – Principles and Practices*. Pearson Prentice Hall
- Kerzner H and Kerzner HR. 2017. *Project Management: a Systems Approach to Planning, Scheduling, and Controlling*. John Wiley & Sons.
- Gopalakrishnan P and Ramamoorthy VE. 2005. *Textbook of Project Management*. Macmillan.

Theory**Unit I**

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Suggested Reading

- Creswell JW. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Sage publications, 2013.
- Kumar R. *Research Methodology: A Step by Step Guide for Beginners*, 2nd Edition, SAGE, 2005.
- Kothari CR, Garg G. *Research Methodology Methods and Techniques*, New Age International publishers, Fourth Edition.
- Bower JA. 2009. *Statistical Methods for Food Science*, Blackwell Publishing Wilson A. *Handbook of Science Communication*, 1998, CRC Press Montgomery DC. 2017. *Design and Analysis of Experiments*, Willey
- Snedecor GW and Cochran WG. 1991. *Statistical Methods*, 8th Edition, Wiley- Blackwell Saguy PI. *Computer aided techniques in Food Technology*, 1983, Taylor and Francis

Theory**Unit I**

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Suggested Reading

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

Course Syllabus and Content of Doctoral Degree in Food Processing Technology

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

Theory

Unit I

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

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|--|---------------|
| 1-4 | Recent advances in novel food processing technology | 10% |
| 5-8 | Membrane processing | 10% |
| 9-13 | Supercritical fluid extraction | 10% |
| 14-20 | Microwave and radio frequency processing | 10% |
| 21-25 | High Pressure processing | 10% |
| 26-30 | Ultrasonic processing | 10% |
| 31-36 | Ozonization | 10% |
| 37-42 | Plasma Technique | 10% |
| 43-48 | Novel drying techniques. | 10% |
| 49-54 | Various techniques to increase shelf life and shelf life prediction. | 10% |
| | Total | 100 |

Suggested Readings

- Gould GW. 2000. *New Methods of Food Preservation*, CRC Press.
- Barbosa-Canovas, 2002. *Novel Food Processing Technologies*, CRC Press.
- Dutta AK and Anantheswaran RC, 1999. *Hand Book of Microwave Technology for Food Applications*, CRC Press.
- Sun DW. 2015. *Emerging Technologies for Food Processing*, Elsevier Ltd.
- Kudra T and Mujumbar AS. 2009. *Advanced Drying Technologies*, CRC Press.
- Kilkast D and Subramaniam P. 2000. *The Stability and Shelf Life of Food*. CRC Press.
- Doona C J and Feeherry F E. 2007. *High Pressure Processing of Foods*. Blackwell Publishing Ltd.

Theory**Unit I**

Recent advances in active and intelligent packaging like Antimicrobial food packaging, Non-migratory bioactive polymers, Freshness indicator, Recycling, biodegradable packaging, Edible Films and Coatings, aseptic packaging, self heating and hydrate packages.

Teaching Schedule**Theory**

| Lecture No | Topic | Weightage (%) |
|------------|--|---------------|
| 1-8 | Recent advances in active and intelligent packaging like Antimicrobial food packaging. | 20% |
| 8-12 | Non-migratory bioactive polymers | 10% |
| 13-18 | Freshness indicator | 10% |
| 19-24 | Recycling | 10% |
| 25-30 | Biodegradable packaging | 15% |
| 31-36 | Edible Films and Coatings | 15% |
| 37-45 | Aseptic packaging | 10% |
| 46-54 | Self heating and hydrate packages. | 10% |
| | Total | 100 |

Suggested Readings

- Ahvenainen R. 2001. *Novel Food Packaging Techniques*, CRC Press.
- Rooney ML. 1988. *Active Food Packaging*, Chapman & Hall.
- Coles R and Kirwan M. 2011. *Food and Beverage Packaging Technology*, Wiley- Blackwell.
- Han J and Han J. 2005. *Innovations in Food Packaging*, Academic Press.
- Yam K and Lee D. 2012. *Emerging Food Packaging Technologies*, Woodhead Publishing.
- Mihindikulasuriya SDF and Lim LT. 2014. *Nanotechnology Development in Food Packaging a Review. Trends in Food Science and Technology*, 149-167.
- Souza VGL and Fernando L. 2016. *Nano-particles in Food Packaging- Biodegradability and Potential Migration to Food – A Review. Food Packaging and Shelf Life*, 63-70.

FPT 604

Plant Food Products

3(3+0)

Theory

Unit I

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

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|--|---------------|
| 1-8 | Post-harvest handling of fresh fruits and vegetables. | 10% |
| 9-13 | Minimally processed fruits and vegetables | 10% |
| 14-18 | Advances in chilling, freezing and drying | 10% |
| 19-23 | Alcoholic and non-alcoholic beverages | 10% |
| 24-27 | Dough quality measurements; bakery, RTE, RTC products | 20% |
| 28-34 | Hydrogenation, fractionation, winterization, inter-esterification etc. | 10% |
| 35-39 | Process for obtaining tailor-made fats and oils | 10% |
| 40-47 | Speciality fats and designer lipids for nutrition and dietetics | 10% |
| 48-54 | Textured Plant proteins | 10% |
| | Total | 100 |

Suggested Readings

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

Theory

Unit I

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

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|---|---------------|
| 1-7 | Research and development activities on meat, fish and poultry products. | 10% |
| 8-13 | Gross and microstructure of muscle | 5% |
| 14-18 | Pre-slaughter care, ante and post mortem, slaughter, handling of offal (edible and inedible) | 5% |
| 19-23 | Methods to improve tenderness | 5% |
| 24-28 | Special poultry products | 10% |
| 29-31 | Breaded poultry | 5% |
| 32-33 | Packaged precooked chicken | 5% |
| 34-36 | Freeze dried poultry meat | 5% |
| 37-40 | Egg preservation, egg powder production | 10% |
| 41-43 | Meat analogues and restructured meat products | 10% |
| 44-48 | Production of fish paste, fish oils, sauce, fish protein concentrates | 10% |
| 49-51 | Irradiation of fish and fisheries products, packaging of fish products, quality control and quality assurance | 10% |
| 52-54 | Allergens, toxins and infectious diseases from meat, poultry and fish products | 10% |
| | Total | 100 |

Suggested Readings

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

Theory

Unit I

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

Unit II

Preparation of concentrate flours from cereals, pulses and oilseeds. Drying of various food products using various dryers and study their kinetics. Calculations of energy required for drying specific food product for specific dryer. Study drying effect on nutritional quality of food product.

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|--|---------------|
| 1-6 | Recent development in concentration and drying processes | 10 |
| 7-13 | Technologies and engineering | 10 |
| 14-20 | Problem solving and case studies | 10 |
| 21-27 | Preparation of concentrate flours from cereals, pulses and oilseeds. | 20 |
| 28-38 | Drying of various food products using various dryers and study their kinetics. | 20 |
| 39-48 | Calculations of energy required for drying specific food product for specific dryer. | 20 |
| 49-54 | Study drying effect on nutritional quality of food product. | 10 |
| Total | | 100% |

Suggested Readings

- Anandharamakrishnan C and Padma IS. 2015. *Spray Drying Techniques for Food Ingredient Encapsulation*. Wiley-Blackwell
- Oetjen GW, Haseley P. 2018. *Freeze-Drying*, 3e. Wiley-VCH
- Krokida M. 2018. *Thermal and Non thermal Encapsulation Methods*. CRC Press
- Anandharamakrishnan C. 2017. *Handbook of Drying for Dairy Products*. Wiley- Blackwell
- Zhang M, Bhandari B, Fang Z. 2017. *Handbook of Drying of Vegetables and Vegetable Products*. CRC Press
- Prakash O, Kumar A. 2017. *Solar Drying Technology: Concept, Design, Testing, Modeling, Economics and Environment*. Springer Singapore
- Karim A, Law CL. 2017. *Intermittent and Non stationary Drying Technologies: Principles and Applications*. CRC Press
- Vasile M. 2016. *Advances in Heat Pump-Assisted Drying Technology*. CRC Press
- MengWai W. 2016. *Computational Fluid Dynamics Simulation of Spray Dryers: An Engineer's Guide*. CRC Press
- Reis FR. 2014. *Vacuum Drying for Extending Food Shelf-Life*. Springer International Publishing
- Rodrigues S. 2008. *Advances in Fruit Processing Technologies*. CRC Press

- Angela M and Meireles A. 2008. *Extracting Bioactive Compounds for Food Products Theory and Applications*. CRC Press
- Rivas EO. 2009. *Processing Effects on Safety and Quality of Foods*. CRC Press
- Lebovka NI, Vorobiev E, Cheimat F. 2012. *Enhancing Extraction Processes in the Food Industry*. CRC Press

Theory

Unit I

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

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|---|---------------|
| 1-7 | Modern food safety risk analysis and management. | 10% |
| 8-13 | Food defense plan and food fraud Mitigation plan | 5% |
| 14-18 | Beyond HACCP: TACCP and VACCP | 10% |
| 19-23 | Advanced block chain and IoT technology behind the lifecycle traceability | 5% |
| 24-28 | Indian requirements and simple solutions | 5% |
| 29-31 | Enzymes as analytical tools for the assessment of food quality and safety | 5% |
| 32-33 | Nanoparticles as biosensors for food quality and safety assessment | 5% |
| 34-36 | Advances in Food identification and authentication with modern analytical tools | 5% |
| 37-40 | Emerging real time quality depicting packaging solutions | 10% |
| 41-43 | Supply chain research gaps pertaining to temperature abuse | 10% |
| 44-48 | Transportation pallet tracking | 10% |
| 49-51 | Refrigerated container management | 10% |
| 52-54 | Automated systems in final distribution, clean labels etc. | 10% |
| | Total | 100 |

Suggested Readings

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

Theory**Unit I**

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

Practical

Practice on UV-Visible, IR, Raman, & Mass spectroscopy. Practice on Fluorescence, Turbidimetric and related techniques. Practice on NMR/ESR spectroscopy. Practice on general and advanced chromatographic (HPLC, GC, Paper, TLC/HPTLC, Ion, Flash etc.) techniques. Practice on biological techniques such as Electrophoresis, PCR/RT-PCR, and Immunoassays etc Practice on Immuno based analytical techniques such as ELISA & Lateral flow assay. Determination of common adherents, colour, flavours and composition using specified methods. Separation of selected biomolecules (protein, colour, amino acids, fat, colour, flavours, peptides, anti/ nutritional factors, casein etc) using different techniques. Gel- filtration of biomolecules. SDS gel electrophoresis and molecular weight determination. Measurement of size and zeta potential of colloidal solution or emulsion using dynamic light scattering/ particle size analyser. Practice on purification of selected biomolecules. Estimation of minerals using AAS. Determination of specific and non-specific antimicrobial factors of selected biomolecules. Determination of health benefits of selected biomolecules/ products. Correlation of offline with online assessment of selected parameters. Correlation among industrial, national and international methods of selected concerned parameters.

Teaching Schedule**Theory**

| Lecture No | Topic | Weightage (%) |
|------------|--|---------------|
| 1-6 | Hands on experience on advance methods, equipment and instruments used for analysis of raw material. | 40% |
| 7-12 | Food products and confirmation of standards. | 30% |
| 13-18 | Offline and online assessment of food properties. | 30% |
| | Total | 100 |

Practical

| Practical No | Topic |
|--------------|--|
| 1-2 | Practice on UV-Visible, IR, Raman, & Mass spectroscopy. |
| 3-4 | Practice on Fluorescence, Turbidimetric and related techniques. |
| 5-6 | Practice on NMR/ESR spectroscopy. |
| 7-10 | Practice on general and advanced chromatographic (HPLC, GC, Paper, TLC/HPTLC, Ion, Flash etc.) techniques. |
| 11-13 | Practice on biological techniques such as Electrophoresis, PCR/RTPCR, and Immunoassays etc. |
| 14-16 | Practice on Immuno based analytical techniques such as ELISA & Lateral flow assay. |
| 17-20 | Determination of common adherents, colour, flavours and composition using specified methods. |
| 21-24 | Separation of selected biomolecules (protein, colour, amino acids, fat, colour, flavours, peptides, anti/ nutritional factors, casein etc) using different techniques. |
| 25 | Gel-filtration of biomolecules. |
| 26-27 | SDS gel electrophoresis and molecular weight determination. |
| 28-29 | Measurement of size and zeta potential of colloidal solution or emulsion using dynamic light scattering/ particle size analyser. |
| 30-31 | Practice on purification of selected biomolecules. Estimation of minerals using AAS. |
| 32-33 | Determination of specific and non-specific antimicrobial factors of selected biomolecules. |
| 34-35 | Determination of health benefits of selected biomolecules/ products. |
| 36-37 | Correlation of offline with online assessment of selected parameters. |
| 38-40 | Correlation among industrial, national and international methods of selected concerned parameters. |

Suggested Readings

- Boziaris IS. 2014. *Novel Food Preservation and Microbial Assessment Techniques*. CRC Press

Theory**Unit I**

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

Teaching Schedule**Theory**

| Lecture No | Topic | Weightage (%) |
|------------|--|---------------|
| 1-6 | Advances in rheological and texture measurement. | 20% |
| 7-12 | Current sensory evaluation approaches | 10% |
| 13-18 | Applications and limitations of n e-nose, e-tongue | 20% |
| 19-24 | Data Analysis for Electronic sensory judgment and validation approaches. | 20% |
| 25-30 | Computer-aided sensory evaluation of foods | 15% |
| 31-36 | Statistical analysis of sensory data | 15% |
| | Total | 100 |

Suggested Readings

- Rao ES. 2013. *Food Quality Evaluation*, Variety Books.
- Meilgard. 1999. *Sensory Evaluation Techniques*, CRC Press
- Maslowitz H. 2000. *Applied Sensory Analysis of Foods*. Vols. I, II. CRC Press.

Theory**Unit I**

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

Suggested Reading

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

Theory**Unit I**

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

Suggested Reading

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

Theory**Unit I**

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

Suggested Reading

- Guineì RPF, Correia PMR. 2013. Engineering Aspects of Cereal and Cereal-based Products. Taylor & Francis
- Mascheroni RH. 2012. Operations in Food Refrigeration. CRC Press
- Farid MM. 2010. Mathematical Modeling of Food Processing. CRC Press
- Teixeira JA and Vicente AK. 2014. Engineering Aspects of Food Biotechnology. CRC Press
- Varzakas T, Tzia C. 2014. Food Engineering Handbook. CRC Press
- Saravacos GD, Maroulis ZB. 2011. Food Process Engineering Operations. CRC Press
- Ron BH Wills, Golding JB. 2015. Advances in Postharvest Fruit and Vegetable Technology. CRC Press
- Petr D, Marilyn R. 2015. Engineering Aspects of Food Emulsification and Homogenization. CRC Press
- Constantina T, Theodoros V. 2016. Handbook of Food Processing: Food Safety, Quality, and Manufacturing Processes. CRC Press

E Resources and List of Journals

- 1) Journal of nutritional science
- 2) Journal of food and drug analysis
- 3) Food and Energy Security
- 4) Asian journal of agriculture and food science
- 5) Nature Sustainability
- 6) Comprehensive Reviews in Food Science and Food Safety
- 7) Trends in Food Science and Technology
- 8) Annual review of food science and technology
- 9) Global Food Security
- 10) Advances in Nutrition
- 11) Food Hydrocolloids
- 12) Nature Food
- 13) Food Policy
- 14) Critical Reviews in Food Science and Nutrition
- 15) Food Chemistry
- 16) NJAS - Wageningen Journal of Life Sciences
- 17) Food Security
- 18) Current Opinion in Food Science
- 19) Current Nutrition Reports
- 20) Meat Science
- 21) Food and Waterborne Parasitology
- 22) Nutrition and Healthy Aging
- 23) Nutrients
- 24) Food Research International
- 25) Food Packaging and Shelf Life
- 26) Journal of Dairy Science
- 27) Postharvest Biology and Technology
- 28) Food Science and Human Wellnes
- 29) Innovative Food Science and Emerging Technologies
- 30) Food Quality and Preference
- 31) Applied and Environmental Microbiology
- 32) Food Microbiology
- 33) Journal of Food Engineering
- 34) Food Control
- 35) Molecular Nutrition and Food Research
- 36) LWT - Food Science and Technology
- 37) Frontiers in Nutrition
- 38) Journal of Food and Drug Analysis
- 39) Food Chemistry: X
- 40) Food and Function
- 41) International Journal of Food Microbiology

Food Process Engineering

Course Layout and Structure of Masters Degree in Food Process Engineering

| Major Courses | | | |
|----------------------|-----------------|---|---------------------|
| Course Code | Semester | Course Title | Credit Hours |
| FPE 501* | I | Emerging Food Engineering Operations | 3 (2+1) |
| FPE 502* | II | Engineering Properties of Food Materials | 3 (2+1) |
| FPE 503* | III | Transport Phenomenon | 3 (2+1) |
| FPE 505 | I | Energy Management and Auditing in Food Industry | 3 (2+1) |
| FPE 507 | I | Computer Aided Design of Food Plant Machinery and Equipment | 3 (1+2) |
| FPE 508 | II | Food Safety and Storage Engineering | 3 (2+1) |
| FPE 511 | II | Process Control in Food Industries | 3 (2+1) |
| | | Grand Total | 21 (13+8) |

Note: Optional Major subjects: the course courses are selected to subjected to availability of infrastructure and facilities and to be decided by SAC committee

| Optional Major Courses | | |
|-------------------------------|--|---------------------|
| Course Code | Course Title | Credit Hours |
| FPE 504 | Bio Processing and Down Stream Engineering | 2+1 |
| FPE 506 | Numerical Techniques and Simulation | 1+1 |
| FPE 509 | Equipment, Machine and System Design for Indigenous Food Product | 0+2 |
| FPE 510 | Operation Research | 2+1 |
| FPE 512 | Project Engineering and Management | 2+1 |
| FPE 513 | Food Process Automation and Robotics | 2+0 |
| FPE 514 | Water and Waste Management | 2+1 |
| FPE 515 | Special problem/ Summer internship | 0+2 |

Minor Disciplines/Subjects :

The minor courses are to be selected from the list of major courses offered by following disciplines / subjects and are to be decided by SAC committee and also selected on the basis of availability of infrastructure and facilities

- (1) Food Processing Technology
- (2) Food Safety and Quality
- (3) Processing and Food Engineering
- (4) Horticulture
- (5) Microbiology

| Suggestive Minor Courses | | | |
|--------------------------|----------|--|---------------|
| Course Code | Semester | Course Title | Credit Hours |
| FPT 503 | I | Industrial Manufacturing of Food and Beverages | 3(2+1) |
| FPT 510 | I | Aseptic Processing and Packaging | 3(2+1) |
| FSQ 504 | II | Global Food Laws and Regulations | 2(2+0) |
| Grand Total | | | 8(6+2) |

Optional Minor subjects: the course courses are selected to subjected to availability of infrastructure and facilities and to be decided by SAC committee

Minor courses from discipline of Food Safety and Quality and Food Processing Technology

| Course Code | Course Title | Credit Hours |
|-------------|---|--------------|
| FPT 502 | Emerging Technologies in Food Packaging | 2+0 |
| FPT 504 | Food Material and Product Properties | 2+1 |
| FSQ 503 | Advanced Food Chemistry | 2+1 |
| FSQ 506 | Process and Products Monitoring for Quality Assurance | 2+0 |
| FSQ 508 | Management of Food By-products and Waste | 2+1 |

Supporting Courses

Supporting Disciplines / subjects: These courses are also selected to son the basis of availability of infrastructure and facilities and on the recommendation of SAC committee. One or two supporting courses are to be selected from following disciplines of

- (1) Food Processing Technology
- (2) Basic sciences,
- (3) Food business management and
- (4) Food Safety and Quality
- (5) Agricultural Statistics, Computer Science and Mathematics

Suggestive Supporting Courses

| Suggestive Supporting Courses | | | |
|--------------------------------------|-----------------|--|---------------------|
| Course Code | Semester | Course Title | Credit Hours |
| FSQ 507 | I | Quality Concepts and Chain Traceability | 2 (2+0) |
| FBM 501 | II | Post-Harvest Management | 3 (2+1) |
| FBM 503 | III | Food Processing Entrepreneurship and Startup | 1 (0+1) |
| | | Grand Total | 6 (4+2) |

Note: Optional Supporting subjects: the course courses are selected to subjected to availability of infrastructure and facilities and to be decided by SAC committee.

Supporting courses from discipline of Basic sciences, Food business management and Food Safety and Quality

| Course Code | Course Title | Credit Hours |
|--------------------|--|---------------------|
| BSH 501 | Research Methodology | 2(2+0) |
| BSH 502 | Food Informatics | 2 (1+1) |
| FBM 502 | Food Business Management | 2(2+0) |
| FSQ 505 | Food Safety Management Systems and Certification | 3(2+1) |

| | | |
|--|-----------------------|----------|
| Seminar | | |
| FPE-591 | Masters Seminar | 1(0+1) |
| Research Work | | |
| FPE-599 | Masters Research work | 30(30+0) |
| Total Course Credits Load = 71 Credits (41 Course Credits + 30 Research Work /Thesis) | | |

Compulsory Common PGS Courses (5 credits Non Credit):

| Course code | Semester | Course Title | Credits |
|--------------------|-----------------|---|----------------|
| PGS 501 | I | Library and Information Services | 0+1 |
| PGS 502 | I | Technical Writing and Communications Skills | 0+1 |
| PGS 503 | II | Intellectual Property and its management in Agriculture | 1+0 |
| PGS 504 | II | Basic Concepts in Laboratory Techniques | 0+1 |
| PGS 505 | II | Agricultural Research, Research Ethics and Rural Development Programmes | 1+0 |
| PGS 506 | III | Disaster Management | 1+0 |

Compulsory Non credit Deficiency Courses:

Students from non Food Science and Technology stream will be required to complete non credit deficiency courses (6 to 10 credits) from the below courses related to the discipline in which admitted and as decided by the Student Advisory Committee.

| Course Number | Course Name | Credits |
|---------------|-----------------------------------|---------|
| FPT-111 | Principles of Food Processing | 3 (2+1) |
| FPT-124 | Food Packaging Technology | 2 (1+1) |
| FPT-2410 | Fruits and Vegetables Processing | 3 (2+1) |
| FCN-235 | Food Chemistry and Micronutrients | 3 (2+1) |
| FMS-122 | Food Microbiology | 3 (2+1) |
| FBM-243 | ICT Application in Food Industry | 3 (1+2) |

Food Process Engineering

Semester wise course layout

| Semester | Course | Course No | Title | Credits |
|-------------|--------------------|---|---|------------------|
| Semester I | Major Courses | FPE 501 | Emerging Food Engineering Operations | 3 (2+1) |
| | | FPE 505 | Energy Management and Auditing in Food Industry | 3 (2+1) |
| | | FPE 507 | Computer Aided Design of Food Plant Machinery and Equipment | 3 (1+2) |
| | Minor Courses | FPT 503 | Industrial Manufacturing of Food and Beverages | 3 (2+1) |
| | | FPT 510 | Aseptic Processing and Packaging | 3 (2+1) |
| | Supporting Courses | FSQ 507 | Quality Concepts and Chain Traceability | 2 (2+0) |
| | Common Courses | PGS-501 | Library and Information Services | 1 (0+1) |
| | | PGS-502 | Technical Writing and Communication Skills | 1 (0+1) |
| | | | Grand Total | 19 (11+8) |
| Semester II | Major Courses | FPE 502 | Engineering Properties of Food Materials | 3 (2+1) |
| | | FPE 508 | Food Safety and Storage Engineering | 3 (2+1) |
| | | FPE 511 | Process Control in Food Industries | 3 (2+1) |
| | Minor Courses | FSQ 504 | Global Food Laws and Regulations | 2 (2+0) |
| | Supporting Courses | FBM 501 | Post-Harvest Management | 3 (2+1) |
| | | | | |
| | Common Courses | PGS-503 | Intellectual Property and its Management in Agriculture | 1 (1+0) |
| PGS-504 | | Basic Concepts in Laboratory Techniques | 1 (0+1) | |
| | | | Grand Total | 16 (11+5) |

Food Process Engineering

| Semester | Course | Course No | Title | Credits |
|--------------|--------------------|-----------|--|------------------|
| Semester III | Major Courses | FPE 503 | Transport Phenomenon* | 3 (2+1) |
| | Supporting Courses | FBM 503 | Food Processing Entrepreneurship and Startup | 1 (0+1) |
| | Common Courses | PGS-505 | Agricultural Research, Research Ethics and rural Development Programme | 1 (1+0) |
| | Research Work | FPE-599 | Masters Research Work | 10 (0+10) |
| | | | Grand Total | 15 (3+12) |
| Semester IV | Major courses | - | - | - |
| | Minor courses | - | - | - |
| | Supporting courses | - | - | - |
| | Common courses | - | - | - |
| | Seminar | FPE-591 | Masters Seminar | 1 (1+0) |
| | Research Work | FPE-599 | Masters Research Work | 20 (0+20) |
| | | | Grand Total | 21 (1+20) |

| ABSTRACT | | | | | | | |
|-----------------------|-----------|----------|------------|----------|----------|---------------|-----------|
| Course Credits | | | | | | | |
| Semester | Major | Minor | Supporting | Seminar | PGS | Research Work | Total |
| I | 9 | 6 | 2 | - | 2 | - | 19 |
| II | 9 | 2 | 3 | - | 2 | - | 16 |
| III | 3 | - | 1 | - | 1 | 10 | 15 |
| IV | - | - | - | 1 | - | 20 | 21 |
| Total | 21 | 8 | 6 | 1 | 5 | 30 | 71 |

Course Layout and Structure of Doctoral Degree in Food Process Engineering

| Major Courses | | | |
|----------------------|----------|---------------------------------------|------------------|
| Course Code | Semester | Course Title | Credit Hours |
| FPE 601 | I | Food Machinery and Utility Design | 3 (3+0) |
| FPE 602 | I | Concentration and Drying Engineering | 3 (3+0) |
| FPE 605 | II | Food Analytical Techniques | 3 (1+2) |
| FPE 606 | III | Food Handling and Storage Engineering | 3 (3+0) |
| Total | | | 12 (10+2) |

Note: Optional Major /Minor subjects: the course courses are selected to subjected to availability of infrastructure and facilities and to be decided by SAC committee

| Major Courses | | |
|----------------------|----------------------------------|--------------|
| Course Code | Course Title | Credit Hours |
| FPE 603 | Automation and Robotics | 2+0 |
| FPE 604 | System Analysis and Optimization | 3+0 |
| FPE 607 | Separation Engineering | 3+0 |
| FPE 608 | Novel Food Process Engineering | 2+0 |
| FPE 609 | Design of Packaging System | 2+0 |
| FPE 610 | Special problem | 0+2 |

Minor Disciplines/Subjects :

The minor courses are to be selected from the list of major courses offered by following disciplines / subjects and are to be decided by SAC committee and also selected on the basis of availability of infrastructure and facilities

- (1) Food Processing Technology
- (2) Food Safety and Quality
- (3) Processing and Food Engineering
- (4) Horticulture
- (5) Microbiology

| Suggestive Minor Courses | | | |
|---------------------------------|----------|---|--------------|
| Course Code | Semester | Course Title | Credit Hours |
| FPT 601 | I | Novel Technologies for Food Processing and Shelf-Life Extension | 3 (3+0) |

Food Process Engineering

| | | | |
|--------------|----|--|----------------|
| FSQ 603 | II | Quality Assurance in Food Supply Chain | 3 (3+0) |
| Total | | | 6 (6+0) |

Minor courses from discipline of Food Safety and Quality and Food Processing Technology

| Minor course | | |
|--------------|---|--------------|
| Course Code | Course Title | Credit Hours |
| FPT 605 | Food Process Modeling and Scale up | 3+0 |
| FSQ 604 | Formulation of Standards of Food Products, Packaging and Labeling | 2+0 |

Supporting Courses

Supporting subjects: These courses are also selected to son the basis of availability of infrastructure and facilities and on the recommendation of SAC committee.

One or two supporting courses are to be selected from following disciplines of

- (1) Food Processing Technology
- (2) Food Safety and Quality
- (3) Basic sciences,
- (4) Food business management and
- (5) Agricultural Statistics, Computer Science and Mathematics

| Suggestive Supporting Courses | | | |
|-------------------------------|----------|-----------------------------|----------------|
| Course Code | Semester | Course Title | Credit Hours |
| FSQ 607 | I | Sensory Evaluation of Foods | 2 (2+0) |
| FPT 602 | II | Food Packaging | 3 (3+0) |
| Total | | | 5 (5+0) |

| Seminar | | | |
|--|-----|---------------------|-----------|
| FPE 691 | III | Doctoral Seminar I | 1(1+0) |
| FPE 692 | IV | Doctoral Seminar II | 1(1+0) |
| Research Work | | | |
| FPE-699 | IV | Doctoral Research | 25 (0+25) |
| FPE-699 | V | Doctoral Research | 25 (0+25) |
| FPE-699 | VI | Doctoral Research | 25 (0+25) |
| Total Course Credits Load = 100 Credits (25 Courses Credits + 75 Research Work /Thesis) | | | |

Food Process Engineering

Semester wise Course Layout

| Semester I | | |
|---------------------------|---|------------------|
| Course Code | Course Title | Credit Hours |
| Major Courses | | |
| FPE 601 | Food Machinery and Utility Design | 3 (3+0) |
| FPE 602 | Concentration and Drying Engineering | 3 (3+0) |
| Minor Courses | | |
| FPT 601 | Novel Technologies for Food Processing and Shelf-Life Extension | 3 (3+0) |
| Supporting Courses | | |
| FSQ 607 | Sensory Evaluation of Foods | 2(2+0) |
| | Total | 11 (11+0) |
| Semester II | | |
| Major Courses | | |
| FPE 605 | Food Analytical Techniques | 3 (1+2) |
| Minor Courses | | |
| FSQ 603 | Quality Assurance in Food Supply Chain | 3 (3+0) |
| Supporting Courses | | |
| FPT 602 | Food Packaging | 3 (3+0) |
| | Total | 9 (7+2) |
| Semester III | | |
| Major Courses | | |
| FPE 606 | Food Handling and Storage Engineering | 3 (3+0) |
| Minor Courses | | |
| - | - | - |
| Supporting Courses | | |
| Seminar | | |
| FPE 691 | Doctoral Seminar I | 1(0+1) |
| | Total | 4 (3+1) |
| Semester IV | | |
| Seminar | | |
| FPE 692 | Doctoral Seminar II | 1(1+0) |
| Research Work | | |
| FPE-699 | Doctoral Research | 25 (0+25) |
| | Total | 26 (1+25) |

Food Process Engineering

| Semester V | | |
|--|--------------------|------------------|
| FPE-699 | Doctoral Research | 25 (0+25) |
| | Grand Total | 25 (0+25) |
| Semester VI | | |
| Research Work FPE-699 | Doctoral Research | 25 (0+25) |
| | Grand Total | 25 (0+25) |
| Total Course Credits Load = 100 Credits (25 Courses Credits + 75 Research Work /Thesis) | | |

| ABSTRACT | | | | | | |
|-----------------------|-----------|----------|------------|----------|---------------|------------|
| Course Credits | | | | | | |
| Semester | Major | Minor | Supporting | Seminar | Research Work | Total |
| I | 6 | 3 | 2 | - | - | 11 |
| II | 3 | 3 | 3 | - | - | 09 |
| III | 3 | - | - | 1 | - | 04 |
| IV | - | - | - | 1 | 25 | 26 |
| V | - | - | - | - | 25 | 25 |
| VI | - | - | - | - | 25 | 25 |
| Total | 12 | 6 | 5 | 2 | 75 | 100 |

Course Syllabus and Content of Masters Degree in Food Process Engineering

FPE 501 Emerging Food Engineering Operations

(2+1)

Theory

Unit I

Ionizing and non-ionizing radiation processing system operations: types of radiations, generation, microwave assisted processing systems, IR assisted processing systems, radio frequency systems, O₃, UV and x-ray assisted processing systems, gamma irradiations systems, e-beam radiation systems and applications.

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Practical

- To evaluate the characteristics of treated water and selected liquid foods using membrane systems (NF, UF, RO, etc)
- To study super critical fluid extraction system and application
- To study microwave system and microwave assisted food processing
- To study efficacy of hot water, steam, microwave, ultrasound blanching of selected fruits and vegetables
- To study the ultrasonicator and applications
- To study cryogenic processing applications
- To prepare Nano emulsion and study of their characteristics
- To study ohmic/inductive heating systems applications
- To study cold plasma applications
- To study gamma irradiation applications
- To study drying kinetics using different drying systems

- To study operations in 3 D printing
- Solving problems in food processing and case studies
- Visits of food industries utilizing advance food processing systems.

Teaching Schedule Theory

| No. of lectures | Topic | Weightage (%) |
|-----------------|--|---------------|
| 1-2 | Ionizing and non-ionizing radiation processing system operations: types of radiations, generation, | 5 |
| 3-8 | Microwave assisted processing systems, IR assisted processing systems. Radio frequency systems, Ozone (O ₃), UV and x-ray assisted processing systems, Gamma irradiations systems, e-beam radiation systems and applications. Pulse electric field (PEF) generation system and applications, Cold plasma generation systems and applications, High pressure processing systems and applications, Ultrasonic processing systems and applications. | 25 |
| 9-11 | Extrusion systems, batch and continuous | 5 |
| 12-16 | Ohmic heating systems and applications. Inductive heating systems and applications, | 20 |
| 17-19 | Nanotechnology, applications of nanotechnology in food processing | 5 |
| 20-25 | Drying systems – General theory of drying, type of drying systems, Superheated steam drying, Refractance window drying, Heat pump drying Freeze drying Spray drying, Foam bed drying, Microwave drying, Instant pressure drop (DIC) drying hybrid drying systems. | 20 |
| 26-28 | Membrane processing systems: UF, MF, NF, Reverse osmosis and vapour permeation, pervaporation, Membrane distillation. | 10 |
| 29-32 | Supercritical fluid extraction: concept, property of near critical fluids (NCF), extraction methods. Cryo-processing-cryogenics properties, systems and their different applications. | 10 |
| | Total | 100 |

Practicals

| Sr. No. | Topic | No. of Practicals |
|--------------|---|----------------------|
| 1. | To evaluate the characteristics of treated water and selected liquid foods using membrane systems (NF, UF, RO, etc) | 2 |
| 2. | To study super critical fluid extraction system and application | 1 |
| 3. | To study microwave system and microwave assisted food processing | 1 |
| 4. | To study efficacy of hot water, steam, microwave, ultrasound blanching of selected fruits and vegetables | 2 |
| 5. | To study the ultrasonicator and applications | 1 |
| 6. | To study cryogenic processing applications | 1 |
| 7. | To prepare Nano emulsion and study of their characteristics | 1 |
| 8. | To study ohmic / inductive heating systems applications | 1 |
| 9. | To study cold plasma applications | 1 |
| 10. | To study gamma irradiation applications | 1 |
| 11. | To study drying kinetics using different drying systems | 1 |
| 12. | To study operations in 3 D printing | 1 |
| 13. | Solving problems in food processing and case studies | 1 |
| 14. | Visits of food industries utilizing advance food processing systems. | 1 |
| Total | | 16 |

Suggested Reading

- Datta AK. 2001. Handbook of Microwave Technology for Food Application. CRC Press.
- Purkait MK and Singh R. 2018. Membrane Technology in Separation Science. CRC PressTaylor and Francis Group.
- Frame ND. 1994. The Technology of Extrusion Cooking. Blackie.
- Gould GW. 2012. New Methods of Food Preservation. Springer Science & Business Media.
- Berk Z. 2018. Food process engineering and technology. Academic press.
- Nema PK, Kaur BP and Mujumdar AS. 2019. Drying technologies for foods: Fundamentals and applications. CRC Press
- Meredith RJ. 1998. Engineers' Handbook of Industrial Microwave Heating (No. 25). Iet.
- Arvanitoyannis IS. 2010. Irradiation of food commodities: techniques, applications, detection, legislation, safety and consumer opinion. Academic Press.
- Yanniotis S. 2008. Solving problems in food processing and case studies. Springer

Theory**Unit I**

Physical characteristics of different food grains, fruits and vegetables; shape and size, volume and density, porosity, surface area, water activity. Thermal properties: Specific heat, thermal conductivity, thermal diffusivity, phase transition, methods of determination, steady state, transient heat flow. Electrical properties; Dielectric loss factor, loss tangent, temperature dependent electrical conductivity and dielectric constant, method of determination, energy absorption from high-frequency electric field.

Unit II

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

Unit III

Contact stresses between bodies, hertz problems, firmness and hardness, mechanical damage, dead load and impact damage, vibration damage, friction, effect of load, sliding velocity and surface roughness. Friction in agricultural materials, rolling resistance, angle of internal friction, angle of repose, flow of bulk granular materials, aero dynamics of agricultural products, drag coefficients, terminal velocity.

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

Unit V

Rheology of semi-solid and solid food; Rheological characterization of foods in terms of stress-strain relationship; Viscoelasticity; Transient tests - Creep Compliance and Stress Relaxation; Mechanical models for viscoelastic foods: Maxwell, Kelvin, Burgers and generalized models and their application; Dynamic measurement of viscoelasticity.

Unit VI

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

Unit VII

Food structuring: traditional food structuring and texture improvement, approaches to food structuring, extrusion and spinning, structuring fat products, structure and stability, gels, gelation mechanisms, mixed gels, the microstructure of gels, structure- property relations angels.

Unit VIII

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

Practical

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

Teaching Schedule

Theory

| No. of lectures | Topic | Weightage (%) |
|-----------------|--|---------------|
| 1-6 | Physical characteristics of different food grains, fruits and vegetables; shape and size, volume and density, porosity, surface area, water activity. Thermal properties: Specific heat, thermal conductivity, thermal diffusivity, phase transition, methods of determination, steady state, transient heat flow. Electrical properties; Dielectric loss factor, loss tangent, temperature dependent electrical conductivity and dielectric constant, method of determination, Energy absorption from high-frequency electric field. | 20 |
| 7-12 | Magnetic properties: paramagnetism, ferromagnetism, diamagnetism, magnetization, applications for magnetic field forces, magnetic resonance; Electromagnetic properties: electric polarization, temperature dependency, frequency dependency, microwave, conversion of microwaves into heat, penetration depth of microwaves, applications; Optical properties: refraction, colorimetry, near infrared, ultraviolet, applications; Acoustical properties: sound, ultrasonic sound and applications; Radioactivity: types of radiation, radioactive decay, measurement of ionizing radiation, natural radioactivity, applications. | 20 |
| 13-18 | Contact stresses between bodies, hertz problems, firmness and hardness. Mechanical damage, dead load and impact damage, vibration damage, friction, effect of load, sliding velocity and surface roughness. Friction in agricultural materials, rolling resistance, angle of internal friction, angle of repose, Flow of bulk granular materials. Aero dynamics of agricultural products, drag coefficients, terminal velocity. Rheological properties and classification of fluid foods: measurement methods and techniques; Mechanisms and relevant models; Effect of temperature; Compositional factors affecting flow behavior; Viscosity of food dispersions – dilute and semi-dilute systems, concentration effects. | 20 |

| | | |
|-------|--|-----|
| 18-22 | Rheology of semi-solid and solid food; Rheological characterization of foods in terms of stress-strain relationship; Viscoelasticity; Transient tests - Creep Compliance and Stress Relaxation; Mechanical models for viscoelastic foods: Maxwell, Kelvin, Burgers and generalized models and their application; Dynamic measurement of viscoelasticity. | 10 |
| 23-25 | Large deformations and failure in foods: fracture, rupture and other related phenomena; Relationship between instrumental and sensory data; Texture Profile Analysis; Instrumental measurements – Empirical and Fundamental methods; Rheometers and Texture Analyzers; Measurement of Extensional viscosity; Acoustic measurements on crunchy foods | 10 |
| 26-28 | Food structuring: traditional food structuring and texture improvement, approaches to food structuring, Extrusion and spinning, structuring fat products, structure and stability, gels, gelation mechanisms, mixed gels, the microstructure of gels, structure-property relations angels. | 10 |
| 29-32 | Examining food microstructures: light microscopy transmission electron microscopy, Scanning Electron Microscopy, other instrumentation and techniques Image analysis: Image acquisition, image processing and analysis. | 10 |
| | Total | 100 |

Practicals

| Sr. No. | Topic | No. of Practical |
|---------|---|------------------|
| 1. | Viscosity measurements of fruit juices and semisolid food products | 1 |
| 2. | Viscosity measurements of semisolid food products | 1 |
| 3. | Comparative analysis of Newtonian and non-Newtonian fluids | 1 |
| 4. | Development of stress and strain curve | 1 |
| 5. | To study viscosity of Newtonian fluids | 2 |
| 6. | To study viscosity of non-newtonian fluids, Temperature dependent and shear dependent rheology | 1 |
| 7. | Pasting analysis of food; | 1 |
| 8. | Determination of thermal conductivity, specific heat and glass transition temperature using differential scanning colorimetry (DSC) | 1 |
| 9. | Texture analysis of fruits and vegetable-based products | 1 |
| 10. | Texture analysis of baked foods products (bread/ biscuit) | 1 |

| | | |
|-----|---|----|
| 11. | Starch characterization using starch master; | 1 |
| 12. | Dough rheology using dough lab or farinograph | 1 |
| 13. | Determination of microstructures in selected foods using light microscopy | 1 |
| 14. | TEM and SEM, image analysis and image processing techniques | 1 |
| 15. | Evaluation of phase transition in colloidal systems, evaluation of structure texture function relations | 1 |
| 16. | Case studies on food properties and applications | 1 |
| | Total Practical | 16 |

Suggested Reading

- Rao MA, Rizvi SS, Datta AK and Ahmed J. 2014. Engineering Properties of Foods. CRC press.
- Applications. Springer Science & Business Media.
- Sahin S and Sumnu SG. 2006. Physical Properties of Foods. Springer Science and Business Media.

- Mohsenin NN. 1980. Thermal properties of foods and agricultural materials. New York. USA.
- Mohsenin NN. 1986. Physical properties of plant and animal materials. Gordon and Breach Science Publishers.
- Peleg M and Bagley EB. 1983. Physical Properties of Foods. In IFT basic symposium series (USA). AVI Pub. Co.
- Ronal J, Felix E, Bengt H, Hans F, Meffert Th., Walter EC and Gilbert V. 1983. Physical Properties of Foods. Applied Science Publishers.
- Bourne M. 2002. Food texture and viscosity: concept and measurement. Elsevier.
- Norton IT, Spyropoulos F and Cox P. 2010. Practical food rheology: an interpretive approach. John Wiley & Sons.

Theory**Unit I**

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

Turbulent transport mechanism - Mathematical analysis; eddy viscosity and eddy diffusivity; velocity, temperature and concentration distribution; time smoothing equations. Inter-phase transport in isothermal system - friction factors for various geometries.

Unit VI

Mass transfer - Fick's law of diffusion, diffusion of gases and liquids through solids, equimodal diffusion, isothermal evaporation of water into air, mass transfer coefficients.

Unit VII

Dimensional analysis – Buckingham Pi-theorem and matrix method, application to transport phenomena, analysis among mass, heat and momentum transfer, Reynolds' analogy. Boundary layer concept - Theoretical and exact solutions for heat, mass and momentum transfer.

Practical

- Effects of water concentration and water vapor pressure on the water vapor permeability and diffusion of chitosan films
- Mass transfer description of the osmo dehydration
- Pretreatment efficiency in osmotic dehydration
- Structural effects of blanching and osmotic dehydration pretreatments on air drying kinetics of fruit tissues
- Thermal processing of particulate foods by steam injection (1. Heating rate index for diced vegetables 2. Convective surface heat transfer coefficient for steam)
- Relating food frying to daily oil abuse (1. Determination of surface heat transfer

coefficients with metal balls 2. A practical approach for evaluating product moisture loss, oil uptake, and heat transfer)

- Heat and mass transfer during the frying process; Influence of liquid water transport on heat and mass transfer during deep-fat frying
- Numerical simulation of transient two-dimensional profiles of temperature, concentration, and flow of liquid food in a can during sterilization
- Case studies on transport phenomenon and its applications.

Teaching Schedule

Theory

| No. of lectures | Topic | Weightage (%) |
|-----------------|---|---------------|
| 1-6 | Introduction to transport phenomena – Molecular transport mechanism, Transport properties and their proportionality constants in momentum, energy and mass transfer. | 10 |
| 7-12 | Principles of Steady and unsteady state heat transfer and governing equations; Transient heat transfer; Lumped system analysis; Estimation of Conductivity and other thermal properties of foods; Overall heat transfer coefficient. | 15 |
| 13-15 | Steady-state equations - Momentum transport equations for Newtonian and non-Newtonian fluids, Continuity equation in different co-ordinates. | 15 |
| 16-19 | Equations of motion - Navier–Stokes equations and their application in viscous fluid flow between parallel plates Equations of motion - Navier–Stokes equations and their application in viscous fluid flow through pipes. | 20 |
| 20-25 | Turbulent transport mechanism - Mathematical analysis; Eddy viscosity and eddy diffusivity; Velocity, temperature and concentration distribution; Time smoothing equations. Inter-phase transport in isothermal system - friction factors for various geometries. | 10 |
| 26-28 | Mass transfer - Fick's law of diffusion, diffusion of gases and liquids through solids, equimodal diffusion, Isothermal evaporation of water into air, Mass transfer coefficients | 15 |

| | | |
|-------|--|-----|
| 29-32 | Dimensional analysis – Buckingham Pi-theorem and matrix method, Application to transport phenomena, Analysis among mass, heat and momentum transfer, Reynolds’ analogy. Boundary layer concept - Theoretical and exact solutions for heat, mass and momentum transfer. | 15 |
| | Total | 100 |

Practical

| Sr. No. | Topic | No. of Practical (s) |
|---------|---|----------------------|
| 1. | Effects of water concentration and water vapor pressure on the water vapor permeability and diffusion of chitosan films | 2 |
| 2. | Mass transfer description of the osmo dehydration | 1 |
| 3. | Pretreatment efficiency in osmotic dehydration | 1 |
| 4. | Structural effects of blanching and osmotic dehydration pretreatments on air drying kinetics of fruit tissues | 2 |
| 5. | Thermal processing of particulate foods by steam injection (Heating rate index for diced vegetables) | 1 |
| 6. | Thermal processing of particulate foods by steam injection (Convective surface heat transfer coefficient for steam) | 1 |
| 7. | Relating food frying to daily oil abuse (Determination of surface heat transfer coefficients with metal balls) | 1 |
| 8. | Relating food frying to daily oil abuse (A practical approach for evaluating product moisture loss, oil uptake, and heat transfer) | 1 |
| 9. | Heat and mass transfer during the frying process; | 1 |
| 10. | Influence of liquid water transport on heat and mass transfer during deep-fat frying | 1 |
| 11. | Numerical simulation of transient two-dimensional profiles of temperature, concentration, and flow of liquid food in a can during sterilization | 2 |
| 12. | Case studies on transport phenomenon and its applications. | 2 |
| | Total Practicals | 16 |

Suggested Reading

- Bird RB, Stewart WE and Lightfoot EN. 2007. Transport phenomena. John Wiley & Sons.
- Treybal RE. 1980. Mass transfer operations. New York.
- Yuan SW. 1969. Foundations of Fluid Mechanics. Prentice Hall of India.
- Welty-Chanes J and Velez-Ruiz, JF. (Eds.). 2016. Transport phenomena in food processing. CRC press.
- Geankoplis CJ. 2003. Transport processes and separation process principles: (includes unit operations). Prentice Hall Professional Technical Reference.

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

Theory

Unit I

General Aspects of Energy Management & Energy Audit: Energy scenario, basics of energy and its various forms, material and energy balance, monitoring and targeting and financial management.

Unit II

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

Unit III

Energy Accounting and Analysis: Energy Accounting and Analysis, The energy use index, Conditioned area, electricity costs, Thermal energy costs, Energy-using systems, Commercial energy use profiles, Identifying potential measures, Industrial audit Opportunities, Industrial Energy Use Profiles.

Unit IV

Energy economics: Simple payback, time value of money, job simulation experience, making decisions for alternate investments, depreciation, taxes and the tax credit, impact of fuel inflation on life cycle costing.

Unit V

Measurements, Survey instrumentation, and data Collection: General audit instrumentation; CO₂, temperature, pressure, fluid and fuel flow, combustion gas composition, electrical and light measurement, measuring building losses, application of IR thermograph, infrared radiation and its measurement, measuring electrical system performance.

Unit VI

Energy and Water Conservation Technologies Applied to Food Processing Facilities: Conservation in steam generation and consumption system, energy conservation in heat exchangers, conservation in compressed air system, conservation in power and electrical systems, waste-heat recovery and thermal energy storage in food processing facilities, building envelope audit, energy consumption and saving opportunities.

Practical

- Study and practice with energy assessment and auditing instrument.
- Performance assessment of motors and variable speed drives
- Performance assessment of pump, fans and blowers
- Performance assessment of refrigeration system
- Performance assessment of heat exchangers
- Performance assessment of furnace

- Performance assessment of boilers
- Conservation possibilities in dairy processing facilities
- Conservation possibilities in grains and oilseeds milling plants
- Conservation possibilities in sugar and confectionary processing facilities
- Conservation possibilities in fruit and vegetable processing facilities
- Conservation possibilities in bakery processing facilities
- Conservation possibilities in meat processing facilities
- Case studies & field reports.

Teaching Schedule

Theory

| No. of lectures | Topic | Weightage (%) |
|-----------------|--|---------------|
| 1-5 | General Aspects of Energy Management & Energy Audit: Energy scenario, Basics of energy and its various forma, material and energy balance, Monitoring and targetting and financial management. | 10 |
| 6-10 | Energy Auditing Basics: ASHRAE definitions of energy audits, the audit process, pre-site and post-site work, audit report. | 10 |
| 11-14 | Energy Accounting and Analysis: Energy Accounting and Analysis, The energy use index, Conditioned area, electricity costs, Thermal energy costs, Energy-using systems, Commercial energy use profiles, Identifying potential measures, Industrial audit Opportunities, Industrial Energy Use Profiles. | 20 |
| 15-18 | Energy economics: Simple payback, time value of money, job simulation experience, making decisions for alternate investments, depreciation, Taxes and the tax credit, impact of fuel inflation on life cycle costing. | 10 |
| 19-24 | Measurements, Survey instrumentation, and data Collection: General audit instrumentation; CO ₂ , temperature, pressure, fluid and fuel flow, Measurement of Combustion gas composition, Electrical and light measurement, measuring building losses, Application of IR thermograph, infrared radiation and its measurement, Measuring electrical system performance. | 20 |
| 25-32 | Energy and Water Conservation Technologies Applied to Food Processing Facilities: Conservation in steam generation and consumption system, energy conservation in heat exchangers, conservation in compressed air system, conservation in power and electrical systems, waste-heat recovery Thermal energy storage in food processing facilities, building envelop audit, Energy consumption and saving opportunities. | 30 |
| | Total | 100 |

Practical

| Sr. No. | Topic | No. of Practical |
|---------|---|------------------|
| 1. | Study and practice with energy assessment and auditing instrument. | 2 |
| 2. | Performance assessment of motors and variable speed drives | 1 |
| 3. | Performance assessment of pump, fans and blowers | 1 |
| 4. | Performance assessment of refrigeration system | 1 |
| 5. | Performance assessment of heat exchangers | 1 |
| 6. | Performance assessment of furnace | 1 |
| 7. | Performance assessment of boilers | 1 |
| 8. | Conservation possibilities in dairy processing facilities | 1 |
| 9. | Conservation possibilities in grains and oilseeds milling plants | 1 |
| 10. | Conservation possibilities in sugar and confectionary processing facilities | 1 |
| 11. | Conservation possibilities in fruit and vegetable processing facilities | 1 |
| 12. | Conservation possibilities in bakery processing facilities | 1 |
| 13. | Conservation possibilities in meat processing facilities | 1 |
| 14. | Case studies & field reports. | 2 |
| | Total Practicals | 16 |

Suggested Reading

- Wang L. 2009. Energy Efficiency and Management in Food Processing Facilities. CRC Press
- Thumann A, Niehus T and Younger WJ. 2013. Handbook of Energy Audits 9e. Fairmont Press
- Klemes J, Smith R and Kim JK. 2008. Handbook of water and energy management in food processing. Elsevier.
- Christopher CS. 2007. Electric Water: The Emerging Revolution in Water and Energy. New Society Publishers
- BEE-NPC Cases studies

FPE 507 Computer Aided Design of Food Plant Machinery and Equipment

3(1+2)

Theory

Unit I

Introduction - Definition of CAD/CAM, product cycle.

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Unit VI

Computer aided NC programming in APT language, elements of APT language, APT vocabulary, symbols, numbers and scalars, punctuation, definition, statement labels, notations for APT statement format, statements defining point, line, circle, vector, planes and curves, point to point motion.

Practical

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

Teaching Schedule

Theory

| No. of lectures | Topic | Weightage (%) |
|-----------------|--|---------------|
| 1-2 | Introduction - Definition of CAD/CAM, product cycle. | 10 |
| 3-5 | Automation, CPU, types of memory, input/output devices, Data presentation, data and file structures, data base design, design work station. | 15 |
| 6-8 | Graphics terminal, operating devices, plotters and other output devices, CPU secondary storage, Turnkey CAD system, selection criteria, evaluation of alternative systems. Geometric Modeling Techniques - wireframe, surface and solid modeling, Geometric transformations, Graphics standards. | 30 |
| 9-12 | CAM - Introduction to Numerical Control (NC) technology, current status of NC, Influence of NC in design & manufacturing. | 15 |
| 13-16 | Computer aided NC programming in APT language, Elements of APT language, APT vocabulary, symbols, numbers and scalars, punctuation, definition, statement labels, Notations for APT statement format, statements Defining point, line, circle, vector, planes and curves, point to point motion. | 30 |
| Total Lectures | | 100 |

Practical

| Sr. No. | Topic | No. of Practical |
|---------|---|------------------|
| 1. | Preparation of manual drawings with dimensions from Models and Isometric drawings of objects and machine components | 2 |
| 2. | Preparation of sectional drawings of selected machine parts | 3 |
| 3. | Drawing of riveted joints and thread fastener | 2 |
| 4. | Demonstration and practice on computer graphics and computer aided drafting using standard softwares such as AutoCAD and/or Inventor and/or Solidworks and/or Creo and/or Catia | 3 |
| 5. | Computer graphics for food engineering applications | 3 |
| 6. | Practice and use of basic and drawing commands on AutoCAD and Solid works | 3 |
| 7. | Generating simple 2-D drawings with dimensioning using AutoCAD and Solidworks | 2 |

| | | |
|-----|---|----|
| 8. | Small projects using CAD | 2 |
| 9. | Practice on assembly using Solidwork assembly tool | 1 |
| 10. | Analysis of machine/equipment component for structural parameters using FEM | 2 |
| 11. | Design optimisation of food machine/equipment using goal driven Optimization technique | 2 |
| 12. | Kinematic and dynamic analysis of mechanism and machines using Solidworks motion study tool | 2 |
| 13. | Small projects using CAM | 2 |
| 14. | To study design standards of general food processing equipment and systems | 3 |
| | Total Practicals | 32 |

Suggested Reading

- Farin G, Hoschek J and Kim MS. 2002. Handbook of computer added geometric design. Elsevier Science
- Goetsch DL. 1988. Micro CADD: Computer aided design and drafting on microcomputers. Prentice Hall
- Holah JT and Lelieveld HLM. 2011. Hygienic design of food factories. Woodhead publishing house.
- Higgins L and Morrow LC. 1977. Maintenance Engineering Hand-Book. McGraw Hill.
- Keating FH. 1959. Chromium-Nickel Austentic Steel. Butterworths Scientific Publ.
- Newcomer JL. 1981. Preventive Maintenance Manual for Dairy Industry. Venus Trading Co., Anand.
- Stanier W. 1959. Plant Engineering Hand-Book. McGraw Hill.

Theory**Unit I**

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

Unit II

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

Unit III

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

Unit IV

Predictive microbial modelling: classification of models: Kinetic & probability, Empirical & mechanistic models, Primary, secondary & tertiary models, Deterministic & stochastic models; Description of main models, Modelling growth curves, Modelling inactivation/survival curves, Secondary models, Probability models; Applications of predictive microbial modelling: Hazard analysis critical control point (HACCP) & quantitative risk assessment (QRA), Microbial shelf-life studies, Temperature function integration and temperature monitors, Product research and development, Design of experiments; Predictive microbial modelling and quantitative risk assessment.

Unit V

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

Unit VI

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

Practical

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

Teaching Schedule

Theory

| No. of lectures | Topic | Weightage (%) |
|-----------------|--|---------------|
| 1-6 | Overview of food microbiology: Foodborne illness, food spoilage, food fermentation, Microbiological physiology and food preservation, microbiological analysis, safety management systems. Overview of foodborne pathogens: Bacterial pathogens, food borne viruses and parasites. Chemical safety of foods: nature of chemical hazards in foods, food safety engineering and control of chemical hazards, Food allergen control. Intrinsic and extrinsic parameters for microbial growth and heat inactivation: Intrinsic and extrinsic factors affecting microbial growth, factors affecting heat resistance, Combining traditional peroration techniques. | 15 |
| 7-10 | Kinetics of microbial inactivation: Microbial inactivation kinetics based on food processing methods: Thermal, pressure, pulsed electric field, microwave and radio frequency, ohmic and inductive heating etc. Kinetic parameter for the inactivation of pathogens: Salmonella, Listeria monocytogenes, Staphylococcus aureus, Escherichia coli, Bacillus cereus, Clostridium, Vibrio, other pathogens. | 10 |
| 11-18 | Predictive microbial modelling: classification of models: Kinetic & probability, Empirical & mechanistic models, Primary, secondary & tertiary models, Deterministic & stochastic models; Description of main models, Modelling growth curves, Modelling inactivation / survival curves, Secondary models, Probability models; Applications of predictive microbial modelling: Hazard analysis critical control point (HACCP) & quantitative risk assessment (QRA), Microbial shelf-life studies, Temperature function integration and temperature monitors, Product research and development, Design of experiments; Predictive microbial modelling and quantitative risk assessment. | 40 |

| | | |
|-------|---|------------|
| | | |
| 19-25 | Process-dependent microbial modeling: Predictive microbial kinetic models, Temperature-dependent microbial growth kinetic models, Irradiation-dependent microbial growth model, Pulsed electric field-dependent microbial growth model, High-pressure-dependent microbial growth model; Process modeling; Integration of process and microbial growth kinetic models. | 25 |
| 26.32 | Storage and handling systems for grains, horticultural and animal based produces; post-harvest physiology of fruits and vegetables; Biochemical changes during storage, production, distribution; Storage capacity estimate models, ecology, storage factors affecting losses, storage requirements. | 10 |
| | Total | 100 |

Practical

| Sr. No. | Topic | No. of Practical |
|---------|---|------------------|
| 1. | Rapid methods and automation in microbiology: trends and predictions | 1 |
| 2. | Study on phage-based detection of foodborne pathogens | 1 |
| 3. | Study on real-time PCR | 1 |
| 4. | Study on DNA Array | 2 |
| 5. | Study on immunoassay | 1 |
| 6. | Offline and online assessments for food safety for industry | 2 |
| 7. | Storage pest, insects and rodent control | 1 |
| 8. | Study on storage systems and structures, Shelf life evaluation of packaged foodproducts | 1 |
| 9. | Recent advancements in storage and handling systems | 2 |
| 10. | Hygienic design standards and codes for food processing equipment/ System | 2 |
| 11. | Case studies on food safety engineering, guidelines, regulations. | 2 |
| | Total Practicals | 16 |

Suggested Reading

- Sun DW. 2015. Handbook of food safety engineering. Wiley Black Well Academic Press, Elsevier Ltd
- International Organization for Standardization. 2018. Food Safety Management Systems: Requirements for Any Organization in the Food Chain. ISO.
- Shejbal J. 1980. Controlled Atmosphere Storage of Grains. Elsevier.
- Vijayaraghavan S. 1993. Grain Storage Engineering and Technology. Batra Book Service
- Chakraverty A and Singh RP. 2014. Postharvest technology and food process engineering. CRC Press
- Chakraverty A, Mujumdar AS and Ramaswamy HS. 2002. Handbook of Post harvest Technology: Cereals, Fruits, Vegetables, Tea, and Spices. CRC Press
- ISO. 22000 Food safety management systems - Requirements for any organization in the food chain. Technical Committee ISO/TC 34, Food products and updates
- Case Studies and Field Reports - Food Safety Engineering

Theory**Unit I**

Process Control: Dynamic behavior of first/second order systems, Response of first order systems/first order system in series. Block diagrams and transfer functions, Feedback control, P, PI, PID controllers.

Unit II

Measurement of Electrical and Non Electrical Quantities. Motion and displacement measurement: Strain gages, Hall effect devices and Proximity sensors, Large displacement measurement using synchros and resolvers, Shaft encoders. Pressure Measurement: Mechanical devices like Diaphragm, Bellows, and Bourdon tube, Variable inductance and capacitance transducers, Piezo electric transducers, Low pressure and vacuum pressure measurement using Pirani gauge, McLeod gauge, Ionization gauge. Force and Torque Measurement: Load cells and their applications, various methods for torque measurement. Flow measurement differential pressure meter like, Rotameter, Turbine flow meter, Electromagnetic flow meter, hot wire anemometer, Ultrasonic flow meter. Temperature Measurement: Resistance type temperature sensors – RTD & Thermistor Thermocouples & thermopiles, Different types of pyrometers. Humidity measurement and Moisture measurement techniques. Liquid level measurement: Resistive, inductive and capacitive techniques for level measurement, Ultrasonic and radiation methods, Air purge system (Bubbler method).

Unit III

Digital Data Acquisition Systems & Control: Use of signal conditioners, scanners, signal converters, recorders, display devices, A/D & D/A circuits in digital data acquisition. Instrumentation systems. Types of Instrumentation systems. Data-acquisition system. Multiplexing systems. Modern digital data acquisition system.

Unit IV

Industrial Automation. PLC, DCS and SCADA System: Introduction, Basic parts of a PLC, Operation of a PLC, Basic symbols used in PLC realization, Difference between PLC and Hardwired systems, Difference between PLC and computer, Relay logic to ladder logic, Ladder commands, Examples of PLC ladder diagram realization, PLC timers, PLC counters and examples, Classification of PLCs, History of DCS, DCS concepts, DCS hardware & software, DCS structure, Advantages and disadvantages of DCS, Representative DCS, SCADA, SCADA hardware & software.

Unit V

Image Processing Applications: Methodology, Shape analysis, Feature detection and object Location, Three-dimensional processing. Application to food industry: Inspection and inspection Procedures, X-Ray, Computer vision systems, Electronic nose and Electronic tongue.

Unit VI

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

Practical

- Study of various for measurement of pressure, temperature, flow, level
- Study of PLC and to program a PLC using Ladder programming & PLC based control of Multi process system
- To make ladder logic diagrams and flow sheet diagrams for control logic
- Study of data loggers- computerized data acquisition and data processing
- Programming and making GUI in LABVIEW and softwares
- Study of SCADA Application Software/ Computerized Control of PC-PLC Based Multi-Process Control System.

Teaching Schedule

Theory

| No. of lectures | Topic | Weightage (%) |
|-----------------|---|---------------|
| 1-4 | Process Control: Dynamic behavior of first/second order systems, Response of first order systems/first order system in series. Block diagrams and transfer functions, Feedback control, P, PI, PID controllers. | 10 |
| 4-18 | Measurement of Electrical and Non Electrical Quantities. Motion and displacement measurement: Strain gages, Hall effect devices and Proximity sensors, Large displacement measurement using synchros and resolvers, Shaft encoders. Pressure Measurement: Mechanical devices like Diaphragm, Bellows, and Bourdon tube, Variable inductance and capacitance transducers, Piezo electric transducers, Low pressure and vacuum pressure measurement using Pirani gauge, McLeod gauge, Ionization gauge. Force and Torque Measurement: Load cells and their applications, various methods for torque measurement. Flow measurement differential pressure meter like, Rotameter, Turbine flow meter, Electromagnetic flow meter, hot wire anemometer, Ultrasonic flow meter. Temperature Measurement: Resistance type temperature sensors – RTD & Thermistor Thermocouples & thermopiles, Different types of pyrometers. Humidity measurement and Moisture measurement techniques. Liquid level measurement: Resistive, inductive and capacitive techniques for level measurement, Ultrasonic and radiation methods, Air purge system (Bubbler method). | 40 |
| 19-22 | Digital Data Acquisition Systems & Control: Use of signal conditioners, scanners, signal converters, recorders, display devices, A/D & D/A circuits in digital data acquisition. Instrumentation systems. Types of Instrumentation systems. Data-acquisition system. Multiplexing systems. Modern digital data acquisition system | 10 |

| | | |
|-------|--|-----|
| 23-28 | Industrial Automation. PLC, DCS and SCADA System: Introduction, Basic parts of a PLC, Operation of a PLC, Basic symbols used in PLC realization, Difference between PLC and Hardwired systems, Difference between PLC and computer, Relay logic to ladder logic, Ladder commands, Examples of PLC ladder diagram realization, PLC timers, PLC counters and examples, Classification of PLCs, History of DCS, DCS concepts, DCS hardware & software, DCS structure, Advantages and disadvantages of DCS, Representative DCS, SCADA, SCADA hardware & software | 30 |
| 29-30 | Image Processing Applications: Methodology, Shape analysis, Feature detection and object Location, Three-dimensional processing. Application to food industry: Inspection and inspection Procedures, X-Rayi, Computer vision systems, Electronic nose and Electronic tongue. | 5 |
| 31-32 | Virtual Instrumentation: Introduction to LABVIEW: Virtual instruments, Parts of VI, Project explorer, Front panel and block diagram window, Creating simple VI | 5 |
| | Total Lectures | 100 |

Practical

| Sr. No. | Topic | No. of Practical |
|---------|--|------------------|
| 1. | Study of various for measurement of pressure, | 1 |
| 2. | Study of various for measurement of temperature | 1 |
| 3. | Study of various for measurement of flow | 1 |
| 4. | Study of various for measurement of level | 1 |
| 5. | Study of PLC and to program a PLC using Ladder programming | 2 |
| 6. | Study of PLC based control of Multi process system | 1 |
| 7. | To make ladder logic diagrams and flow sheet diagrams for control logic | 2 |
| 8. | Study of data loggers- computerized data acquisition | 1 |
| 9. | Study of data loggers- computerized data processing | 1 |
| 10. | Programming and making GUI in LABVIEW and softwares | 1 |
| 11. | Study of SCADA Application Software | 2 |
| 12. | Study of Computerized Control of PC-PLC Based Multi- Process Control System. | 2 |
| | Total Practicals | 16 |

Suggested Reading

- McFarlane I. 1995. Automatic Control of Food Manufacturing Processes, 2e. Springer Science and Business Media
- Bhanot S. 2008. Process Control: Principles and Application. Oxford University Press.
- Singh SK. 2005. Industrial Instrumentation & Control, 2e. Tata McGraw-Hill Education.
- Krishnaswamy K. 2003. Industrial Instrumentation (Vol. 1). New Age International.
- Liptak BG. 2018. Instrument Engineers' Handbook, Volume Two: Process Control and Optimization. CRC press.
- Jain RK. 1988. Mechanical and Industrial Measurements. Khanna Publishers.
- Rangan CS, Sarma GR and Mani VSV. 1983. Instrumentation: Devices and Systems. Tata McGraw-Hill.
- Patranabis D. 1976. Principles of Industrial Instrumentation. Tata McGraw-Hill Publishing.

Theory**Unit I**

Introduction: Interaction of biochemical engineering, biochemistry and microbiology, Reaction kinetics, kinetics of batch and continuous cultures, process variables, biocatalyst and enzyme kinetics, scope and present status in India in relation to food industry.

Unit II

Fermenter and bioreactors: Transport phenomenon in microbial systems, types of reactor, working principles, aeration and agitation, sterilization and sanitation, advances in continuous fermentation, developments in solid-state fermentation for food applications.

Unit III

Alcoholic beverages: Production of alcoholic beverages: raw materials, culture, fermentation technology of non-distilled beverages (beer and wine) and distilled alcoholic beverages (brandy, whiskey, vodka, rum, gin).

Unit IV

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

Organic acids/acidulants: Raw materials, Starters and fermentation conditions, recovery and applications, Case studies production of acetic acid (vinegar), citric acid, lactic acid and gluconic acid.

Unit VI

Biocatalysts in food processing: Sources of enzymes, advantages of microbial enzymes, mechanism of enzyme function, Production and purification of enzymes, immobilization and applications of biocatalysts in food processing, enzyme biosensors.

Unit VII

Down-stream processing: Handling of materials in microbial systems, filtration, centrifugation, sedimentation, chromatography, membrane separation (UF and NF) and electrophoresis, separation and disintegration of cells for product recovery operations. Biological waste treatment and in-plant sanitation.

Unit VIII

Modeling, simulation and scale-up: Bioprocess modeling and simulation and its application in industrial fermentation, scale-up of fermentation processes, design and analysis of biological fermenter and bioreactors.

Practical

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

Suggested Reading

- Schügerl K and Zeng AP. 2010. *Advances in Biochemical Engineering Biotechnology: Tools and Applications of Biochemical Engineering Science*. Springer
- Scheper Th.(Ed). *Advances in Biochemical Engineering and Biotechnology Series*. Springer
- Ghose TK and Fiechter A. 1971. *Advances in Biochemical Engineering-I. Indian Journal of Physics*, 47, 189-192.
- James EB and David FO. 1986. *Biochemical Engineering Fundamentals*. McGraw-Hill Book Co. Inc., New York
- Scheper T, Bajpai P, Bajpai PK, Dochain D, Dutta NN, Ghosh AC, Mathur RK, Mukhopadhyay A, Perrier M, Rogers PL, Shin HS, Wang B. 1996. *Biotreatment, downstream processing and modelling*. Springer
- Doran PM. 1995. *Bioprocess engineering principles*. Elsevier
- Perry JH. 2007. *Chemical engineers' handbook*, 8e. McGraw-Hill Professional
- Stumbo CR. 2013. *Thermo bacteriology in food processing*. Elsevier
- Stanbury PF, Whitaker A and Hall SJ. 2013. *Principles of fermentation technology*. Elsevier
- Hitzmann B 2017. *Measurement, modeling and automation in advanced food processing*. Springer

Theory**Unit I**

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

Unit II

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

Unit III

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

Unit VI

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

Unit V

Computational fluid dynamics (CFD) applications in food processing.

Practical

- Introduction to various features in different spreadsheet softwares
- Solving problems using functions and/or add-Ins and/or Analysis Tool pack in spread sheets
- Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data
- Testing linearity and normality assumption, Testing the goodness of fit of different models
- Testing the hypothesis for one sample t-test, two sample t-test, paired t-test, test for large samples - Chi-squares test, F test, Analysis of variance
- Practice on modeling and simulation softwares i.e. MATLAB, FLUENT, GAMBIT, EDEM, Solid works, ANSYS.
- Practice on process optimization softwares i.e. SAS, SPSS, Origin Pro, Design Expert(DX), Minitab, Matlab
- Practice on design optimization softwares i.e. Solid works, ANSYS.

Suggested Reading

- Das H. 2005. *Food Processing Operations Analysis*. Asian Books Private Limited
- Denn MM. 1986. *Process Modeling*. Longman
- Holland CD. 1975. *Fundamentals and Modeling of Separation Processes*. Prentice Hall.
- Luyben WL. 1990. *Process Modeling Simulation and Control for Chemical Engineers* 2ed. McGraw Hill.
- Najim K. 1990. *Process Modeling and Control in Chemical Engineering*. CRC
- Aris R. 1999. *Mathematical Modeling, Vol. 1: A Chemical Engineering Perspective (Process System Engineering)*. Academic Press.
- Kreyszig E. 2005. *Advanced Engineering Mathematics*. John Wiley & Sons publication
- Granato D and Ares G. 2014. *Mathematical and statistical methods in food science and technology*. IFT Press, Wiley Blackwell
- Standard software for modelling, analysis and simulations

FPE 509 Equipment, Machine and System Design for Indigenous Food Product

2 (0+2)

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

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

Practical

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

Suggested Reading

- Holah J and Lelieveld H. (Eds.). 2011. *Hygienic Design of Food Factories*. Elsevier.
- Steinkraus K. 2004. *Industrialization of Indigenous Fermented Foods, Revised and Expanded*. CRC Press.
- Steinkraus KH. 1995. *Handbook of Indigenous Fermented Foods*. CRC press
- Couper JR, Penney WR, Fair JR and Walas SM. 2012. *Chemical Process Equipment - Selection and Design*, 3e. Elsevier
- Saravacos GD and Kostaropoulos AE. 2002. *Handbook of food processing equipment*. Kluwer Academic/Plenum.
- George SG, Kostaropoulos AE. 2015. *Handbook of Food Processing Equipment*, 2e. Springer
- Cramer MM. 2013. *Food plant sanitation: design, maintenance, and good manufacturing practices*, 2e. CRC Press.
- Willey RR. 2006. *Practical Design, Construction and Operation of Food Facilities*. Academic Press
- Baker CG and Christopher GJB (Ed.). 2013. *Handbook of food factory design*. New York, NY: Springer.
- Joshi MV and Mahajani VV. 2000. *Process Equipment Design*, 3e. Macmillan India.
- Brownell LE, Young EH. 1968. *Process equipment design*, 2e. Wiley Eastern Edn. New York
- Ahmad T. 2009. *Dairy Plant Engineering and Management*, 8e. Kitab Mahal
- Hygienic design and sanitary guidelines and related documents/ publications

FPE 510

Operation Research

3 (2+1)

Theory

Unit I

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

Unit II

Linear programming problem: Mathematical formulation of the linear programming problem and its graphical solution, Simplex method.

Unit III

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

Unit IV

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

Unit V

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

Unit VI

Queuing theory: Introduction and classification of queues, Solution of queuing models.

Unit VII

Project planning and network analysis: Introduction and basic definitions in Network Analysis, Rules for drawing network analysis, Critical path method (CPM), Project evaluation and review technique (PERT).

Practical

- Studies on application of Linear Programming on food product standardization
- Studies on use of Transportation and Assignment Problems in food plant operations
- Studies on Economic Order Quantity and Replacement Model
- Studies on Sequencing of food plant operations; Studies on Queuing Model
- Network Analysis using CPM and PERT.

Suggested Reading

- Ackoff RK and Sassiioni MW. 1978. *Fundamentals of Operations Research*. Wiley Eastern, New Delhi
- Wagner HM. 1978. *Principles of Operations Research, with Applications to Management Decisions*. Prentice Hall of India, New Delhi
- Taha HA. 2007. *Operations Research: An Introduction*. Pearson Prentice Hall, New Jersey
- Goel BS and Mittal SK. 1985. *Operations Research*. PragatiPrakashan, Meerut

- Panneerselvam R. 2012. *Operations Research*. PHI Learning Pvt.Ltd.
- Prasanna C. 2009. *Projects*. Tata McGraw-Hill Publication, New Delhi.
- Nicolas JM. 2003. *Project Management for Business and Technology – Principles and Practices*. Pearson Prentice Hall
- Kerzner H and Kerzner HR. 2017. *Project Management: a Systems Approach to Planning, Scheduling, and Controlling*. John Wiley & Sons.
- Gopalakrishnan P and Ramamoorthy VE. 2005. *Textbook of Project Management*. Macmillan.

FPE 512

Project Engineering and Management

3 (2+1)

Theory

Unit I

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

Unit II

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

Feasibility studies

Unit III

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

Unit IV

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

Unit V

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

Unit VI

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

Unit VII

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

Practical

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

Suggested Reading

- Patel JB and Allampalli, D. G. 1991. *A Manual on How to Prepare a Project Report*.
- Patel JB and Modi SS. 1995. *A Manual on Business Opportunity Identification and Selection*.
- *Manual for Entrepreneurs* by EDI Ahmedabad (2005). Tata McGraw Hill Education.
- Chandra P. *Projects: Planning, Analysis, Selection, Financing, Implementation, and Review*
- Peters MS and Timmerhaus KD. *Plant Design and Economics for Chemical Engineers*
- Rase HF. *Project Engineering of Process Plants*
- Panneerselvam R. 2012. *Operations Research*. PHI Learning Pvt. Ltd.
- Prasanna C. 2009. *Projects*. Tata McGraw-Hill Publication, New Delhi.
- Nicolas JM. *Project Management for Business and Technology – Principles and Practices*. Pearson Prentice Hall
- Kerzner H and Kerzner HR. 2017. *Project management: a systems approach to planning, scheduling, and controlling*. John Wiley & Sons.
- Gopalakrishnan P and Ramamoorthy VE. 2005. *Textbook of Project Management*. Macmillan.

Theory**Unit I**

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Unit VI

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

Unit VII

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

Unit VIII

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

Practical

- To study different types of sensors for measurement of temperature, pressure, flow and level
- To study interfacing systems for analogue to digital signals
- To study sensors for automated food process control
- To study different logic controlling systems
- To study computer vision systems used in industries
- To study machine vision systems used in industries

- To study optical sensors and online spectroscopy for automated quality and safety inspection of food products
- To study supervisory Control and Data Acquisition (SCADA) and related systems for automated process control in the food industry
- To study different configurations of industrial robots
- To study gripper technologies for food industry robots
- To study wireless sensor networks (WSNs) components in the agricultural and food industries
- To study intelligent quality control systems in food processing based on fuzzy logic
- Application of automation and robotics for bulk sorting, chilling and freezing, meat processing, poultry industry, seafood processing, packaging in confectionery
- etc in food processing industries
- Case studies and field reports on Food Process Automation and Robotics.

Suggested Reading

- Caldwell DG. (Ed.). 2012. *Robotics and automation in the food industry: Current and future technologies*. Elsevier.
- Dwivedi SN, Verma AK and Sneckenberger JE. 1991. *CAD/CAM robotics and factories of the future*. Springer
- Doebelin EO and Manik DN. 2003. *Measurement systems: applications and design, 5e*. Tata McGraw Hill.
- Kuo BC and Golnaraghi F. 1995. *Automatic control systems*, 9e. Prentice-Hall.
- Rajput RK. 2008. *Robotics and Industrial Automation*, 2e. S. Chand Publishing
- Groover MP, Weiss M, Nagel RN and Odrey NG. 1986. *Industrial Robotics: Technology, Programming, and Applications*. McGraw-Hill.
- Huang Y, Whittaker AD and Lacey RE. 2001. *Automation for Food Engineering: Food Quality Quantization and Process Control*. CRC Press.
- Bhuyan M. 2006. *Measurement and Control in Food Processing*. CRC Press.
- Zude M. 2008. *Optical Monitoring of Fresh and Processed Agricultural Crops*. CRC press.
- Dochain D. 2001. *Automatic Control of Bioprocesses. Control Systems, Robotics and Manufacturing Series*. Wiley-ISTE
- Sun DW. (Ed.). 2012. *Computer Vision Technology in the Food and Beverage Industries*. Elsevier.
- Kress-Rogers E and Brimelow CJ. (Eds.). 2001. *Instrumentation and Sensors for the Food Industry*. Woodhead Publishing.

Theory**Unit I**

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

Unit II

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

Unit III

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

Unit IV

Waste water treatment systems. Physical separations, coagulation and flocculation; micro-strainers, filters, ultra-filtration and reverse osmosis; water softening. Physicochemical separations: activated carbon adsorption, ion-exchange electro-dialysis and magnetic separation. Chemical oxidations and treatment coagulation and flocculation. Disinfection. Handling disposal of sludge.

Unit V

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

Practical

- Determination of Alkalinity, Acidity and pH of a given waste water sample
- Determination of electric conductivity of a given sample
- Determination of hardness (Chlorides and Sulphates) of a given waste water sample
- Determination of Solids in wastewater, Total Solids, Suspended Solids, Dissolved Solids, Volatile Solids, Fixed Solids, Settleable Solids
- Estimation of dissolved oxygen and BOD exerted by the given waste water sample
- Estimation of COD exerted by the given waste water sample
- Determination of Nitrates in waste water
- Determination of Fats, oils and greases in waste water

- Determination of fecal contamination of water-qualitative and quantitative
- Estimation
- Determination of SPC of different wastes
- Visit of an effluent treatment plant in a food processing industry.

Suggested Reading

- Arvanitoyannis IS. 2010. *Waste management for the food industries*. Academic Press.
- Zall RR. 2008. *Managing food industry waste: Common sense methods for food processors*. John Wiley and Sons.
- Shuler ML, Kargi F, DeLisa M. 2017. *Bioprocess engineering: basic concepts*. Prentice- Hall.
- Waldron KW. (Ed.). 2009. *Handbook of waste management and co-product recovery in food processing*. Elsevier.
- Mattsson B and Sonesson U. (Eds.). 2003. *Environmentally-friendly food processing*. Woodhead publishing.
- Environment (Protection) Act 1986, Govt of India and relevant publications

FPE 515

Special problem/ Summer Internship

2 (0+2)

Practical's

- Summer internships will be usually of eight to twelve weeks duration, where the students will be attached with the special problem for skill development and first hand experience of working in Industry.
- Student *will be asked to work on special problem either at college or any academic institute or industrial firms*

Suggestive Problems

- Post-harvest management,
- Food processing entrepreneurship and startup,
- Global food laws and regulations,
- Food safety management systems and certification,
- Quality concepts and chain traceability
- Process and equipment validation,
- Food quality and safety assessment,
- Toxicology and risk assessment

Theory

Unit I

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

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

Unit II

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

Unit III

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

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

Unit IV

Beverages: Production technology of beer and wine Non-alcoholic beverages: Carbonated beverages: carbonation equipment, - ingredients-preparation of syrups-Filling system-packaging-containers and closures. Non-carbonated beverage: Coffee bean preparation- processing-brewing- decaffeination- instant coffee, Tea types-black, green, Fruit juices and beverages,. Flash pasteurization, Aseptic Packaging of beverages Tea/coffee and cocoa beverages, Grain based and malted beverages. Packaged drinking water: types, manufacturing processes, quality evaluation and raw and processed water, methods of water treatment, BIS quality standards of bottled water; mineral water, natural spring water, flavoured water, carbonated water.

Practical

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

- Preparation of fruits/vegetable based ready to serve beverages and quality evaluation
- Heat classification of milk powders.
- Determination of degree of browning-chemical/physical methods.
- Determination of quality of packaged drinking water.
- Preparation of wine and beer
- Preparation of soy milk.
- Determination of quality of canned food.

Teaching Schedule

Theory

| No. of lectures | Topic | Weightage (%) |
|-----------------|---|---------------|
| 1-8 | Grain products: Industrial manufacturing of grain-based products: formulation, processes, machinery Material balance of baked, rolled, shredded, puffed, flaked, roasted products. Extrusion technology: Importance and applications of extrusion in food processing; Pre and post extrusion treatments; Manufacturing process of extruded products; Change of functional properties of food components during extrusion. Breakfast cereals, RTE/RTC foods, instant premixes, functional foods. | 20 |
| 9-12 | Fruit and vegetable products: Industrial manufacturing of fruit and vegetable-based products formulation, processes, machinery and Material balance of minimally processed, Retorted products, IMF, high moisture stable foods, IQF; Machines and equipment for batch and continuous processing of fruit and vegetable products. | 20 |
| 13-20 | Chocolates and candies: Coating or enrobing of chocolate (including pan-coating); Maintenance, safety and hygiene of bakery plants. Fats and oils processing: Technology of refined oil, winterized oil, hydrogenated fat texturized fat, by-products of fat/oil processing industries – oil seed protein isolates; Quality standards of fats and fatty foods; Antioxidants and its mechanism of application | 20 |
| 21-32 | Beverages: Production technology of beer and wine, Non- alcoholic beverages: Carbonated beverages: carbonation equipment, - ingredients-preparation of syrups- Filling system- packaging- containers and closures. Non-carbonated beverage: Coffee bean preparation-processing-brewing- decaffeination- instant coffee, Tea types-black, green, Fruit juices and beverages, Flash pasteurization, Aseptic Packaging of beverages, Tea/coffee and cocoa beverages, Grain based and malted beverages. Packaged drinking water: types, manufacturing processes, Quality evaluation and raw and processed water, Methods of water treatment, BIS quality standards of bottled water; mineral water, natural spring water, flavoured water, carbonated water | 40 |
| | Total | 100 |

Practical

| Sr. No. | Topic | No. of Practical |
|-------------------------|---|------------------|
| 1. | Preparation of cereals based fried snack foods | 1 |
| 2. | Preparation of cereal, pulses based ready-to-eat snack food by extrusion cooking their quality evaluation | 2 |
| 3. | Preparation of cereal grain based puffed products | 1 |
| 4. | Development of instant food premixes | 1 |
| 5. | Preparation of cereal and legume based roasted snack | 1 |
| 6. | Preparation of flaked rice product | 1 |
| 7. | To study the effect of roasting time and temperature on quality of pop- corn | 1 |
| 8. | Determination of shelf-life and packaging requirements of snack food products | 1 |
| 9. | Preparation of fruits/vegetable based ready to serve beverages and Quality evaluation | 1 |
| 10. | Heat classification of milk powders. | 1 |
| 11. | Determination of degree of browning-chemical/physical methods. | 1 |
| 12. | Determination of quality of packaged drinking water. | 1 |
| 13. | Preparation of wine and beer | 1 |
| 14. | Preparation of soy milk. | 1 |
| 15. | Determination of quality of canned food. | 1 |
| Total Practicals | | 16 |

Suggested Reading

- Edmund WL, 2001. Snack Foods Processing, CRC Press.
- Gordon BR. 1990. Snack Food, Springer US.
- Frame ND, 1994. Technology of Extrusion Cooking, Springer US
- O'Brien RD, 2008. Fats and Oils: Formulating and Processing for Application, CRC Press.
- Davis B, Lockwood A, Alcott P and Pantelidis L, 2012. Food and Beverage Management, CRC Press.
- Kunze W, 2010. Technology: Brewing and Malting, VLB.
- Dhillon PS and Verma S, 2012. Food and Beverage: Production Management for Hospitality Industry, Abhijeet Publications.
- Bamforth CW, 2006. Brewing: New Technologies, Woodhead Pub.
- Tomar SK, 2011. Functional Dairy Foods Concepts and Applications, Satish Serial Publishing House.
- Gupta RK, Bansal S and Mangal M, 2012. Health Food Concept, Technology and Scope, Biotech Books.

Theory**Unit I**

Introduction: present and future of aseptic processing, Advantages and disadvantages, processing of semi-solid and fluid and particulate foods. Aseptic processing operations: pre-sterilization, loss of sterility, water-to-product and product-to-water separation, cleaning, control, CIP.

Unit II

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

Unit III

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

Unit IV

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

Practical

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

Teaching Schedule

Theory

| No. of lectures | Topic | Weightage (%) |
|-----------------|---|---------------|
| 1-5 | Introduction: present and future of aseptic processing, Advantages and disadvantages, processing of semi-solid and fluid and particulate foods. Aseptic processing operations: pre-sterilization, loss of sterility, water-to-product and product-to-water separation, Cleaning, control, CIP. | 15 |
| 6-10 | Quality Assurance: Effect of aseptic processing on nutrients, microorganisms, in- process and post-process assurance, HACCP, regulatory aspects of processing and packaging, Shelf-life modules. | 15 |
| 11-20 | Sanitary design and Equipments requirements: Pumps and Heat exchangers, homogenizers, Sanitary design and Equipment's requirements: aseptic process and packaging system for retail and institutional packages. | 20 |
| 21-32 | Packaging of aseptic processed foods Packaging materials characteristics, Packaging of aseptic processed foods: Aseptic filling, sterilization of packaging materials, package design, aseptic packaging system, Type of pack and equipment's: Fill and seal, Form, fill and seal, Erect, fill and seal, Thermoform, fill, sealed, Blow mold, fill, seal; Geometry, materials and size of retail and bulk package, seal and closures. | 50 |
| Total | | 100 |

Practical

| Sr. No. | Topic | No. of Practical |
|---------|---|------------------|
| 1. | Effect of aseptic processing on microbial quality of juice based beverage | 2 |
| 2. | Effect of aseptic processing on vitamins in selected foods | 2 |
| 3. | Effect of aseptic processing on minerals in selected foods. | 1 |
| 4. | Effect of aseptic processing on colour pigments in selected foods. | 1 |
| 5. | Effect of aseptic processing on browning of milk | 1 |
| 6. | Effect of aseptic processing on viscosity of milk | 2 |
| 7. | Effect of aseptic processing on proteins in selected foods | 1 |
| 8. | Effect of different chemical sterilant on microbial quality of packaging material | 2 |

| | | |
|-----|---|----|
| 9. | To estimate chemical sterilant residue on packaging materials | 2 |
| 10. | Estimation of package integrity and leakage | 1 |
| 11. | Shelf life models and prediction. | 1 |
| | Total Practicals | 16 |

Suggested Reading

- Robertson GL, 2012. Food Packaging: Principles and Practices, CRC Press.
- David JRD, Graves RH and Szemplenski T, 2016. Handbook of Aseptic Processing and Packaging, CRC Press.
- Reuter H, 1993. Aseptic Processing of Foods, CRC Press.
- Willhoft EM, 1993. Aseptic Processing and Packaging of Particulate Foods, Springer.

Theory
Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Teaching
Schedule Theory

| No. of lectures | Topic | Weightage (%) |
|-----------------|--|---------------|
| 1-6 | International Plant Protection Convention, world organization for animal health (OIE), Sanitary and Phytosanitary measures (SPS), Codex Alimentarius, FAOLEX, OECD Agriculture and Fisheries, International Trade Centre's Standards Map, FAO Food safety and quality emergency Prevention, JFSCA, | 20 |
| | Fundamental Principles of food safety governance, Risk | |

| | | |
|-------|---|-----|
| | Analysis as a Method to Determine the Regulatory Outcome, Increasing Responsibility of Businesses (Private) Risk Assessors, Concept of harmonization of global food Laws. | |
| 7-15 | EU Food Safety Standards - Regulation 178 of 2002, The European food safety authority (EFSA), A critical overview of the EU food safety policy and standards, COMESA Food Safety Standards - An overview, Case Studies in Food Safety Standards in EU-COMESA Trade, Private voluntary standards (PVS) and EU food safety standards, FDA Food safety modernization Act (FSMA), FSPCA Preventive Controls for Human Food, Foreign Supplier Verification Programs (FSVP), Food Facility Registration, FDA - Current Good Manufacturing Practices (CGMPs) | 25 |
| 16-24 | Hazard Analysis & Critical Control Points (HACCP) guidelines, Foreign Food Facility Inspection Program, International and Interagency Coordination, Registration of Food Facilities, Seafood Imports and Exports, Regulation on GM Foods, Regulations on Irradiated foods, Global Regulations on Health Foods, International Law on Adequacy of thermal processing, Grain Fumigation for Export, Law of trading horticultural Products, Safety Frame Applied to Food Applications of Nanotechnology. | 30 |
| 26-32 | Review of Indian Regulatory Scenario in Food and Food Products - Food Safety and Standards (FSS) Act, 2006, FSS Rules and Regulations, Agricultural Produce Act, 1937 (Grading and Marketing), Export (Quality Control & Inspection), Act, 1963 and Rules, Bureau of Indian Standards relevant to food safety, Legal Metrology Act, International Food Control Systems/ Laws | 25 |
| | Total | 100 |

Suggested Reading

- Osiero O. 2018. Food Safety Standards in International Trade: The Case of the EU and the COMESA, CRC
- Villarreal AM. 2018. International Standardization and the Agreement on Technical Barriers to Trade, Cambridge University Press
- Meulen B, Bremmers H, Purnhagen K, Gupta N, Bouwmeester HL and Geyer L. 2014.
- Governing Nano Foods: Principles-Based Responsive Regulation
- Understanding the Codex Alimentarius, 3rd ed., 2006.
- Vapnek J and Spreij M. 2005. Perspectives and Guidelines on Food Legislation, with a new model food law for the Development Law Service FAO Legal Office
- US FDA Website
- European Food Safety Authority (EFSA) website

Theory**UNIT I**

Active and intelligent packaging: Active Packaging Techniques and intelligent Packaging Techniques, current use of novel Packaging Techniques, consumers and novel Packaging Oxygen, ethylene and other scavengers: Oxygen scavenging technology, selecting right types of oxygen scavenger, ethylene scavenging technology, carbon dioxide and other scavengers. Antimicrobial food packaging: Antimicrobial agents, constructing antimicrobial packaging systems, factors affecting the effectiveness of antimicrobial packaging.

UNIT II

Non-migratory bioactive polymers (NMBP): Advantages of NMBP, Inherently bioactive synthetic polymers: types and application, Polymers with immobilized bioactive compounds and their applications. Time Temperature labels and indicators (TTIs): Defining and classifying TTIs, Requirements for TTIs, development of TTIs, Maximizing the effectiveness of TTIs, Application of TTIs- to monitor shelf-life, and optimization of distribution and stock rotation, leakage indicators, oxygen indicators, micro indicators etc. Freshness indicator in packaging: Compounds indicating the quality of packaged food products, freshness indicators, pathogen indicators, other methods for spoilage detection. Self- heating /rehydrating packages.

UNIT III

Packaging-flavour interaction: Factors affecting flavor absorption, role of food matrix, role of differing packaging materials, flavour modification and sensory quality, Study of packaging materials compatibility with foods. Developments in modified atmosphere packaging (MAP): Permeability properties of polymer packaging, measurement of permeability – water and gases. Selection criteria of packaging films, Novel MAP gas, testing novel MAP applications, applying high oxygen MAP. Recycling packaging materials: Recyclability of packaging plastics, improving the recyclability of plastics packaging, testing safety and quality of recycled materials, uses of recycled plastics in packaging.

UNIT IV

Green plastics for food packaging: Problems of plastic packaging wastes, range of biopolymers, developing novel biodegradable materials. Edible Films and Coatings: Properties, types, sources, applications, advantages, disadvantages, theories of plasticization, challenges and opportunities.

PFS machine, seal and closures. Safety and legislative aspects of packaging: Regulatory considerations, plastic, metal, paper and glass packaging.

Practical

- Determination of WVTR in different packaging materials
- Determination of GTR in different packaging materials.
- Study of different ethylene scavengers and their analysis

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

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|---|---------------|
| 1-4 | Active and intelligent packaging: Active Packaging Techniques and intelligent Packaging Techniques, current use of novel Packaging Techniques, consumers and novel Packaging. | 20% |
| 5-8 | Oxygen, ethylene and other scavengers: Oxygen scavenging technology, selecting right types of oxygen scavenger, ethylene scavenging technology, carbon dioxide and other scavengers. | |
| 9-12 | Antimicrobial food packaging: Antimicrobial agents, constructing antimicrobial packaging systems, factors affecting the effectiveness of antimicrobial packaging. | |
| 13-15 | Non-migratory bioactive polymers (NMBP): Advantages of NMBP, Inherently bioactive synthetic polymers: types and application, Polymers with immobilized bioactive compounds and their applications. | 30% |
| 16-18 | Time Temperature labels and indicators (TTIs): Defining and classifying TTIs, Requirements for TTIs, development of TTIs, Maximizing the effectiveness of TTIs, Application of TTIs- to monitor shelf-life, and optimization of distribution and stock rotation, leakage indicators, oxygen indicators, micro indicators etc. | |
| 19-20 | Freshness indicator in packaging: Compounds indicating the quality of packaged food products, freshness indicators, pathogen indicators, other methods for spoilage detection. Self-heating /rehydrating packages. | |

Food Process Engineering

| | | |
|-------|--|------|
| 21-22 | Packaging-flavour interaction: Factors affecting flavor absorption, role of food matrix, role of differing packaging materials, flavour modification and sensory quality. | 30 % |
| 23-24 | Study of packaging materials compatibility with foods. Developments in modified atmosphere packaging (MAP): Permeability properties of polymer packaging, measurement of permeability – water and gases. | |
| 25-26 | Selection criteria of packaging films, Novel MAP gas, testing novel MAP applications, applying high oxygen MAP. | |
| 27-32 | Recycling packaging materials: Recyclability of packaging plastics, improving the recyclability of plastics packaging, testing safety and quality of recycled materials, uses of recycled plastics in packaging. | |
| 33-34 | Green plastics for food packaging: Problems of plastic packaging wastes, range of biopolymers, developing novel biodegradable materials. | 20% |
| 35-36 | Edible Films and Coatings: Properties, types, sources, applications, advantages, disadvantages, theories of plasticization, challenges and opportunities. | |
| 37-38 | PFS machine, seal and closures. Safety and legislative aspects of packaging: Regulatory considerations, plastic, metal, paper and glass packaging. | |
| | Total | 100 |

Practical

| Practical No | Topic |
|--------------|--|
| 1 | Determination of WVTR in different packaging materials |
| 2 | Determination of GTR in different packaging materials. |
| 3 | Study of different ethylene scavengers and their analysis |
| 4 | Study of different oxygen scavengers systems and their analysis |
| 5 | Application of anti-microbial packaging for moisture sensitive foods |
| 6 | Evaluation of chemical residue migration from package to food |
| 7 | Application of MAP packaging in selected foods |
| 8 | Study of TTI label, leakage indicators etc. |
| 9 | Determination of oxidative changes in packaged foods |
| 10 | Comparative evaluation of flexible and rigid packages for fragile foods |
| 11 | Packaging of foods under inert atmosphere. |
| 12 | To study textural characteristics of selected fruit/ vegetable under MAP storage |
| 13 | Shelf life evaluation and mode up of packaged food product. |

| | |
|----|---|
| 14 | Determination of oil and grease resistant test for packaging films |
| 15 | Determination of respiration rate in fresh fruits and vegetables |
| 16 | Determination of shelf life of fresh fruits and vegetables by using edible coating and films. |
| 17 | Effect of edible coating and films on respiration behaviour, chemical, physical and sensory characteristics of fresh fruits and vegetables. |
| 18 | Visit to food packaging material manufacturing industry |

Suggested Readings

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

Theory**Unit I**

Introduction: Biomaterials and their properties in relation to processing and product development. Physico-chemical characteristics: Shape, sphericity, size, volume, microstructure, density, porosity, surface area, coefficients of friction and angle of repose and influence of constituents on processing.

Unit II

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

Unit III

Thermal, electrical and optical properties: Specific heat, thermal conductivity, phase transition, thermodynamics-basic principles and laws, Thermodynamic properties of moist air, kinetics of water absorption, heat capacity, thermal diffusivity, electrical resistance and conductance, dielectric constant, reflectivity, transmittivity and absorptivity of incident rays. Food microstructure: Methods and systems for food microstructure, determination of light microscopy, transmission electron microscopy, scanning electron microscopy, other instrumentation and techniques, image analysis: image acquisition, image processing, measurement analysis.

Unit IV

Functional properties: Dextrinization, Gelatinisation, Crystallisation, gelation, foaming, coagulation, denaturation and syneresis, foaming, emulsification. Sensory attributes: Sensory properties and correlation with objective indices, microstructure and its relation to texture from their mechanical models and its examination. Sorption behaviour of food: sorption isotherm, modelling.

Practical

- To determine physical dimension and shape for suitability of processing and packaging of food materials
- To determine bulk, true density and porosity of samples
- To determine the angle of repose using rough and smooth surface
- Analysis of powder characteristics using powder flow analyser.
- To determine the mixing and strength characteristics of wheat flour using faringograph/ mixograph/ mixolab
- To determine the amyolytic activity using falling number of wheat flour
- Development of stress and strain curve and to study viscosity of Newtonian and non-Newtonian fluid
- Effect of temperature on viscosity profile of a food sample
- Texture profile analysis of foods samples.

- Effect of temperature on textural profile of food
- Determination of thermal properties of foods using DSC.
- To estimate dielectric constant of foods
- Organoleptic evaluation of food materials
- TEM and SEM, image analysis and image processing techniques
- To determine water activity of food
- To determine colour value of food, viz. Lab, whiteness index, yellow index, browning index

Suggested Reading

- Rao MA and Rizvi SSH, 1986. Engineering Properties of Foods, Marcel Dekker.
- Aguilera JM & Stanley DW, 1999. Microstructural Principles of Food Processing and Engineering, Springer.
- Mohsenin NN, 1986. Physical Properties of Plant and Animal Materials, Gordon & Breach Science.
- Bourne MC, 1981. Food Texture and Viscosity; Concept and Measurement, Academic Press. Steffe JF, 1992. Rheological Methods in Food Process Engineering, Freeman Press.
- Aguilera JM, 1999. Microstructure: Principles of Food Processing Engineering, Springer.
- Rahman MS, 2009. Food Properties Handbook, CRC Press.
- Serpil S & Sumnu SG, 2006. Physical Properties of Foods, Springer-Verlag.
- Pomeranz Y, 1991. Functional Properties of Food Components, Academic Press

Theory**UNIT I**

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

UNIT II

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

UNIT III

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

UNIT IV

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

Practical

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

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

Teaching Schedule

Theory

| Lecture No | Topic | Weightage (%) |
|------------|--|---------------|
| 1-4 | Composition, nutritional and functional value of food. | 25% |
| 5-6 | Water activity and sorption phenomenon, Engineered foods and influencing water activity and shelf-life. | |
| 7-10 | Chemical reactions of carbohydrates—oxidation, reduction, with acid & alkali. | |
| 9-11 | Maillard reaction, Caramelization, Ascorbic acid oxidation. | |
| 12-15 | Resistant Starch, Soluble and Insoluble fibre, Pigments and approaches to minimize the impact of food processing, Molecular Mobility. | |
| 16-18 | Structure and Properties of proteins; electrophoresis, sedimentation, amphoterism, denaturation, viscosity, gelation, texturization, emulsification, foaming, protein-protein and other interactions in food matrix. | 25 % |
| 19-21 | Lipids: melting point, softening point, smoke, flash and fire point, turbidity point, polymorphism and polytypism; Lipids: melting point, softening point, smoke, flash and firepoint, turbidity point, polymorphism and polytypism; | |
| 22-24 | Polymerization and polymorphism, flavor reversion, autooxidation and its prevention, fat in food matrix like fat globule in milk. | |
| 25-28 | PUFA, MUFA, CLA, ω - fatty acids, trans fatty acids, phytosterol, etc. | |
| 29-30 | Description of food flavours; Flavour enhancers, Food acids their tastes and flavours. | 25% |
| 31-33 | Principles and techniques of flavour encapsulation, types of encapsulation; Factors affecting stabilization of encapsulated flavour and their applications in food industry. | |

| | | |
|-------|--|-----|
| 34-35 | Processing and packaging induced chemicals and their control – acrylamide, nitrosamines, carcinogenic and genotoxic chloropropanols such as 3-monochloropropane-1,2-diol (3-MCPD). | 25% |
| 36-38 | PAHs (in grilled and smoked products), dioxine, histamine, ethyl carbamate, furan, bisphenol A or phthalates from plastic materials, microplastics, 4-methylbenzophenone and 2-isopropyl thioxanthone from inks, mineral oil from recycled fibers or semicarbazide from a foaming agent in the plastic gasket. | |
| | Total | 100 |

Practical

| Practical No | Topic |
|--------------|---|
| 1 | Estimation of protein content in food samples using spectroscopic methods |
| 2 | Study of effect of heat on protein denaturation using enzymes |
| 3 | Study of effect of various salt solutions on solubility of proteins |
| 4 | Separation of milk proteins by salting out method |
| 5 | Separation of proteins using chromatographic methods |
| 6 | Fractionation of proteins |
| 7 | Extraction and purification of essential oil/ flavouring compound of a natural source |
| 8-10 | Study the process of starch retrogradation, gelatinization and modification |
| 11 | Estimation of crude and dietary fibres in given food sample |
| 12 | Analysis of resistant starches |
| 13 | Estimation of various antioxidants, polar compounds and free fatty acids in frying oils |
| 14-15 | Extraction and purification of natural plant pigment |
| 16 | Functional properties and isoelectric point of proteins |
| 17 | Qualitative and quantitative evaluation of processing and packaging induced chemicals |
| 18 | Qualitative identification of different flavouring compounds |

Suggested Readings

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

FSQ 506

Process and Products Monitoring for Quality Assurance

2 (2+0)

Theory

Unit I

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

Unit II

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

Unit III

Machine vision for the food industry, Ultrasonic methods, Sampling procedures for online quality.

Unit IV

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

Suggested Reading

- Rodríguez MEP. 2018. *Process Monitoring and Improvement Handbook*, Second Edition 2018 by ISBN: 978-0-87389-974-1 *Food Process Monitoring Systems* 1993, Springer

Theory**Unit I**

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

Unit II

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

Unit III

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

Unit IV

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

Practical

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

Suggested Reading

- Wastewater treatment and use in agriculture - FAO irrigation and drainage paper 47, <http://www.fao.org/docrep/t0551e/t0551e00.htm#Contents>
- Waste Biomass Valor (2017) 8:2209–2227 DOI: 10.1007/s12649-016-9720-0

| | | | |
|------------|---------------------|----------|---|
| I | Course Title | : | Management of Food By-products and Waste |
| II | Course Code | : | FSQ 508 |
| III | Credit Hours | : | 3 (2+1) |

IV Theory :

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

VI Practicals

- Study of waste utilization processes by site visit/ site plan studies
- Characterization of effluent for Dissolved solids (TDS), Suspended solids, BoD, CoD,
- Nitrogen (as N), Phosphorus (as P), Alkalinity (as CaCO₃), Sulphate (as SO₄), Total organic carbon (TOC)
- Characterization of food waste as feedstock for anaerobic digestion
- Various treatments in use for waste disposal: study on operational precautions;
- Extraction of banana fibre,
- Utilization of ghee residue in caramel toffee;

- Extraction of volatile oils from organic waste;
- Use of fruit/vegetable residue for the production of cellulose;
- Use of mango kernels for manufacturing of starch;
- Production of pectin/citric acid from organic waste

Teaching Schedule

Theory

| No. of Lecture | Topic | Weightage |
|----------------|--|-----------|
| 1-5 | Management of Food Waste, Principles of sustainable systems and Green chemistry, Waste management purpose and strategies, Waste & its consequences in pollution and global warming | 15.0% |
| 6-9 | Food waste classification, Mitigation measures for food processing wastes, Food waste Handling and Management laws – National and international. | 12.0% |
| 10-15 | Approaches to Solid Waste Management - Bio gas and electricity generation, Bioactive compounds extraction, Sourcing natural colour, Valorization, Biofueling, Biofertilizers, Bio-ethanol, Activated carbon, Biochar, other biological approaches, Use for biodegradable plastic, biofertilizers and environmental bioremediation. | 20.0% |
| 16-18 | Approaches to Effluent Waste Management Basic unit operations in wastewater treatment, Anaerobic digestion of organic residues and wastes | 10.0% |
| 19-24 | Fundamentals and applications of anaerobic digestion for sustainable treatment of food industry wastewater, Effluent treatment strategies for dairy/ brewery/ winery, Common biological treatment processes and on-site treatment systems. | 20.0% |
| 25-30 | Case studies, commercially viable practices and success stories of value added products of waste and by-products from processing of different plant and animal food products. | 20.0% |
| 31-32 | Food waste for pulp & paper, flavorings and aromas production. | 3.0% |
| | Total | 100 |

Practical

| Sr. No. | Topic | No. of Practical |
|---------|---|------------------|
| 1. | Study of waste utilization processes by site visit/ site plan studies | 1 |
| 2. | Characterization of effluent for Dissolved solids (TDS), | 2 |

| | | |
|----|---|----|
| | Suspended solids, BoD, CoD, | |
| 3. | Nitrogen (as N), Phosphorus (as P), Alkalinity (as CaCO ₃), Sulphate (as SO ₄), | 2 |
| 4. | Total organic carbon (TOC) | 1 |
| 5. | Characterization of food waste as feedstock for anaerobic digestion | 1 |
| 6. | Various treatments in use for waste disposal: study on operational precautions; | 1 |
| 7 | Extraction of banana fibre, | 1 |
| 8 | Utilization of ghee residue in caramel toffee; | 1 |
| 9 | Extraction of volatile oils from organic waste; | 2 |
| 10 | Use of fruit/vegetable residue for the production of cellulose; | 1 |
| 11 | Use of mango kernels for manufacturing of starch; | 1 |
| 12 | Production of pectin/citric acid from organic waste | 2 |
| | Total | 16 |

VI Suggested Reading

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

Theory

Unit I

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

Unit II

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

Unit III

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

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

Practical

- Study of a regulated market,
- Study of a fruit and vegetable market,
- Study of State and Central Warehousing Corporation
- Study of functioning of a regional rural bank and commercial bank for loan.
- Study of food processing enterprise,
- Formulation of project reports for financing food Industry,
- Working out repayment plans,
- Legal Issues in Product Development, Marketing and Market Segments
- Case studies: Innovations in Dairy industry, Bakery industry, fats and oils industry, fruit and vegetable industry, primary and secondary processing of cereals, brewing industry.

Teaching Schedule

Theory

| No. of lectures | Topic | Weightage (%) |
|-----------------|--|---------------|
| 1-4 | Assessing overall business environment in the Indian economy. Overview of Indian social, political and economic systems and their implications for decision making by individual entrepreneurs. Globalisation and the emerging business/ entrepreneurial environment. | 20 |
| 5-8 | Concept of entrepreneurship; entrepreneurial and managerial characteristics; managing an enterprise; Motivation and entrepreneurship development; importance of planning, monitoring, evaluation and follow up; Managing competition; entrepreneurship development programs; Social Responsibility of Business. | 30 |
| 9-16 | SWOT analysis, Generation, incubation and commercialization of ideas and innovations. Government schemes and incentives for promotion of entrepreneurship. Government policy on Small and Medium Enterprises (SMEs)/ SSIs. Export and Import Policies relevant to food sector. Venture capital. Contract farming and joint ventures, public-private partnerships. Overview of horti inputs industry. Characteristics of Indian food processing and export industry. Communication Skills: Structural and functional grammar; meaning and process of communication, verbal and non-verbal communication; listening and note taking, writing skills, oral presentation skills; field diary and lab record; indexing, footnote and bibliographic procedures. Reading and comprehension of general and technical articles, précis writing, summarizing, abstracting; Individual and group presentations, impromptu presentation, Public speaking; Group discussion. Organizing seminars and conferences. | 50 |
| Total Lectures | | 100 |

Practical

| Sr. No. | Topic | No. of Practical |
|---------|---|------------------|
| 1. | Study of a regulated market, | 1 |
| 2. | Study of a fruit and vegetable market, | 2 |
| 3. | Study of State and Central Warehousing Corporation | 1 |
| 4. | Study of functioning of a regional rural bank and commercial bank for loan. | 1 |
| 5. | Study of food processing enterprise, | 1 |
| 6. | Formulation of project reports for financing food Industry, | 2 |

| | | |
|-----|--|----|
| 7. | Working out repayment plans, | 1 |
| 8. | Legal Issues in Product Development, Marketing and Market Segments | 1 |
| 9. | Case studies: Innovations in Dairy industry | 1 |
| 10. | Case studies: Innovations in Bakery industry , | 1 |
| 11. | Case studies: Innovations in Fats and Oil industry, | 1 |
| 12. | Case studies: Innovations in Fruits and vegetable industry, | 1 |
| 13. | Case studies: Innovations in Primary and Secondary processing cereals, | 1 |
| 14. | Case studies: Innovations in Brewing industry , | 1 |
| | Total Practicals | 16 |

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

Suggested Reading

- Hu, R. 2005. Food Product Design A Computer-Aided Statistical Approach, Technomic Publishers.
- Moskowitz H R, Saguy S. and Straus T. 2006. An Integrated Approach to New Food Product Development, CRC Press
- Moskowitz H R, Porretta S. and Silcher M. 2006. Concept Research in Food Product Design And Development, Blackwell Publishing Ltd.
- Peters MS and Timmerhaus KD. 2005. Plant Designs and Economics for Chemical Engineers, McGraw Hill, 5th Edition,
- Ahmad T. 2009. Dairy Plant Engineering and Management., Kitab Mahal, 8th Edition.
- ISO 22000 Standard Procedures for Food Safety Management Systems, 2008, Bizmanualz, Inc.
- Dillon M and Griffith C (ed). 2001. Auditing in the Food Industry - From Safety and Quality to Environmental and Other Audits, CRC Press
- Intez A. 2003. Food Quality Assurance: Principles and Practices, CRC Press
- Respective certification documents

Theory**Unit I**

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

Unit II

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

Unit III

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

Unit IV

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

Practical

- Macro quality analysis, grading, packaging.
- Harvesting indices of different vegetable crops;
- Grading and packing of vegetables;
- Practice in judging the maturity of various fruits and vegetables.
- Conservation of zero energy cool chambers for on farm storage.
- Determination of physiological loss in weight (PLW), total soluble solids (TSS), total sugars, acidity and ascorbic and content in fruits and vegetables.
- Packing methods and types of packing and importance of ventilation.

Teaching Schedule

Theory

| No. of lectures | Topic | Weightage (%) |
|-----------------|--|---------------|
| 1-8 | Post-harvest handling of F&V. Maturity indices, harvesting and post-harvest handling of fruits and vegetables. Respiration and ripening process. Factors affecting respiration and ripening. Pre and post-harvest factors affecting quality on post-harvest shelf life. Chemicals used for hastening and delaying ripening of fruits and vegetables. Methods of storage – precooling, pre storage treatments, low temperature storage, controlled atmospheric storage, hypobaric storage, irradiation and low cost storage structures, Cleaning & Washing machinery and methods for grading. | 25 |
| 9-16 | Packing technology for export. Fabrication of types of containers, cushioning material, vacuum packing, poly shrink packing, specific packing for export of mango, banana, grapes kinnow, sweet orange, and mandarin etc. Principles of preservation by heat, low temperature, chemicals and fermentation. Cut fruits and vegetables. | 20 |
| 17-22 | Post-harvest practices for safe storage of food grains. Preparation of threshing, threshers for different crops, parts, terminology, care and maintenance. Winnowing, manual and power operated winnowers. Groundnut decorticators- hand and power operated, principles of working Maize shellers & castor shellers. Drying-grain drying method and equipment. Grain storage and practices. | 20 |
| 23-32 | Post-harvest technology for major spices (black pepper, cardamom, coriander, cinnamon, ginger, onion and garlic, paprika, saffron, turmeric), their post-harvest diseases and storage pests and their management; Packaging and storage of spices and spice powders. | 35 |
| | Total | 100 |

Practical

| Sr. No. | Topic | No. of Practical |
|---------|---|------------------|
| 1. | Macro quality analysis of fruits and vegetables during grading and packaging | 2 |
| 2. | Harvesting indices of different fruits and vegetable crops; | 2 |
| 3. | Grading and packing of fruits and vegetables; | 2 |
| 4. | Practice in judging the maturity of various fruits and vegetables. | 2 |
| 5. | Conservation of zero energy cool chambers for on farm storage. | 2 |
| 6. | Determination of physiological loss in weight (PLW) content in fruits and vegetables. | 1 |

| | | |
|-----|---|----|
| 7. | Determination of total soluble solids (TSS) content in fruits and vegetables. | 1 |
| 8. | Determination of total sugars content in fruits and vegetables. | 1 |
| 9. | Determination of acidity in fruits and vegetables. | 1 |
| 10. | Determination of ascorbic acid content in fruits and vegetables. | 1 |
| 11. | Packing methods and types of packing and importance of ventilation. | 1 |
| | Total Practicals | 16 |

Suggested Reading

- Pantastico B. *Post Harvest Physiology, Handling and Utilization of Tropical and Subtropical*
- *Fruits and Vegetables*. The AVI Publishing Co. Inc, Westport
- Ryall, AL and Lipton WJ. *Handling, Storage and Transportation of Fruits & Vegetables*. Vol I. The AVI Pub. Company
- Ryall AL and Peltzer WT. *Handling, Storage and Transportation of Fruits and Vegetables* – Vol II. The AVI Pub. Co.
- Rydstm Heele S. *Post Harvest Physiology and Pathology of Vegetables*. Marcel Dekker

FSQ 507

Quality Concepts and Chain Traceability

2 (2+0)

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Teaching Schedule

Theory

| No. of lectures | Topic | Weightage (%) |
|-----------------|---|---------------|
| 1-3 | Quality – Concepts, Quality as winning strategy, Total quality management TQM: Introduction, definitions and principles of operation, TQM : Tools and Techniques, such as, quality circles, 5 S | 20 |

| | | |
|-------|--|-----|
| | Practice, TQM implementation and limitations, JH – Autonomous maintenance Total quality control (TQC), Total employee involvement (TEI), Problem solving process, Quality function deployment (QFD), Failure mode and effect analysis (FMEA), Fault Tree Analysis (FTA), Kizen, Poka- Yoke, QC Tools, PDCA Cycle, Quality Improvement Tools | |
| 4-6 | Introduction, Content, Methods, Advantages and Limitation of: Just –in –Time and Quality Management KANBAN system, Total productive maintenance (TPM), QS 9000. Basic concept, Principle, methodology of contemporary trends: Lean manufacturing, Agile manufacturing, World class manufacturing, Concurrent engineering, Bench marking, Cost of quality (COQ) system. | 20 |
| 7-10 | Reliability engineering fundamentals; Failure data analysis; Failure rate; mortality curve; Concept of burn in period; Useful life and wear out phase of a system; Mean time to failure (MTTF); Mean time between failure, (MTBF) and mean time to repair (MTTR); Reliability in terms of Hazard rate and failure density, Measurement systems analysis for accuracy, Probability for quality. | 20 |
| 11-14 | SQC -Statistical quality control– X/ R/ p and c chart, Shewhart and types of control charts, SQC - Process capability analysis, process capability index. Acceptance sampling by variables and attributes, design of sampling plans, single, double, sequential and continuous sampling plans, design of various sampling plans for food industry (Note: SQC tables can be used in the examination), Capability analysis. Statistical process control. | 20 |
| 15-16 | Traceability in food safety management, Applications of traceability, Traceability challenges, Traceability requirements and standards: ISO 22005, Traceability implementation & application : Traceability data & process flow, Traceability process participants, Traceable item, Batch/Lot and Traceability links management, Food authenticity tools. | 20 |
| | Total | 100 |

Suggested Reading

- Montgomery, Jennings and Pfund. 2010. Managing, Controlling and Improving Quality, Wiley
- Arora KC. 2016 (4th Edition). Total Quality Management, S K Kataria & Sons Pub

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Suggested Reading

- Creswell JW. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Sage publications, 2013.
- Kumar R. Research Methodology: A Step by Step Guide for Beginners, 2nd Edition, SAGE, 2005.
- Kothari CR, Garg G. Research Methodology Methods and Techniques, New Age International publishers, Fourth Edition.
- Bower JA. 2009. Statistical Methods for Food Science, Blackwell Publishing
- Wilson A. Handbook of Science Communication, 1998, CRC Press
- Montgomery DC. 2017. Design and Analysis of Experiments, Wiley
- Snedecor GW and Cochran WG. 1991. Statistical Methods, 8th Edition, Wiley-Blackwell
- Saguy PI. Computer aided techniques in Food Technology, 1983, Taylor and Francis

Theory**Unit I**

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Suggested Reading

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

Theory**Unit I**

Business management; introduction, theories and functions, food industry management; marketing management and human resource development, personal management. Sectors in food industry and scale of operations in India. Human resource management, study the basics about HR and related policies and capacity mapping approaches for better management. Consumer Behavior towards food consumption, consumer surveys by various institutes and agencies, Various journals on consumer behaviour and market research, Internet based data search.

Unit II

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

Project management – project preparation evaluation measures.

Unit III

International trade; basics, classical theory, theory of absolute advantage. theory of comparative, modern theory, free trade- protection, methods of protection, quotas, bounties, exchange control, devaluation, commercial treaties, terms of trade, balance of payments, EXIM policy, foreign exchange, mechanics of foreign exchange, GATT, WTO, role of WTO, International Trade in agriculture. World trade agreements related with food business, export trends and prospects of food products in India

Unit IV

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

Suggested Reading

- David D and Erickson S. 1987. Principles of Agri Business Management. Mc Graw Hill Book Co., New Delhi.
- Acharya SS and Agarwal NL. 1987. Agricultural Marketing in India. Oxford & ISH Publishing Co., New Delhi.
- Cundiff Higler. 1993. Marketing in the International Environment, Prentice Hall of India, New Delhi.
- Batra GS and Kumar N. 1994. GAD Implications of Denkel Proposals - Azmol Publications Pvt., New Delhi.
- Phill Kotler. 1994. Marketing Management - Prentice Hall of India, New Delhi

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

Theory

Unit I

Food safety management systems and its requirements for any organization in the Restructured and Revised Syllabi of Post-graduate Programmes Vol. 4 540 food chain, Block chain concept, Global food safety initiative (GFSI), PAS 220, Prerequisite programs on food safety for food manufacturing, Audits: Introduction, objectives, documentation, responsibilities.

Unit II

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

Unit III

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

Unit IV

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

Suggested Reading

- Salazar E. 2013. Understanding Food Safety Management Systems: A Practical Approach to the Application of ISO-22000:2005, Create Space Independent Publishing Platform.
- ISO 22000 Standard Procedures for Food Safety Management Systems, 2008, Bizmanualz, Inc.
- Dillon M and Griffith C (ed). 2001. Auditing in the Food Industry - From Safety and Quality to Environmental and Other Audits, CRC Press
- Inteaz A. 2003. Food Quality Assurance: Principles and Practices, CRC Press
- Respective certification document

Course Syllabus and Content of Doctoral Degree in Food Process Engineering

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

Theory

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

Teaching Schedule Theory

| No. of Lectures | Topic | Weightage (%) |
|-----------------|---|---------------|
| 1-4 | Current trends in use of machinery and utilities | 6 |
| 5-8 | Utilities for production of indigenous food products, | 6 |
| 9-12 | Systems used in mass food production, | 10 |
| 13-16 | Codes and standards applicable, | 10 |
| 17-20 | Performance assessment, | 10 |
| 21-24 | Safety and hygiene requirement with respect to machine, | 10 |
| 25-28 | Products and operator, | 10 |
| 29-32 | Suitability and scale of automation, | 10 |
| 33-36 | Innovativeness in food machineries, | 10 |
| 37-40 | Environmentally friendly, | 10 |
| 41-44 | Ergonomics for food Machineries | 4 |
| 45-48 | Resource utilization and assessment | 4 |
| | Total | 100 |

Suggested Reading

- Myer K. 2013. Handbook of Farm, Dairy, and Food Machinery, 2e. Academic Press
- Hitzmann B. 2017. Measurement, Modeling and Automation in Advanced Food Processing. Springer
- Norton RL. 2003. Design of Machinery. McGraw-Hill
- Traitler H, Coleman B, Hofmann K. 2014. Food Industry Design, Technology and Innovation. Wiley-Blackwell.
- Piramuthu S and Zhou W. 2015. RFID and Sensor Network Automation in the Food Industry. Wiley-Blackwell.
- Holah J and Lelieveld H. 2011. Hygienic Design of Food Factories. Woodhead Publishing

FPE 602

Concentration and Drying Engineering

3(3+0)

Theory

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

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage (%) |
|-----------------|--|---------------|
| 1-12 | Recent development in concentration and drying processes, | 25 |
| 13-24 | Technologies and engineering - Concentration and Drying processes, | 25 |
| 25-36 | Concentration and Drying processes - Problem solving | 25 |
| 37-48 | Case studies - Concentration and Drying processes (industrial) | 25 |
| | Total | 48 |

Suggested Reading

- Anandharamakrishnan C and Padma IS. 2015. Spray Drying Techniques for Food Ingredient Encapsulation. Wiley-Blackwell
- Oetjen GW, Haseley P. 2018. Freeze-Drying, 3e. Wiley-VCH
- Krokida M. 2018. Thermal and Nonthermal Encapsulation Methods. CRC Press
- Anandharamakrishnan C. 2017. Handbook of Drying for Dairy Products. Wiley-Blackwell
- Zhang M, Bhandari B, Fang Z. 2017. Handbook of Drying of Vegetables and Vegetable Products. CRC Press
- Prakash O, Kumar A. 2017. Solar Drying Technology: Concept, Design, Testing, Modeling, Economics and Environment. Springer Singapore
- Karim A, Law CL. 2017. Intermittent and Nonstationary Drying Technologies: Principles and Applications. CRC Press
- Vasile M. 2016. Advances in Heat Pump-Assisted Drying Technology. CRC Press
- MengWai W. 2016. Computational Fluid Dynamics Simulation of Spray Dryers: An Engineer's Guide. CRC Press
- Rodrigues S. 2008. Advances in Fruit Processing Technologies. CRC Press
- Angela M and Meireles A. 2008. Extracting Bioactive Compounds for Food Products Theory and Applications. CRC Press
- Rivas EO. 2009. Processing Effects on Safety and Quality of Foods. CRC Press
- Lebovka NI, Vorobiev E, Cheimat F. 2012. Enhancing Extraction Processes in the Food

Theory

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

Practical

- Practice on UV-Visible, IR, Raman, & Mass spectroscopy. Practice on Fluorescence, Turbidimetric and related techniques. Practice on NMR/ESR spectroscopy.
- Practice on general and advanced chromatographic (HPLC, GC, Paper, TLC/HPTLC, Ion, Flash etc.) techniques.
- Practice on biological techniques such as Electrophoresis, PCR/RT-PCR, Immunoassays etc
- Practice on Immuno based analytical techniques such as ELISA & Lateral flow assay.
- Determination of common adherents, colour, flavours and composition using specified methods.
- Separation of selected biomolecules (protein, colour, amino acids, fat, colour, flavours, peptides, anti/ nutritional factors, casein etc) using different techniques.
- Gel-filtration of biomolecules.
- SDS gel electrophoresis and molecular weight determination.
- Measurement of size and zeta potential of colloidal solution or emulsion using dynamic light scattering/ particle size analyser.
- Practice on purification of selected biomolecules. Estimation of minerals using AAS.
- Determination of specific and non-specific antimicrobial factors of selected biomolecules.
- Determination of health benefits of selected biomolecules/ products. Correlation of offline with online assessment of selected parameters.
- Correlation among industrial, national and international methods of selected concerned parameters.

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage (%) |
|-----------------|---|---------------|
| 1-12 | Hands on experience on advance methods, equipment and instruments used for analysis of raw material, food products and confirmation of standards. | 70 |
| 13-16 | Offline and online assessment of food properties. | 30 |
| | Total | 100 |

Practicals

| Sr. No. | Topic | No. of Practical |
|-------------------------|--|------------------|
| 1. | Practice on UV-Visible, IR, Raman, & Mass spectroscopy. Practice on Fluorescence, Turbidimetric and related techniques. Practice on NMR/ESR spectroscopy. | 3 |
| 2. | Practice on general and advanced chromatographic (HPLC, GC, Paper, TLC/HPTLC, Ion, Flash etc.) techniques. | 3 |
| 3. | Practice on biological techniques such as Electrophoresis, PCR/RTPCR, Immunoassays etc | 2 |
| 4. | Practice on Immuno based analytical techniques such as ELISA & Lateral flow assay. | 2 |
| 5. | Determination of common adherents, colour, flavours and composition using specified methods. | 3 |
| 6. | Separation of selected biomolecules (protein, colour, amino acids, fat, colour, flavours, peptides, anti/ nutritional factors, casein etc) using different techniques. | 3 |
| 7. | Gel-filtration of biomolecules. | 2 |
| 8. | SDS gel electrophoresis and molecular weight determination. | 2 |
| 9. | Measurement of size and zeta potential of colloidal solution or emulsion using dynamic light scattering/ particle size analyser. | 3 |
| 10. | Practice on purification of selected biomolecules. Estimation of minerals using AAS. | 2 |
| 11. | Determination of specific and non-specific antimicrobial factors of selected biomolecules. | 2 |
| 12. | Determination of health benefits of selected biomolecules/ products. Correlation of offline with online assessment of selected parameters. | 3 |
| 13. | Correlation among industrial, national and international methods of selected concerned parameters. | 2 |
| Total Practicals | | 32 |

Suggested Reading

- Boziaris IS. 2014. Novel Food Preservation and Microbial Assessment Techniques. CRC Press

Theory

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

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage (%) |
|-----------------|---|---------------|
| 1-3 | Recent development in handling and storage. | 6 |
| 4-6 | Bulk storage structure, | 6 |
| 7-11 | Silos – types and design considerations & specifications | 15 |
| 12-18 | Cold storages – Design & utilization | 15 |
| 19-25 | CA storages - Design & utilization , | 10 |
| 26-30 | Modified atmosphere storage - Design & utilization | 10 |
| 31-36 | Transportation and cold chain systems, | 10 |
| 37-39 | Handling and storage low and ambient temperatures, during supply chain, | 10 |
| 40-42 | Codes and standards – Storage equipments , | 10 |
| 42-44 | Problem solving – Design of Storage structure | 4 |
| 45-48 | Case studies –Different types of Storage structures | 4 |
| | Total | 100 |

Suggested Reading

- Guineè RPF, Correia PMR. 2013. Engineering Aspects of Cereal and Cereal-based Products. Taylor & Francis
- Mascheroni RH. 2012. Operations in Food Refrigeration. CRC Press
- Farid MM. 2010. Mathematical Modeling of Food Processing. CRC Press
- Teixeira JA and Vicente AK. 2014. Engineering Aspects of Food Biotechnology. CRC Press
- Varzakas T, Tzia C. 2014. Food Engineering Handbook. CRC Press
- Saravacos GD, Maroulis ZB. 2011. Food Process Engineering Operations. CRC Press
- Ron BH Wills, Golding JB. 2015. Advances in Postharvest Fruit and Vegetable Technology. CRC Press
- Petr D, Marilyn R. 2015. Engineering Aspects of Food Emulsification and Homogenization. CRC Press
- Constantina T, Theodoros V. 2016. Handbook of Food Processing: Food Safety, Quality, and Manufacturing Processes. CRC Press

Theory

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

Suggested Reading

- Caldwell DG. 2013. Robotics and Automation in the Food Industry: Current and Future Technologies. Woodhead Publishing
- Huang Y, Whittaker AD, Lacey RE. 2001. Automation for Food Engineering: Food Quality Quantization and Process Control. CRC Press
- Greeves T and Moore CA. 1995. Automation in the Food Industry. Springer
- Sandeep KP. 2011. Thermal Processing of Foods: Control and Automation. Wiley- Blackwell
- Derby SJ. 2005. Design of Automatic Machinery. Marcel Dekker
- Piramuthu S and Zhou W. 2015. RFID and Sensor Network Automation in the Food Industry. Wiley-Blackwell

Theory

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

Suggested Reading

- Lisnianski A, Frenkel I, Ding Y. 2010. Multi-state system reliability analysis and optimization for engineers and industrial managers.
- Huang Y, Whittaker AD, Lacey RE. 2001. Automation for Food Engineering: Food Quality Quantization and Process Control. CRC Press
- Haug EJ. 1984. Computer aided Analysis and Optimization of Mechanical System Dynamics. Springer
- Zin TT, Lin JCW. 2019. Big Data Analysis and Deep Learning Applications. Springer • Ratner B. 2011. Statistical and Machine-Learning Data Mining: Techniques for Better Predictive Modeling and Analysis of Big Data, 2e. CRC Press
- Erdogdu F. 2008. Optimization in Food Engineering. CRC Press

Theory

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

Suggested Reading

- Field RW, Molnar EB, Lipnizki F, Vatai G. 2017. Engineering Aspects of Membrane Separation and Application in Food Processing. CRC Press
- Holland CD. 1983. Computer Methods for Solving Dynamic Separation Problems. Mcgraw Hill
- Wankat PC. 2012. Separation Process Engineering, 3ed. Prentice Hall
- Sridhar S. 2019. Membrane Technology. CRC Press
- Rushton A, Ward AS, Holdich RG. 1996. Solid-Liquid Filtration and Separation Technology. Wiley-VCH
- Tewari PK. 2016. Nanocomposite Membrane Technology. CRC Press
- Basile A, Figoli A, Khayet M. 2015. Pervaporation, vapour permeation and membrane distillation: principles and applications. Woodhead Publishing

Theory

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

Suggested Reading

- Houška M, Vinagre Silva FVM. 2017. High Pressure Processing of Fruit and Vegetable Products. CRC Press
- Lebovka NI, Vorobiev E; Cheimat F. 2012. Enhancing Extraction Processes in the Food Industry. CRC Press
- Passos, and Ribeiro P. 2016. Innovation in Food Engineering: New Techniques and Products. CRC Press
- Tokusoglu O, Swanson BG. 2014. Improving Food Quality with Novel Food Processing Technologies. CRC, Taylor and Francis
- Koutchma T. 2014. Adapting High Hydrostatic Pressure (HPP) for Food Processing Operations. Academic Press
- Ojha KS, Tiwari BK. 2016. Novel Food Fermentation Technologies. Springer International Publishing
- Rahman MA, Mukhopadhyay SC, Yu PL. 2014. Novel Sensors for Food Inspection: Modelling, Fabrication and Experimentation. Springer International Publishing
- Boziaris IS. 2014. Novel Food Preservation and Microbial Assessment Techniques. CRC Press
- Angela A and Meireles A. 2008. Extracting Bioactive Compounds for Food Products Theory and Applications. CRC Press

Theory

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

Suggested reading

- Piringer OG, Baner AL. 2008. Plastic Packaging: Interactions with Food and Pharmaceuticals, 2e. Wiley-VCH
- Piringer OG and Baner AL. 2000. Plastic Food Packaging Materials: Barrier Function, Mass Transport, Quality Assurance, Legislation. Wiley-VCH
- Brody AL. 2001. Active Packaging for Food Applications. CRC Press
- Sun DW. 2000. Handbook of Frozen Food Processing and Packaging. CRC Press
- Angelo CM. 2015. Edible Food Packaging: Materials and Processing Technologies. CRC Press
- Robertson GL. 2009. Food Packaging and Shelf Life A Practical Guide. CRC Press
- Moskowitz HR, Reisner M, Lawlor JB, Deliza R. 2009. Packaging Research in Food Product Design and Development. Wiley-Blackwell
- RinusRijk and Veraart R. 2010. Global Legislation for Food Packaging Materials. Wiley- VCH
- Contemporary Food Engineering Series of CRC Press

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

Theory

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

Suggested Reading

- Gould GW. 2000. New Methods of Food Preservation, CRC Press.
- Barbosa-Canovas, 2002. Novel Food Processing Technologies, CRC Press.
- Dutta AK and Anantheswaran RC, 1999. Hand Book of Microwave Technology for Food Applications, CRC Press.
- Sun DW. 2015. Emerging Technologies for Food Processing, Elsevier Ltd.
- Kudra T and Mujumbar AS. 2009. Advanced Drying Technologies, CRC Press.
- Kilkast D and Subramaniam P. 2000. The Stability and Shelf Life of Food. CRC Press.
- Doona C J and Feeherry F E. 2007. High Pressure Processing of Foods. Blackwell Publishing Ltd.

Theory

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

Suggested Reading

- Herschdoerfer, SM. 1984. *Quality Control in the Food Industry*. Vol. 1 Academic Press.
- Herschdoerfer SM. 2012. *Quality Control in the Food Industry*. Vol. 2 Elsevier Science.
- Hubbard MR. 2003. *Statistical Quality Control for the Food Industry*. Springer.
- Mehmet M. 2011. *Biosensors in Food Processing, Safety, and Quality Control*. CRC Press.
- Palling SJ. 1980. *Developments in Food Packaging*. Applied Science Publisher.
- Sacharow S and Grittin RC. 1980. *Principles of Food Packaging*. AVI Publisher.
- Yanbo H, Whittaker AD and Lacey RE. 2001. *Automation for Food Engineering*. Food Quality Quantization and Process Control-CRC Press.

I Course Title : Formulation of standards of Food Products, Packaging and Labeling

II Course Code : FSQ 604

III Credit Hours : 2(2+0)

IV Theory :

Key requirements for successful product development, Managing and improving product development, Standards developments, testing of physical, chemical and microbial characteristics, clinical testing, toxicological evaluation of foods and validation of quality parameters. Packaging and labeling requirements of different foods, Labelling of Pre-packaged Foods, Nutritional information, USFDA regulations, FSSAI regulations, EU regulations, Codex regulations, Product specific requirements for packaging of different foods, “Health claims, Declaration regarding Food Additives, Specific Requirements/ Restrictions on manner of labelling

V Suggested Reading

- By Mary Earle, Richard Earle and Allan Anderson (2009). Food Product Development. Published by Woodhead Publishing Limited.
- USFDA regulations- <https://www.fda.gov/>
- FSSAI regulations- <https://www.fssai.gov.in/>
- EU regulations- https://food.ec.europa.eu/horizontal-topics/general-food-law_en
- Codex regulations.

| | | | |
|------------|---------------------|----------|---|
| I | Course Title | : | Food Process Modeling and Scale up |
| II | Course Code | : | FPT 605 |
| III | Credit Hours | : | 3 (3+0) |

IV Theory :

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

V Suggested Reading

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

Theory

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

Suggested Reading

- Rao ES. 2013. Food Quality Evaluation, Variety Books.
- Meilgard. 1999. Sensory Evaluation Techniques, CRC Press
- Maslowitz H. 2000. Applied Sensory Analysis of Foods. Vols. I, II. CRC Pres

Theory

Recent advances in active and intelligent packaging like Antimicrobial food packaging, Non-migratory bioactive polymers, Freshness indicator, Recycling, biodegradable packaging, Edible Films and Coatings, aseptic packaging, self heating and hydrate packages.

Suggested Reading

- Ahvenainen R. 2001. Novel Food Packaging Techniques, CRC Press.
- Rooney ML. 1988. Active Food Packaging, Chapman & Hall.
- Coles R and Kirwan M. 2011. Food and Beverage Packaging Technology, Wiley- Blackwell.
- Han J and Han J. 2005. Innovations in Food Packaging, Academic Press.
- Yam K and Lee D. 2012. Emerging Food Packaging Technologies, Woodhead Publishing.
- Mihindukulasuriya SDF and Lim LT. 2014. Nanotechnology Development in Food Packaging Review. Trends in Food Science and Technology, 149-167.
- Souza VGL and Fernando L. 2016. Nano-particles in Food Packaging- Biodegradability and Potential Migration to Food – A Review. Food Packaging and Shelf Life, 63-70

E Resources and List of Journals

| S.No | Titles | ISSN |
|------|---|-----------|
| 1 | Bioscience of Microbiota Food and Health | 2186-6953 |
| 2 | Comprehensive Reviews in Food Science and Food Safety | 1541-4337 |
| 3 | Critical Reviews in Food Science and Nutrition | 1040-8398 |
| 4 | Current Opinion in Food Science | 2214-7993 |
| 5 | Food Additives and Contaminants: Part A (Food Additives and Contaminants) | 1944-0049 |
| 6 | Food Additives and Contaminants: Part B (Food Additives and Contaminants) | 1939-3210 |
| 7 | Food Analytical Methods | 1936-9751 |
| 8 | Food Biophysics | 1557-1858 |
| 9 | Food Bioscience | 2212-4292 |
| 10 | Food Biotechnology | 0890-5436 |
| 11 | Food Chemistry | 0308-8146 |
| 12 | Food Control | 0956-7135 |
| 13 | Food Engineering Reviews | 1866-7910 |
| 14 | Food Microbiology | 0740-0020 |
| 15 | Food Packaging and Shelf Life | 2214-2894 |
| 16 | Food Quality and Preference | 0950-3293 |
| 17 | Food Research International | 0963-9969 |
| 18 | Food Reviews International | 8755-9129 |
| 19 | Food Science & Technology - Lebensmittel- Wissenschaft & Tech | 0023-6438 |
| 20 | Food Security | 1876-4517 |
| 21 | Food and Bioprocess Technology | 1935-5130 |
| 22 | Food and Bioproducts Processing | 0960-3085 |
| 23 | Food and Chemical Toxicology | 0278-6915 |
| 24 | Food and Function | 2042-6496 |
| 25 | Foodborne Pathogens and Disease | 1535-3141 |
| 26 | Foods | 2304-8158 |
| 27 | GM Crops & Food-Biotechnology in Agriculture and the Food Chain | 2164-5698 |
| 28 | Innovative Food Science and Emerging Technologies | 1466-8564 |
| 29 | International Journal of Food Engineering | 2194-5764 |
| 30 | International Journal of Food Microbiology | 0168-1605 |
| 31 | International Journal of Food Properties | 1094-2912 |
| 32 | International Journal of Food Science and Technology | 0950-5423 |
| 33 | Journal of Consumer Protection and Food Safety | 1661-5751 |
| 34 | Journal of Food Composition and Analysis | 0889-1575 |
| 35 | Journal of Food Engineering | 0260-8774 |
| 36 | Journal of Food Measurement and Characterization | 2193-4126 |

Food Process Engineering

| | | |
|----|---|-----------|
| 37 | Journal of Food Process Engineering | 0145-8876 |
| 38 | Journal of Food Quality | 0146-9428 |
| 39 | Journal of Food Safety | 0149-6085 |
| 40 | Journal of Food and Drug Analysis | 1021-9498 |
| 41 | Journal of Functional Foods | 1756-4646 |
| 42 | Journal of Medicinal Food | 1096-620X |
| 43 | Molecular Nutrition and Food Research | 1613-4125 |
| 44 | Nutrition | 0899-9007 |
| 45 | Nutrition Research | 0271-5317 |
| 46 | Nutrition Reviews | 0029-6643 |
| 47 | Nutrition Research Reviews | 0954-4224 |
| 48 | Plant Foods for Human Nutrition | 0921-9668 |
| 49 | Quality Assurance and Safety of Crops & Foods | 1757-8361 |
| 50 | Trends in Food Science and Technology | 0924-2244 |

Course Layout and Structure of Masters Degree in Food Safety and Quality

| Major Courses | | | |
|--|----------|---|-------------|
| Course Code | Semester | Course Title | Credit Hrs. |
| FSQ 501* | I | Techniques in Food Quality Analysis | 4 (2+2) |
| FSQ 502* | I | Microbiology of Food Spoilage and Pathogens | 3 (2+1) |
| FSQ 503 | II | Advanced Food Chemistry | 3 (2+1) |
| FSQ 504 | III | Global Food Laws and Regulations | 2 (2+0) |
| FSQ 506 | I | Process and Products Monitoring for Quality Assurance | 2 (2+0) |
| FSQ 507* | II | Quality Concepts and Chain Traceability | 2 (2+0) |
| FSQ 508 | II | Management of Food By-products and Waste | 3 (2+1) |
| FSQ 511 | III | Food Plant Utilities and Sanitation | 2 (2+0) |
| Optional Major courses are subjected to availability of infrastructure and facilities and to be decided by SAC committee of the student | | | |
| FSQ 505 | | Food Safety Management Systems and Certification | 3(2+1) |
| FSQ 509 | | Special Problem/ Summer Internship | 2(0+2) |
| FSQ 510 | | Toxicology of Food Ingredients and Products | 3(2+1) |
| Minor Courses | | | |
| FPT 502 | II | Emerging Technologies in Food Packaging | 2 (2+0) |
| FPT 503 | I | Industrial Manufacturing of Food and Beverages | 3 (2+1) |
| FPE 504 | I | Bioprocessing and Down Stream Engineering | 3 (2+1) |
| Optional Minor courses are subjected to availability of infrastructure and facilities and to be decided by SAC committee of the student from Food Processing Technology and Food Process Engineering | | | |
| FPT 504 | | Food Material and Product Properties | 3 (2+1) |
| FPT 514 | | Food Ingredients and Additives | 3 (2+1) |
| FPT 510 | | Aseptic Processing and Packaging | 3 (2+1) |
| FPE 502 | | Engineering Properties of Food Materials | 3(2+1) |
| FPE 506 | | Numerical Technique and Stimulation | 2(1+1) |
| FPE 508 | | Food Safety and Storage Engineering | 3(2+1) |
| Supporting courses | | Proposed | |
| FBM 501 | III | Post-Harvest Management | 3 (2+1) |
| FBM 502 | I | Food Business Management | 2 (2+0) |
| FBM 503 | II | Food Processing Entrepreneurship and Start up | 1 (0+1) |
| Optional supporting courses are subjected to availability of infrastructure and facilities and to be decided by SAC committee of the student from Basic sciences and Humanities and Food Process Engineering | | | |
| BSH 501 | | Research Methodology | 2(2+0) |
| BSH 502 | | Food Informatics | 2 (1+1) |
| FPE 510 | | Operation Research | 3 (2+1) |
| FPE 505 | | Energy Management and Auditing in Food Industry | 3 (2+1) |
| FSQ 591* | IV | Master's Seminar | 1(1+0) |
| | | | Total |
| | | | 36 (27+9) |
| FSQ 599* | III, IV | Master's Research | 30 (0+30) |

*Compulsory Courses

Minor and Supporting Courses

Minor Disciplines / Subjects

1. Food Processing Technology
2. Food Process Engineering
3. Post Harvest Management
4. Basic Sciences
5. Post Harvest Technology
6. Food Chemistry and Nutrition
7. Food Microbiology and Safety
8. Food Business Management
9. Food Plant Operations

Suggestive Minor Courses

| Minor Courses | | Proposed | |
|--|----|--|---------|
| FPT 502 | II | Emerging Technologies in Food Packaging | 2 (2+0) |
| FPT 503 | I | Industrial Manufacturing of Food and Beverages | 3 (2+1) |
| FPE 504 | I | Bioprocessing and Down Stream Engineering | 3 (2+1) |
| Optional Minor courses are subjected to availability of infrastructure and facilities and to be decided by SAC committee of the student from Food Processing Technology and Food Process Engineering | | | |
| FPT 504 | | Food Material and Product Properties | 3 (2+1) |
| FPT 514 | | Food Ingredients and Additives | 3 (2+1) |
| FPT 510 | | Aseptic Processing and Packaging | 3 (2+1) |
| FPE 502 | | Engineering Properties of Food Materials | 3(2+1) |
| FPE 506 | | Numerical Technique and Stimulation | 2(1+1) |
| FPE 508 | | Food Safety and Storage Engineering | 3(2+1) |

Supporting Disciplines

1. Food Processing Technology
2. Food Safety and Quality
3. Post Harvest Management
4. Food Chemistry and Nutrition
5. Food Microbiology and Safety
6. Food Business Management
7. Food Plant Operations

Suggestive Supporting Courses

| | | | |
|--|-----|---|---------|
| FBM 501 | III | Post-Harvest Management | 3 (2+1) |
| FBM 502 | I | Food Business Management | 2 (2+0) |
| FBM 503 | II | Food Processing Entrepreneurship and Start up | 1 (0+1) |
| Optional supporting courses are subjected to availability of infrastructure and facilities and to be decided by SAC committee of the student from Basic sciences and Humanities and Food Process Engineering | | | |
| BSH 501 | | Research Methodology | 2(2+0) |
| BSH 502 | | Food Informatics | 2 (1+1) |

| | | | |
|---------|--|---|---------|
| FPE 510 | | Operation Research | 3 (2+1) |
| FPE 515 | | Energy Management and Auditing in Food Industry | 3 (2+1) |

Compulsory Common PGS Courses (5 credits Non Credit):

| Course code | Semester | Course Title | Credits |
|-------------|----------|---|---------|
| PGS 501 | I | Library and Information Services | 0+1 |
| PGS 502 | I | Technical Writing and Communications Skills | 0+1 |
| PGS 503 | II | Intellectual Property and its management in Agriculture | 1+0 |
| PGS 504 | II | Basic Concepts in Laboratory Techniques | 0+1 |
| PGS 505 | II | Agricultural Research, Research Ethics and Rural Development Programmes | 1+0 |
| PGS 506 | III | Disaster Management | 1+0 |

Compulsory Non credit Deficiency Courses:

Students from non Food Science and Technology stream will be required to complete non credit deficiency courses (6 to 10 credits) from the below courses related to the discipline in which admitted and as decided by the Student Advisory Committee.

| Course Number | Course Name | Credits |
|---------------|-----------------------------------|---------|
| FPT-111 | Principles of Food Processing | 3 (2+1) |
| FPT-124 | Food Packaging Technology | 2 (1+1) |
| FPT-2410 | Fruits and Vegetables Processing | 3 (2+1) |
| FCN-235 | Food Chemistry and Micronutrients | 3 (2+1) |
| FMS-122 | Food Microbiology | 3 (2+1) |
| FBM-243 | ICT Application in Food Industry | 3 (1+2) |

Semester wise Layout and distribution of courses

| Semester | Course | Course No | Title | Credits |
|--------------------|--------------------|--------------------|---|-------------------------|
| Semester-I | Major Courses | FSQ 501 | Techniques in Food Quality Analysis* | 4 (2+2) |
| | | FSQ 502 | Microbiology of Food Spoilage and Pathogens* | 3 (2+1) |
| | | FSQ 506 | Process and Products Monitoring for Quality Assurance | 2 (2+0) |
| | Minor courses | FPT 503 | Industrial Manufacturing of Food and Beverages | 3 (2+1) |
| | | FPE 504 | Bio-processing and Down Stream Engineering | 3 (2+1) |
| | Supporting courses | FBM 502 | Food Business Management | 2 (2+0) |
| | Common Courses | PGS 501 | Library and Information Services | 1(0+1) |
| | | PGS 504 | Basic Concepts in Laboratory Techniques | 1(0+1) |
| | | | Grand Total | 19(12+7) |
| | Semester - II | Major Courses | FSQ 503 | Advanced Food Chemistry |
| FSQ 507 | | | Quality Concepts and Chain Traceability* | 2 (2+0) |
| FSQ 508 | | | Management of Food By-products and Waste | 3(2+1) |
| Minor courses | | FPT 502 | Emerging Technologies in Food Packaging | 2 (2+0) |
| Supporting courses | | FBM 503 | Food Processing Entrepreneurship and Start up | 1 (0+1) |
| Common Courses | | PGS 502 | Technical Writing and Communications Skills | 1 (1+0) |
| | | PGS 503 | Intellectual Property and its Management in Agriculture | 1 (0+1) |
| | | Grand Total | 13 (9+4) | |
| Semester - III | Major Courses | FSQ 504 | Global Food Laws and Regulations | 2 (2+0) |
| | | FSQ 511 | Food Plant Utilities and Sanitation | 2 (2+0) |
| | Minor courses | - | - | - |
| | Supporting courses | FBM 501 | Post-Harvest Management | 3 (2+1) |
| Research work | FSQ 599 | Research work | 10 (0+10) | |

Food Safety and Quality

| | | | | |
|---------------|----------------|---------|--|------------------|
| | Common Courses | PGS 505 | Agricultural Research, Research Ethics and Rural Development Programme | 1 (1+0) |
| | | | Grand Total | 18 (7+11) |
| Semester - IV | Seminar | FSQ 591 | Masters Seminar | 1 (1+0) |
| | Research work | FSQ 599 | Masters Research work | 20 (0+20) |
| | | | Grand Total | 21 (1+20) |

ABSTRACT

| Course Credits | | | | | | | |
|----------------|-----------|----------|------------|----------|----------|---------------|-----------|
| Semester | Major | Minor | Supporting | Seminar | PGS | Research Work | Total |
| I | 9 | 6 | 2 | - | 2 | - | 19 |
| II | 8 | 2 | 1 | - | 2 | - | 13 |
| III | 4 | - | 3 | - | 1 | 10 | 18 |
| IV | - | - | - | 1 | - | 20 | 21 |
| Total | 21 | 8 | 6 | 1 | 5 | 30 | 71 |

Course Layout and Structure of Doctoral Degree in Food Safety and Quality

| Major Courses | | | |
|--|-----------|--|-------------|
| Course Code | Semester | Course Title | Credit Hrs. |
| FSQ 601 | I | Food Quality and Safety Assessment | 3 (1+2) |
| FSQ 602 | I | Food Toxicology and Risk Assessment | 3 (3+0) |
| FSQ 605 | II | Food and Nutraceutical Chemistry | 3 (3+0) |
| FSQ 606 | II | Food Microbiology and Safety | 3 (3+0) |
| Optional Major courses are subjected to availability of infrastructure and facilities and to be decided by SAC committee of the student | | | |
| FSQ 603 | | Quality Assurance in Food Supply Chain | 3(3+0) |
| FSQ 604 | | Formulation of standards of Food Products, Packaging and Labelling | 2(2+0) |
| FSQ 607 | | Sensory Evaluation of Foods | 2(2+0) |
| FSQ 608 | | Special problem | 2(0+2) |
| Minor Courses | | | |
| FPT 601 | I | Novel Technologies for Food Processing and Shelf-Life Extension | 3 (3+0) |
| FPE 606 | II | Food Handling and Storage Engineering | 3 (3+0) |
| Optional Minor courses are subjected to availability of infrastructure and facilities and to be decided by SAC committee of the student from Food Processing Technology and Food Process Engineering | | | |
| FPT 605 | | Food Process Modeling and Scale up | 3 (3+0) |
| FPE 602 | | Concentration and Drying Engineering | 3(3+0) |
| Supporting courses | | | |
| FPE 605 | I | Food Analytical Techniques | 3 (1+2) |
| FSQ 607 | III | Sensory Evaluation of Foods | 2 (2+0) |
| FSQ 691* | III | Doctoral Seminar I | 1(0+1) |
| FSQ 692* | IV | Doctoral Seminar II | 1(0+1) |
| | | Total | 25(19+6) |
| FSQ 699* | IV, V, VI | Doctoral Research | 75(0+75) |

*Compulsory Courses

Semester wise Layout and distribution of courses

| Semester I | | |
|---------------------------|--|---------------------|
| Course Code | Course Title | Credit Hours |
| Major Courses | | |
| FSQ 601 | Food Quality and Safety Assessment | 3 (1+2) |
| FSQ 602 | Food Toxicology and Risk Assessment | 3 (3+0) |
| Minor Courses | | |
| FPT 601 | Novel Technologies for Food Processing and Shelf- Life Extension | 3 (3+0) |
| Supporting Courses | | |
| FPE 605 | Food Analytical Techniques | 3 (1+2) |
| Grand Total | | 12(8+4) |
| Semester II | | |
| Major Courses | | |
| FSQ 605 | Food and Nutraceutical Chemistry | 3 (3+0) |
| FSQ 606 | Food Microbiology and Safety | 3 (3+0) |
| Minor Courses | | |
| FPE 606 | Food Handling and Storage Engineering | 3 (3+0) |
| Supporting Courses | | |
| Grand Total | | 9(9+0) |
| Semester III | | |
| Major Courses | | |
| - | - | - |
| Minor Courses | | |
| - | - | - |
| Supporting Courses | | |
| FSQ 607 | Sensory Evaluation of Foods | 2 (2+0) |
| FSQ 691 | Doctoral Seminar-I | 1 (0+1) |
| Research Work | | |
| - | - | - |
| Grand Total | | 03 (2+1) |
| Semester IV | | |
| FSQ 692 | Doctoral Seminar-II | 1 (0+1) |
| FSQ 699 | Doctoral Research | 25 (0+25) |
| Grand Total | | 26 (0+26) |
| Semester V | | |
| FSQ 699 | Doctoral Research | 25 (0+25) |
| Grand Total | | 25 (0+25) |
| Semester VI | | |
| FSQ 699 | Doctoral Research | 25 (0+25) |
| Grand Total | | 25 (0+25) |

ABSTRACT

Course Credits

| Semester | Major | Minor | Supporting | Seminar | Research Work | Total |
|--------------|-------|-------|------------|---------|---------------|-------|
| I | 6 | 3 | 3 | - | - | 12 |
| II | 6 | 3 | - | - | - | 09 |
| III | - | - | 2 | 1 | - | 03 |
| IV | - | - | - | 1 | 25 | 26 |
| V | - | - | - | - | 25 | 25 |
| VI | - | - | - | - | 25 | 25 |
| Total | 12 | 6 | 5 | 2 | 75 | 100 |

Course Syllabus and Content of Masters Degree in Food Safety and Quality

I Course Title : Techniques in Food Quality Analysis*

II Course Code : FSQ 501

III Credit Hours : 4(2+2) IV

IV Theory :

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

V Practical :

- Analysis and characterization of pigment in fruits by UV-VIS.
- Characterization of starches by FTIR spectroscopy.
- Assessment of microstructure of food components by SEM/Reviewing a micrograph obtained through SEM
- Study of thermal denaturation of proteins and food enzymes by DSC.
- Quantization of allergenic proteins by LCMS
- Separate and identification of pesticides in food samples by HPLC.

- Identification and molecular characterization of proteins by SDS-PAGE.
- Quantization of lipids and fatty acids using TLC.
- Assessment of pasting properties of starches and flours/flour-blends using RVA.
- Analysis of textural properties of food products with texture analyzer.
- Comparative rheological study of wheat flour samples of different varieties.
- Differential thermal analysis (DTA) and Thermogravimetric Analysis of a food samples
- A rapid, visual demonstration of protein separation by gel filtration chromatography.
- Amino acid profiling of food samples

Teaching Schedule

Theory

| No. of Lecture | Topic | Weightage |
|----------------|---|-------------|
| 1-4 | Sampling Procedures, Calibration and Standardization: Sub- sampling and its procedures, LOD, LOQ, Internal standards, Reference standards and certified reference materials | 12.0% |
| 5-7 | Spectroscopy techniques: Operation, calibration and standardization procedures as applicable to particular technique | 10.0% |
| 8-9 | Principles and applications of pH Meter, Digital analyzer, Auto-analyzer, | 6.0% |
| 10-13 | Ultraviolet-visible spectroscopy (UV-VIS), Infra-Red, Fourier-Transform Infrared Spectroscopy (FTIR), Near Infra-Red (NIR), Atomic Absorption spectroscopy (AAS). | 15.0% |
| 14-19 | Chromatography Techniques: Principles, Components and applications of (i) Paper Chromatography-Ascending and Descending-One dimensional & Two dimensional (ii) Thin layer chromatography (iii) Ion Exchange (iv) GC (v) GLC (vi) HPLC (vii) HPTLC (viii) GCMS (ix) LCMS (x) Amino acid Analyzer. | 18.0% |
| 20-23 | Separation Techniques: Dialysis, Gel filtration, Electrophoresis: Principles, components and applications of (i) Paper (ii) Starch (iii) Gel (iv) Agar-gel (v) Polyacrylamide gel (vi) Moving boundary (vii) Immuno electrophoresis | 10.0% |
| 24-29 | Principle, Components and Applications of (i) Differential scanning calorimetry (DSC) (ii) Thermogravimetric analysis (TGA) (iii) Isothermal microcalorimetry (IMC) (iv) Thermomechanical analysis (TMA) (v) Isothermal titration calorimetry (ITC) (vi) Dynamic elemental thermal analysis (DETA) (vii) Nuclear magnetic resonance (NMR) (viii) Scanning electron microscopy (SEM) (ix) Transmission electron microscopy (TEM) (x) X-ray diffraction technique (XRD) | 20% |
| 30 | (xi)Rapid visco-analyzer | 3.0% |
| 31-32 | (xii) Texture analyzer and (xiii) Micro-dough lab | 6.0% |
| | Total | 100% |

Practical

| Sr. No. | Topic | No. of Practical (s) |
|---------|--|----------------------|
| 1. | Analysis and characterization of pigment in fruits by UV-VIS. | 3 |
| 2. | Characterization of starches by FTIR spectroscopy | 2 |
| 3. | Assessment of microstructure of food components by SEM/ Reviewing a micrograph obtained through SEM | 2 |
| 4. | Study of thermal denaturation of proteins and food enzymes by DSC | 2 |
| 5. | Quantization of allergenic proteins by LCMS | 2 |
| 6. | Separate and identification of pesticides in food samples by HPLC | 3 |
| 7 | Identification and molecular characterization of proteins by SDS-PAGE | 2 |
| 8 | Quantization of lipids and fatty acids using TLC. | 3 |
| 9 | Assessment of pasting properties of starches and flours/flour-blends using RVA | 2 |
| 10 | Analysis of textural properties of food products with texture analyzer | 2 |
| 11 | Comparative rheological study of wheat flour samples of different varieties | 2 |
| 12 | Differential thermal analysis (DTA) and Thermogravimetric Analysis of a food samples | 2 |
| 13 | A rapid, visual demonstration of protein separation by gel filtration chromatography | 2 |
| 14 | Amino acid profiling of food samples | 3 |
| | Total | 32 |

VI Suggested Reading

- Ongkowijoyo P, Luna-Vital DA, de Mejia EG. 2018. Extraction Techniques and Analysis of Anthocyanins from Food Sources by Mass Spectrometry: An Update Food chemistry.
- Trimigno A, Maricola FC, Dellarosa N, Picone G and Laghi L. 2015. Definition of Food quality by NMR-based Foodomics, Current Opinion in Food Science 4:99- 104.
- Pare JRJ and Bélanger JMR. 2015. Instrumental Methods of Food Analysis: Elsevier.
- Cifuentes A. 2012. Food Analysis: Present, Future, and Foodomics, ISRN Analytical Chemistry.
- Skoog DA, Holler FJ and Nieman TA. 1998. Principles of Instrumental Analysis (5 Ed.):

| | | | |
|------------|---------------------|----------|--|
| I | Course Title | : | Microbiology of Food Spoilage and Pathogens |
| II | Course Code | : | FSQ 502 |
| III | Credit Hours | : | 3 (2+1) |

IV Theory :

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

V Practical :

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

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage |
|-----------------|---|-------------|
| 1-7 | Food Borne Pathogens, Host Invasion, Pathogenesis, Significance to public health Food hazards and risk factors, Pathogenic food borne microorganisms – Salmonella, Pathogenic Escherichia coli and other enterobacteriaceae, Staphylococcus aureus, Listeria monocytogenes, Clostridium botulinum, Clostridium perfringens and Bacillus cereus Other Gram-positive pathogens, Campylobacter, Brucella, Aeromonas, Vibrio cholerae, Mycobacterium, Shigella. | 25.0% |
| 8-11 | Fungal and viral food-borne disorders, Food-borne important animal parasites, Mycotoxins, Incidence and behavior of microorganisms in meat, poultry, milk and milk products, fresh agro produce, sea foods | 12.0% |
| 12-17 | Controlling pathogens and microbial toxin via food processing, Microbial growth and shelf life, Modeling of microbial growth, Safety concerns of food processed through non thermal processing, management of microbial risk and toxin in foods through HACCP, Risk in antimicrobial nano materials, Risk assessment and predictive Modeling | 20.0% |
| 18-21 | Molecular approaches for detection and identification of food borne pathogens, Enzyme Immunoassay (EIA), Enzyme-linked immunosorbent assay (ELISA), Radioimmunoassay (RIA) - instrumentation and applications of each immunoassay technique | 15.0% |
| 22-24 | DNA: DNA purification, DNA Fingerprinting. PCR/RT-PCR (Real time) based analysis and sequencing | 6.0% |
| 25-26 | Biosensors | 6.0% |
| 27-28 | Recombinant DNA technology | 6.0% |
| 29-32 | Microchip based techniques, cDNA and genomic libraries, immunochemical techniques. | 10.0% |
| | Total | 100% |

Practical

| Sr. No. | Topic | No. of Practicals |
|---------|---|-------------------|
| 1. | Preparation of common laboratory media and special media for cultivation of bacteria, yeast & molds. | 2 |
| 2. | Isolation and identification of pathogens | 1 |
| 3. | Coliforms analysis of milk and water samples. | 2 |
| 4. | Identification tests for bacteria in foods: IMVIC urease, catalase, coagulase, gelatin and fermentation (acid/gas). | 1 |
| 5. | Determination of thermal death characteristics of bacteria | 1 |
| 6. | Determination of DNA and RNA of spoilage microorganism using PCR. | 2 |
| 7 | Detection of DNA of trace components allergens, like nuts using ELISA. | 1 |
| 8 | DNA/RNA based microarray experiment. | 1 |

| | | |
|----|--|----|
| 9 | Demonstration of DNA fingerprinting. | 1 |
| 10 | Determination of growth and activity of microorganisms in incubator. | 1 |
| 11 | Determination of preservatives and food colours using Biosensor. | 1 |
| 12 | Process time calculation for an indicator organism | 1 |
| 13 | Microbes responsible recall – case studies. | 1 |
| | Total | 16 |

VI Suggested Reading

- Ray B and Bhunia A. 2007. Fundamental Food Microbiology, 4th Ed. CRC Press, Boca Ratan, FL.
- Food and Drug Administration. Food-Borne Pathogenic Microorganisms and Natural Toxins Handbook: The Bad Bug Book.
- Fratamico PM, Bhunia AK and Smith JL. 2005. Food-Borne Pathogens: Microbiology and Molecular Biology. Caister Academic Press.
- Juneja VK, Dwivedi HR and ofos JN. (Eds) 2017, Microbial Control and Food Preservation - Theory and Practice, Springer
- Schmidt RH and Rodrick GE. 2013 Food Safety Handbook Wiley

| | | | |
|------------|---------------------|----------|--------------------------------|
| I | Course Title | : | Advanced Food Chemistry |
| II | Course Code | : | FSQ 503 |
| III | Credit Hours | : | 3 (2+1) |

IV Theory :

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

V. Practicals

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

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

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage |
|-----------------|--|------------|
| 1-2 | Composition, nutritional and functional value of food | 6.0% |
| 3-6 | Water activity and sorption phenomenon, Engineered foods and influencing water activity and shelf-life; Chemical reactions of carbohydrates–oxidation, reduction, with acid & alkali; Maillard reaction, Caramelization, Ascorbic acid oxidation | 10.0% |
| 7 | Resistant Starch, Soluble and Insoluble fibre | 3.0% |
| 8-9 | Pigments and approaches to minimize the impact of food processing, Molecular Mobility | 7.0% |
| 10-13 | Structure and Properties of proteins; electrophoresis, sedimentation, amphoterism, denaturation, viscosity, gelation, texturization, emulsification, foaming, protein-protein and other interactions in food matrix; | 13.0% |
| 14-18 | Lipids: melting point, softening point, smoke, flash and fire point, turbidity point, polymorphism and polytypism; polymerization and polymorphism, flavor reversion, auto-oxidation and its prevention, fat in food matrix like fat globule in milk, PUFA, MUFA, CLA, ω -fatty acids, trans fatty acids, phytosterol, etc. | 18.0% |
| 19-24 | Description of food flavours; Flavour enhancers, Food acids their tastes and flavours, Principles and techniques of flavour encapsulation, types of encapsulation; Factors affecting stabilization of encapsulated flavour and their applications in food industry | 15.0% |
| 25-32 | Processing and packaging induced chemicals and their control acrylamide, nitrosamines, carcinogenic and genotoxic chloropropanols such as 3- monochloropropane-1, 2-diol (3-MCPD), PAHs (in grilled and smoked products), dioxine, histamine, ethyl carbamate, furan, bisphenol A or phthalates from plastic materials, microplastics, 4-methylbenzophenone and 2-isopropylthioxanthone from inks, mineral oil from recycled fibres or semicarbazide from a foaming agent in the plastic gasket. | 28.0% |
| Total | | 100 |

Practical

| Sr. No. | Topic | No. of Practicals |
|--------------|---|-------------------|
| 1. | Estimation of protein content in food samples using spectroscopic methods | 1 |
| 2. | Study of effect of heat on protein denaturation using enzymes | 1 |
| 3. | Study of effect of various salt solutions on solubility of proteins | 1 |
| 4. | Separation of milk proteins by salting out method | 1 |
| 5. | Separation of proteins using chromatographic methods | 1 |
| 6. | Fractionation of proteins | 1 |
| 7 | Extraction and purification of essential oil/ flavouring compound of a natural source | 1 |
| 8 | Study the process of starch retrogradation, gelatinization and modification | 1 |
| 9 | Estimation of crude and dietary fibres in given food sample | 1 |
| 10 | Analysis of resistant starches | 1 |
| 11 | Estimation of various antioxidants, polar compounds and free fatty acids in frying oils | 1 |
| 12 | Extraction and purification of natural plant pigment | 2 |
| 13 | Functional properties and isoelectric point of proteins | 1 |
| 14 | Qualitative and quantitative evaluation of processing and packaging induced chemicals | 1 |
| 15 | Qualitative identification of different flavouring compounds | 1 |
| Total | | 16 |

VI Suggested Reading

- Fennema OR, Ed., 2008. Food Chemistry, Marcel and Dekker, Inc., New York, NY.
- Belitz HD, Grosch W and Schieberle P. 2009. Food Chemistry. Springer.
- Varelis P, Melton L and Shahidi F. 2019. Encyclopedia of Food Chemistry. Elsevier.
- Cheung P, Mehta CK and Bhavbhuti M. 2015. Handbook of Food Chemistry. Springer

I Course Title : Global Food Laws and Regulations
II Course Code : FSQ 504
III Credit Hours : 2 (2+0)

IV Theory :

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage |
|-----------------|--|-----------|
| 1-3 | International Plant Protection Convention, world organization for animal health (OIE), sanitary and phytosanitary measures (SPS), Codex Alimentarius, FAO LEXO ECD Agriculture and Fisheries, International Trade Centre’s Standards Map | 10.0% |
| 4-5 | FAO Food safety and quality emergency Prevention, JFSCA, Fundamental Principles of food safety governance | 6.0% |
| 6-7 | Risk Analysis as a Method to Determine the Regulatory Outcome, Increasing Responsibility of Businesses (Private) Risk Assessors, Concept of harmonization of global food laws. | 6.0% |

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|--------------|--|-------------|
| 8-10 | EU Food Safety Standards - Regulation 178 of 2002, The European food safety authority (EFSA), A critical overview of the EU food safety policy and standards, COMESA Food Safety Standards – An overview, Case Studies in Food Safety Standards in EU-COMESA Trade, Private voluntary standards (PVS) and EU food safety standards | 10.0% |
| 11-14 | FDA Food safety modernization Act (FSMA), FSPCA Preventive Controls for Human Food, Foreign Supplier Verification Programs (FSVP), Food Facility Registration, FDA - Current Good Manufacturing Practices (CGMPs). | 15.0% |
| 15-16 | Hazard Analysis & Critical Control Points (HACCP) guidelines, Foreign Food Facility Inspection Program, International and Interagency Coordination | 7.0% |
| 17-19 | Registration of Food Facilities, Seafood Imports and Exports, Regulation on GM Foods, Regulations on Irradiated foods, Global Regulations on Health Foods | 10.0% |
| 20-23 | International Law on Adequacy of thermal processing, Grain Fumigation for Export, Law of trading horticultural Products, Safety Frame Applied to Food Applications of Nanotechnology. | 10.0% |
| 24-26 | Review of Indian Regulatory Scenario in Food and Food Products - Food Safety and Standards (FSS) Act, 2006, FSS Rules and Regulations | 9.0% |
| 26-27 | Agricultural Produce Act, 1937 (Grading and Marketing), Export (Quality Control & Inspection), Act, 1963 and Rules | 6.0% |
| 29-30 | Bureau of Indian Standards relevant to food safety | 6.0% |
| 31 | Legal Metrology Act | 3.0% |
| 32 | International Food Control Systems/ Laws | 5.0% |
| Total | | 100% |

VI Suggested Reading

- Osiero O. 2018. Food Safety Standards in International Trade: The Case of the EU and the COMESA, CRC
- Villarreal AM. 2018. International Standardization and the Agreement on Technical Barriers to Trade, Cambridge University Press
- Meulen B, Bremmers H, Purnhagen K, Gupta N, Bouwmeester HL and Geyer L. 2014. *Understanding Nano Foods: Principles-Based Responsive Regulation*
- *Understanding the Codex Alimentarius*, 3rd ed., 2006.
- Vapnek J and Spreij M. 2005. *Perspectives and Guidelines on Food Legislation, with a new model food law for the Development Law Service* FAO Legal Office
- US FDA Website
- European Food Safety Authority (EFSA) website
- FSSAI website

- I Course Title : Process and Products Monitoring for Quality Assurance**
- II Course Code : FSQ 506**
- III Credit Hours : 2 (2+0)**

IV Theory :

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage |
|-----------------|--|-------------|
| 1-6 | Variability of the Production Process - Control chart of the middle values and ranges, Medians and ranges, Middle values and standard deviations | 20% |
| 7-10 | Largest and smallest selected value and other individual values | 10.0% |
| 11-16 | Automation of the Control of Production Processes, fluorescence cytometry for the rapid analysis of food microorganisms, Infrared spectroscopic methods. | 20.0% |
| 17-20 | Machine vision for the food industry, Ultrasonic methods, Sampling procedures for on line quality | 13.0% |
| 21-23 | Evaluation the Capability of Production Process and Machine | 10.0% |
| 24-25 | Chemical sensors | 7.0% |
| 26-28 | RFID | 7.0% |
| 29-32 | Analysis of the Current State of the Regulation of Manufacturing Processes | 13.0% |
| Total | | 100% |

V Suggested Reading

- Rodríguez MEP. 2018. Process Monitoring and Improvement Handbook, Second Edition 2018 by ISBN: 978-0-87389-974-1
- Food Process Monitoring Systems 1993, Springer

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|------------|---|----------|--|
| I | Course Title | : | Quality Concepts and Chain Traceability |
| II | Course Code | : | FSQ 507 |
| III | Credit Hours | : | 2 (2+0) |
| IV | Theory | : | |
| | <p>Unit I Quality – Concepts, Quality as winning strategy, Total quality management TQM: Introduction, definitions and principles of operation, Tools and Techniques, such as, quality circles, 5 S Practice, Total quality control (TQC), Total employee involvement (TEI), Problem solving process, Quality function deployment (QFD), Failure mode and effect analysis (FMEA), Fault Tree Analysis (FTA), Kizen, Poka- Yoke, QC Tools, PDCA Cycle, Quality Improvement Tools, TQM implementation and limitations, JH – Autonomous maintenance</p> <p>Unit II Introduction, Content, Methods, Advantages and Limitation of: Just –in –Time and Quality Management KANBAN system, Total productive maintenance (TPM), QS 9000. Basic concept, Principle, methodology of contemporary trends: Lean manufacturing, Agile manufacturing, World class manufacturing, Concurrent engineering, Bench marking, Cost of quality (COQ) system.</p> <p>Unit III Reliability engineering fundamentals; Failure data analysis; Failure rate; mortality curve; Concept of burn in period; Useful life and wear out phase of a system; Mean time to failure (MTTF); Mean time between failure, (MTBF) and mean time to repair (MTTR); Reliability in terms of Hazard rate and failure density, Measurement systems analysis for accuracy, Probability for quality.</p> <p>Unit IV SQC -Statistical quality control– X/ R/ p and c chart, Shewhart and types of control charts, Process capability analysis, process capability index. Acceptance sampling by variables and attributes, design of sampling plans, single, double, sequential and continuous sampling plans, design of various sampling plans for food industry (Note:SQC tables can be used in the examination), Capability analysis. Statistical process control.</p> <p>Unit V Traceability in food safety management, Applications of traceability, Traceability challenges, Traceability requirements and standards: ISO 22005, Traceability implementation & application: Traceability data & process flow, Traceability process participants, Traceable item, Batch/Lot and Traceability links management, Food authenticity tools.</p> | | |

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage |
|-----------------|--|-------------|
| 1-3 | Quality – Concepts, Quality as winning strategy, Total quality management TQM: Introduction, definitions and principles of operation, Tools and Techniques, such as, quality circles, 5 S Practice, Total quality control (TQC), Total employee involvement (TEI) | 9.0% |
| 4-5 | Problem solving process, Quality function deployment (QFD), Failure mode and effect analysis (FMEA), Fault Tree Analysis (FTA), Kizen, Poka- Yoke, QC Tools, PDCA Cycle, | 6.0% |
| 6-7 | Quality Improvement Tools, TQM implementation and limitations, JH – Autonomous maintenance | 7.0% |
| 8-10 | Introduction, Content, Methods, Advantages and Limitation of: Just –in –Time and Quality Management KANBAN system | 9.0% |
| 11-14 | Total productive maintenance (TPM), QS 9000. Basic concept, Principle, methodology of contemporary trends: Lean manufacturing, Agile manufacturing, World class manufacturing, Concurrent engineering, Bench marking, Cost of quality (COQ) system. | 15.0% |
| 15-16 | Reliability engineering fundamentals; Failure data analysis; Failure rate; mortality curve; Concept of burn in period | 6.0% |
| 17-19 | Useful life and wear out phase of a system; Mean time to failure (MTTF); Mean time between failure, (MTBF) and mean time to repair (MTTR); Reliability in terms of Hazard rate and failure density, Measurement systems analysis for accuracy, Probability for quality | 12.0% |
| 20-23 | SQC -Statistical quality control– X/ R/ p and c chart, Shewhart and types of control charts, Process capability analysis, process capability index. Acceptance sampling by variables and attributes, design of sampling plans, single, double, sequential and continuous sampling plans, design of various sampling plans for food industry (Note: SQC tables can be used in the examination | 12.0% |
| 24-26 | Capability analysis | 6.0% |
| 27-28 | Statistical process control. | 6.0% |
| 29-30 | Traceability in food safety management, Applications of traceability, Traceability challenges, Traceability requirements and standards: ISO 22005 | 6.0% |
| 31-32 | Traceability implementation & application: Traceability data & process flow, Traceability process participants, Traceable item, Batch/Lot and Traceability links management, Food authenticity tools. | 6.0% |
| | Total | 100% |

V Suggested Reading

- Montgomery, Jennings and Pfund. 2010. Managing, Controlling and Improving Quality, Wiley
- Arora KC. 2016 (4th Edition). Total Quality Management, S K Kataria & Sons Pub
- Grant EL and Leavenworth RS. 1996., 7th Ed 1996, Statistical Quality Control, McGraw- Hill

| | | | |
|------------|---------------------|----------|---|
| I | Course Title | : | Management of Food By-products and Waste |
| II | Course Code | : | FSQ 508 |
| III | Credit Hours | : | 3 (2+1) |

IV Theory :

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

V Practicals

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

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage |
|-----------------|--|------------|
| 1-5 | Management of Food Waste, Principles of sustainable systems and Green chemistry, Waste management purpose and strategies, Waste & its consequences in pollution and global warming | 15.0% |
| 6-9 | Food waste classification, Mitigation measures for food processing wastes, Food waste Handling and Management laws – National and international. | 12.0% |
| 10-15 | Approaches to Solid Waste Management - Bio gas and electricity generation, Bioactive compounds extraction, Sourcing natural colour, Valorization, Biofueling, Biofertilizers, Bio-ethanol, Activated carbon, Biochar, other biological approaches, Use for biodegradable plastic, biofertilizers and environmental bioremediation. | 20.0% |
| 16-18 | Approaches to Effluent Waste Management Basic unit operations in wastewater treatment, Anaerobic digestion of organic residues and wastes | 10.0% |
| 19-24 | Fundamentals and applications of anaerobic digestion for sustainable treatment of food industry wastewater, Effluent treatment strategies for dairy/ brewery/ winery, Common biological treatment processes and on-site treatment systems. | 20.0% |
| 25-30 | Case studies, commercially viable practices and success stories of value added products of waste and by-products from processing of different plant and animal food products. | 20.0% |
| 31-32 | Food waste for pulp & paper, flavorings and aromas production. | 3.0% |
| Total | | 100 |

Practical

| Sr. No. | Topic | No. of Practicals |
|---------|--|-------------------|
| 1. | Study of waste utilization processes by site visit/ site plan studies | 1 |
| 2. | Characterization of effluent for Dissolved solids (TDS), Suspended solids, BoD, CoD, | 2 |
| 3. | Nitrogen (as N), Phosphorus (as P), Alkalinity (as CaCO ₃), Sulphate (as SO ₄) | 2 |
| 4. | Total organic carbon (TOC) | 1 |
| 5. | Characterization of food waste as feedstock for anaerobic digestion | 1 |
| 6. | Various treatments in use for waste disposal: study on operational precautions; | 1 |
| 7 | Extraction of banana fibre, | 1 |
| 8 | Utilization of ghee residue in caramel toffee; | 1 |
| 9 | Extraction of volatile oils from organic waste; | 2 |

| | | |
|--------------|---|-----------|
| 10 | Use of fruit/vegetable residue for the production of cellulose; | 1 |
| 11 | Use of mango kernels for manufacturing of starch; | 1 |
| 12 | Production of pectin/citric acid from organic waste | 2 |
| Total | | 16 |

VI Suggested Reading

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

| | | | |
|---|---------------------|----------|--|
| I | Course Title | : | Food Plant Utilities and Sanitation |
| II | Course Code | : | FSQ 511 |
| III | Credit Hours | : | 2 (2+0) |
| IV | Theory | : | |
| <p>Unit I General principles of food plant Design and layout, CIP system, sanitizers used in food industry. Personnel hygiene and assessment of surface sanitation by swab and rinse method.</p> <p>Unit II Sanitation of coolers/chillers/freezers, Design of warehouses, conventional & modern storage structures for fruits, vegetables, meat and marine products, pest and rodent control.</p> <p>Unit III Waste disposal for Food Plant Hygiene and Sanitation, ETP design and layout, Food hygiene and safety in transportation, with a focus on warehouse storage and refrigerated ships, Process water quality and treatments at plant level, Process plant sanitation - chemistry and water in CIP.</p> <p>Unit IV Preparation of a sanitation schedule for food preparation area, testing of sanitizers and disinfectants, Steam generation and performance, Boiler operation, forced and induced draught. Flue gas composition and performance analysis, Process air generation, air requirement & supply system. Air Moving and vacuum equipment, Power supply system for food process plants and plant earthing.</p> | | | |

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage |
|-----------------|---|-----------|
| 1-6 | General principles of food plant Design and layout, CIP system, sanitizers used in food industry. Personnel hygiene and assessment of surface sanitation by swab and rinse method. | 18.0% |
| 7-12 | Sanitation of coolers/chillers/freezers, Design of warehouses, conventional & modern storage structures for fruits, vegetables, meat and marine products, pest and rodent control. | 18.0% |
| 13-19 | Waste disposal for Food Plant Hygiene and Sanitation, ETP design and layout, Food hygiene and safety in transportation, with a focus on warehouse storage and refrigerated ships, Process water quality and treatments at plant level, Process plant sanitation - chemistry and water in CIP. | 20.0% |

| | | |
|--------------|--|-------------|
| 20-24 | Preparation of a sanitation schedule for food preparation area, testing of sanitizers and disinfectants, Steam generation and performance, Boiler operation, forced and induced draught. | 19.0% |
| 25-32 | Flue gas composition and performance analysis, Process air generation, air requirement & supply system. Air Moving and vacuum equipment, Power supply system for food process plants and plant earthing. | 25.0% |
| Total | | 100% |

VI Suggested Reading

- Marriott NG and Gravani RB. 2006. Principles of Food Sanitation, 5th edition
- Rao DG. 2010. Fundamentals of Food Engineering, PHI learning Private Ltd.
- James A. 2013. The Supply Chain Handbook, Distribution Group.
- FAO, US. 1984. Design and Operations of Cold Store in Developing.

| | | | |
|------------|---------------------|----------|---|
| I | Course Title | : | Food Safety Management Systems and Certification |
| II | Course Code | : | FSQ 505 |
| III | Credit Hours | : | 2 (2+0) |

IV Theory :

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

VI Suggested Reading

- Salazar E. 2013. Understanding Food Safety Management Systems: A Practical Approach to the Application of ISO-22000:2005, Create Space Independent Publishing Platform.
- ISO 22000 Standard Procedures for Food Safety Management Systems, 2008, Bizmanualz, Inc.
- Dillon M and Griffith C (ed). 2001. Auditing in the Food Industry - From Safety and Quality to Environmental and Other Audits, CRC Press
- Inteaz A. 2003. Food Quality Assurance: Principles and Practices, CRC Press Respective certification documents

| | | | |
|---|--|----------|---|
| I | Course Title | : | Special Problem/ Summer Internship |
| II | Course Code | : | FSQ 509 |
| III | Credit Hours | : | 2 (0+2) |
| IV | Practical's | | |
| | <ul style="list-style-type: none"> • Summer internships will be usually of eight to twelve weeks duration, where the students will be attached with the special problem for skill development and first hand experience of working in Industry. • Student will be asked to work on special problem either at college or any academic institute or industrial firms | | |
| Suggestive Problems | | | |
| <ul style="list-style-type: none"> • Microbial Quality Control and Testing in Food • Recent Advances in Food Processing Technology & Applications • Recent Advances in Food Drying Technologies • Methods of Food Analysis • Methods of Food Preservation • Quality Management System ISO 9001 • Food Storage, Transpiration and Marketing | | | |

| | | | |
|------------|---------------------|----------|--|
| I | Course Title | : | Toxicology of Food Ingredients and Products |
| II | Course Code | : | FSQ 510 |
| III | Credit Hours | : | 3 (2+1) |

IV Theory :

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

V Practical

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

VI Suggested Reading

- Introduction to Food Toxicology: By Takayuki Shibamoto and Leonard F. Bjeldanes. 2nd edition; Academic Press
- Safety Evaluation of Certain Contaminants in Food, WHO Food Additives Series: 63, FAO JECFA Monographs 8, <http://www.fao.org/3/a-at881e.pdf>
- Chapter 30: Food Toxicology. In Casarett and Doull's Toxicology: The Basic Science of Poisons by Curtis D. Klaassen. 8th edition; McGraw-Hill Medical Publishing Division
- Food Toxicology: Current Advances and Future Challenges by Ashish Sachan, Suzanne Hendrich, 2017, Apple Academic Press
- Food Toxicology by Debasis Bagchi, Anand Swaroop, 2016, CRC Press
- General Standard For Contaminants and Toxins in Food and Feed (CODEX STAN 193-1995) Amended up to 2015, www.fao.org/input/download/standards/17/CXS_193e_2015.pdf.

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|------------|---------------------|----------|--|
| I | Course Title | : | Emerging Technologies in Food Packaging |
| II | Course Code | : | FPT 502 |
| III | Credit Hours | : | 2 (2+0) |

IV Theory :

Unit I

Active and intelligent packaging: Active Packaging Techniques and intelligent Packaging Techniques, current use of novel Packaging Techniques, consumers and novel Packaging Oxygen, ethylene and other scavengers: Oxygen scavenging technology, selecting right types of oxygen scavenger, ethylene scavenging technology, carbon dioxide and other scavengers. Antimicrobial food packaging: Antimicrobial agents, constructing antimicrobial packaging systems, factors affecting the effectiveness of antimicrobial packaging

Unit II

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

Time Temperature labels and indicators (TTIs): Defining and classifying TTIs, Requirements for TTIs, development of TTIs, Maximizing the effectiveness of TTIs, Application of TTIs- to monitor shelf-life, and optimization of distribution and stock rotation, leakage indicators, oxygen indicators, micro indicators etc. Freshness indicator in packaging: Compounds indicating the quality of packaged food products, freshness indicators, pathogen indicators, other methods for spoilage detection.

Self-heating/rehydrating packages.

Unit III

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

Developments in modified atmosphere packaging (MAP): Permeability properties of polymer packaging, measurement of permeability – water and gases. Selection criteria of packaging films, Novel MAP gas, testing novel MAP applications, applying high oxygen MAP.

Recycling packaging materials: Recyclability of packaging plastics, improving the recyclability of plastics packaging, testing safety and quality of recycled materials, uses of recycled plastics in packaging.

Unit IV

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

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage |
|-----------------|---|-----------|
| 1-4 | Active and intelligent packaging: Active Packaging Techniques and intelligent Packaging Techniques, current use of novel Packaging Techniques, consumers and novel Packaging Oxygen, ethylene and other scavengers: Oxygen scavenging technology, selecting right types of oxygen scavenger, ethylene scavenging technology, carbon dioxide and other scavengers. | 15.0 % |
| 5-6 | Antimicrobial food packaging: Antimicrobial agents, constructing antimicrobial packaging systems, factors affecting the effectiveness of antimicrobial packaging | 5.0 % |
| 7-8 | Non-migratory bioactive polymers (NMBP): Advantages of NMBP, Inherently bioactive synthetic polymers: types and application | 5.0 % |
| 9-10 | Polymers with immobilized bioactive compounds and their applications. | 5.0 % |
| 11-13 | Time Temperature labels and indicators (TTIs): Defining and classifying TTIs, Requirements for TTIs, development of TTIs, Maximizing the effectiveness of TTIs, Application of TTIs- to monitor shelf-life, and optimization of distribution and stock rotation, leakage indicators, oxygen indicators, micro indicators etc | 10.0 % |
| 14-15 | Freshness indicator in packaging: Compounds indicating the quality of packaged food products, freshness indicators | 5.0% |
| 16-17 | Pathogen indicators, other methods for spoilage detection. | 5.0 % |
| 18 | Self-heating/rehydrating packages. | 3.0 % |
| 19-20 | Packaging-flavour interaction: Factors affecting flavor absorption, role of food matrix, role of differing packaging materials, flavour modification and sensory quality, Study of packaging materials compatibility with foods. | 5.0 % |
| 21-23 | Developments in modified atmosphere packaging (MAP): Permeability properties of polymer packaging, measurement of permeability – water and gases. Selection criteria of packaging films, Novel MAP gas, testing novel MAP applications, applying high oxygen MAP. | 15.0 % |
| 24-25 | Recycling packaging materials: Recyclability of packaging plastics, improving the recyclability of plastics packaging, testing safety and quality of recycled materials, uses of recycled plastics in packaging. | 7.0 % |
| 26-27 | Green plastics for food packaging: Problems of plastic packaging wastes, range of biopolymers, developing novel biodegradable materials | 5.0 % |
| 28-29 | Edible Films and Coatings: Properties, types, sources, applications, advantages, disadvantages, theories of plasticization, challenges and opportunities | 5.0% |

| | | |
|-------|--|------------|
| 30 | PFS machine, seal and closures | 4.0% |
| 31-32 | Safety and legislative aspects of packaging: Regulatory considerations, plastic, metal, paper and glass packaging. | 5.0% |
| | Total | 100 |

VI Suggested Reading

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

| | | | |
|------------|---------------------|----------|---|
| I | Course Title | : | Industrial Manufacturing of Food and Beverages |
| II | Course Code | : | FPT 503 |
| III | Credit Hours | : | 3 (2+1) |

IV Theory :

Unit I

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

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

Unit II

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

Unit III

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

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

Unit IV

Beverages: Production technology of beer and wine, Non-alcoholic beverages: Carbonated beverages: carbonation equipment, - ingredients-preparation of syrups- Filling system-packaging-containers and closures.

Non-carbonated beverage: Coffee bean preparation-processing-brewing decaffeination- instant coffee, Tea types-black, green, Fruit juices and beverages, Flash pasteurization, Aseptic Packaging of beverages Tea/coffee and cocoa beverages, Grain based and malted beverages.

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

V Practicals

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

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

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage |
|-----------------|--|-----------|
| 1-3 | Grain products: Industrial manufacturing of grain based products: formulation, processes, machinery and material balance of baked, rolled, shredded, puffed, flaked, roasted products. | 10.0% |
| 4-5 | Extrusion technology: Importance and applications of extrusion in food processing; Pre and post extrusion treatments; Manufacturing process of extruded products; Change of functional properties of food components during extrusion | 9.0% |
| 6-7 | Breakfast cereals, RTE/RTC foods, instant premixes, functional foods. | 6.0% |
| 8-12 | Fruit and vegetable products: Industrial manufacturing of fruit and vegetable based products: formulation, processes, machinery and material balance of minimally processed, Retorted products, IMF, high moisture stable foods, IQF; Machines and equipment for batch and continuous processing of fruit and vegetable products | 10.0% |
| 13-14 | Chocolates and candies: Coating or enrobing of chocolate (including pan-coating); Maintenance, safety and hygiene of bakery plants. | 5.0% |
| 15-16 | Fats and oils processing: Technology of refined oil, winterized oil, hydrogenated fat, texturized fat, by-products of fat/oil processing industries – oil seed protein isolates; | 5.0% |
| 17-18 | Quality standards of fats and fatty foods; Antioxidants and its mechanism of application | 7.0% |
| 19-20 | Beverages: Production technology of beer and wine | 7.0% |
| 21-23 | Non-alcoholic beverages: Carbonated beverages: carbonation equipment, - ingredients-preparation of syrups-Filling system-packaging-containers and closures. | 12.0% |

| | | |
|--------------|---|-------------|
| 24-25 | Non-carbonated beverage: Coffee bean preparation-processing-brewing decaffeination- instant coffee | 7.0% |
| 26 | Tea types-black, green | 3.0% |
| 27 | Fruit juices and beverages | 3.0% |
| 28-29 | Flash pasteurization, Aseptic Packaging of beverages Tea/coffee and cocoa beverages, Grain based and malted beverages. | 5.0% |
| 30 | Packaged drinking water: types, manufacturing processes, quality evaluation and raw and processed water, methods of water treatment | 5.0% |
| 31-32 | BIS quality standards of bottled water; mineral water, natural spring water, flavoured water, carbonated water | 7.0% |
| Total | | 100% |

Practical

| Sr. No. | Topic | No. of Practicals |
|--------------|---|-------------------|
| 1. | Preparation of cereals based fried snack foods | 1 |
| 2. | Preparation of cereal, pulses based ready-to-eat snack food by extrusion cooking their quality evaluation | 2 |
| 3. | Preparation of cereal grain based puffed products | 1 |
| 4. | Development of instant food premixes | 1 |
| 5. | Preparation of cereal and legume based roasted snack | 1 |
| 6. | Preparation of flaked rice product | 1 |
| 7 | To study the effect of roasting time and temperature on quality of pop- corn | 1 |
| 8 | Determination of shelf-life and packaging requirements of snack food products | 1 |
| 9 | Preparation of fruits/vegetable based ready to serve beverages and quality evaluation | 1 |
| 10 | Heat classification of milk powders. | 1 |
| 11 | Determination of degree of browning-chemical/physical methods. | 1 |
| 12 | Determination of quality of packaged drinking water. | 1 |
| 13 | Preparation of wine and beer | 1 |
| 14 | Preparation of soy milk. | 1 |
| 15 | Determination of quality of canned food. | 1 |
| Total | | 16 |

VI Suggested Readings

- Edmund WL, 2001. Snack Foods Processing, CRC Press.
- Gordon BR. 1990. Snack Food, Springer US.
- Frame ND, 1994. Technology of Extrusion Cooking, Springer US
- O'Brien RD, 2008. Fats and Oils: Formulating and Processing for Application, CRC Press.

- Davis B, Lockwood A, Alcott P and Pantelidis L, 2012. Food and Beverage Management, CRC Press.
- Kunze W, 2010. Technology: Brewing and Malting, VLB.
- Dhillon PS and Verma S, 2012. Food and Beverage: Production Management for Hospitality Industry, Abhijeet Publications.
- Bamforth CW, 2006. Brewing: New Technologies, Woodhead Pub.

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|------------|---------------------|----------|---|
| I | Course Title | : | Bio-processing and Down Stream Engineering |
| II | Course Code | : | FPE 504 |
| III | Credit Hours | : | 3 (2+1) |

IV Theory :

Unit I

Introduction: Interaction of biochemical engineering, biochemistry and microbiology, Reaction kinetics, kinetics of batch and continuous cultures, process variables, biocatalyst and enzyme kinetics, scope and present status in India in relation to food industry.

Unit II

Fermentor and bioreactors: Transport phenomenon in microbial systems, types of reactor, working principles, aeration and agitation, sterilization and sanitation, advances in continuous fermentation, developments in solid-state fermentation for food applications.

Unit III

Alcoholic beverages: Production of alcoholic beverages: raw materials, culture, fermentation technology of non-distilled beverages (beer and wine) and distilled alcoholic beverages (brandy, whiskey, vodka, rum, gin).

Unit IV

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

Unit V

Organic acids/acidulants: Raw materials, Starters and fermentation conditions, recovery and applications, Case studies production of acetic acid (vinegar), citric acid, lactic acid and gluconic acid.

Unit VI

Biocatalysts in food processing: Sources of enzymes, advantages of microbial enzymes, mechanism of enzyme function, Production and purification of enzymes, immobilization and applications of biocatalysts in food processing, enzyme biosensors.

Unit VII

Down-stream processing: Handling of materials in microbial systems, filtration, centrifugation, sedimentation, chromatography, membrane separation (UF and NF) and electrophoresis, separation and disintegration of cells for product recovery operations. Biological waste treatment and in-plant sanitation.

Unit VIII

Modeling, simulation and scale-up: Bioprocess modeling and simulation and its application in industrial fermentation, scale-up of fermentation processes, design and analysis of biological fermenter and bioreactors.

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

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage |
|-----------------|---|-----------|
| 1-4 | Introduction: Interaction of biochemical engineering, biochemistry and microbiology, Reaction kinetics, kinetics of batch and continuous cultures, process variables, biocatalyst and enzyme kinetics, scope and present status in India in relation to food industry | 13.0% |
| 5-8 | Fermentor and bioreactors: Transport phenomenon in microbial systems, types of reactor, working principles, aeration and agitation, sterilization and sanitation, advances in continuous fermentation, developments in solid-state fermentation for food applications | 13.0% |
| 9-12 | Alcoholic beverages: Production of alcoholic beverages: raw materials, culture, fermentation technology of non-distilled beverages (beer and wine) and distilled alcoholic beverages (brandy, whiskey, vodka, rum, gin). | 13.0% |
| 13-16 | Single Cell Proteins: Single cell proteins production, substrates, | 12.0% |
| | factors effecting SCP production, composition, uses, economic parameters and constrains including safety aspects. | |
| 17-20 | Organic acids/acidulants: Raw materials, Starters and fermentation conditions, recovery and applications, Case studies production of acetic acid (vinegar), citric acid, lactic acid and gluconic acid. | 12.0% |

| | | |
|--------------|---|------------|
| 21-24 | Biocatalysts in food processing: Sources of enzymes, advantages of microbial enzymes, mechanism of enzyme function, Production and purification of enzymes, immobilization and applications of biocatalysts in food processing, enzyme biosensors | 13.0% |
| 25-28 | Down-stream processing: Handling of materials in microbial systems, filtration, centrifugation, sedimentation, chromatography, membrane separation (UF and NF) and electrophoresis, separation and disintegration of cells for product recovery operations. Biological waste treatment and in-plant sanitation | 12.0% |
| 29-32 | Modeling, simulation and scale-up: Bioprocess modeling and simulation and its application in industrial fermentation, scale-up of fermentation processes, design and analysis of biological fermenter and bioreactors. | 12.0% |
| Total | | 100 |

Practical

| Sr. No. | Topic | No. of Practicals |
|--------------|--|-------------------|
| 1. | Studying biochemical changes during handling of important food items | 2 |
| 2. | Study of fermenter and fermentation process | 2 |
| 3. | Study of bioprocess instrumentation and control system | 1 |
| 4. | Study of bacterial growth in batch culture | 1 |
| 5. | Production and maintenance of starter culture | 1 |
| 6. | Production of enzyme, extraction and purification | 1 |
| 7 | Production of SCP; Production of microbial pigments | 2 |
| 8 | Production of amino acids | 1 |
| 9 | Production of alcohol and alcoholic beverages | 1 |
| 10 | Visit to brewery | 1 |
| 11 | Visit to effluent treatment plant | 1 |
| 12 | Bioprocess modeling and simulation | 1 |
| 13 | Case Studies & Reports. | 1 |
| Total | | 16 |

VI Suggested Reading

- Schügerl K and Zeng AP. 2010. Advances in Biochemical Engineering Biotechnology: Tools and Applications of Biochemical Engineering Science. Springer

- Scheper Th.(Ed). Advances in Biochemical Engineering and Biotechnology Series. Springer
- Ghose TK and Fiechter A. 1971. Advances in Biochemical Engineering-I. Indian Journal of Physics, 47, 189-192.
- James EB and David FO. 1986. Biochemical Engineering Fundamentals. McGraw- Hill Book Co. Inc., New York
- Scheper T, Bajpai P, Bajpai PK, Dochain D, Dutta NN, Ghosh AC, Mathur RK, Mukhopadhyay A, Perrier M, Rogers PL, Shin HS, Wang B. 1996. Biotreatment, downstream processing and modelling. Springer
- Doran PM. 1995. Bioprocess engineering principles. Elsevier
- Perry JH. 2007. Chemical engineers' handbook, 8e. McGraw-Hill Professional
- Stumbo CR. 2013. Thermobacteriology in food processing. Elsevier
- Stanbury PF, Whitaker A and Hall SJ. 2013. Principles of fermentation technology. Elsevier
- Hitzmann B 2017. Measurement, modeling and automation in advanced food processing. Springer

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|------------|---------------------|----------|---|
| I | Course Title | : | Food Material and Product Properties |
| II | Course Code | : | FPT 504 |
| III | Credit Hours | : | 3 (2+1) |

IV Theory :

Unit I

Introduction: Biomaterials and their properties in relation to processing and product development. Physico-chemical characteristics: Shape, sphericity, size, volume, microstructure, density, porosity, surface area, coefficients of friction and angle of repose and influence of constituents on processing.

Unit II

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

Unit III

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

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

Unit IV

Functional properties: Dextrinization, Gelatinisation, Crystallisation, gelation, foaming, coagulation, denaturation and syneresis, foaming, emulsification. Sensory attributes: Sensory properties and correlation with objective indices, microstructure and its relation to texture from their mechanical models and its examination. Sorption behaviour of food: sorption isotherm, modelling.

V Practicals

- To determine physical dimension and shape for suitability of processing and packaging of food materials
- To determine bulk, true density and porosity of samples
- To determine the angle of repose using rough and smooth surface
- Analysis of powder characteristics using powder flow analyser.
- To determine the mixing and strength characteristics of wheat flour using farinograph/ mixograph/ mixolab
- To determine the amyolytic activity using falling number of wheat flour
- Development of stress and strain curve and to study viscosity of Newtonian and non-Newtonian fluid
- Effect of temperature on viscosity profile of a food sample
- Texture profile analysis of foods samples.
- Effect of temperature on textural profile of food

- Determination of thermal properties of foods using DSC.
- To estimate dielectric constant of foods
- Organoleptic evaluation of food materials
- TEM and SEM, image analysis and image processing techniques
- To determine water activity of food
- To determine colour value of food, viz. Lab, whiteness index, yellow index, browning

VI Suggested Reading

- Rao MA and Rizvi SSH, 1986. Engineering Properties of Foods, Marcel Dekker.
- Aguilera JM & Stanley DW, 1999. Microstructural Principles of Food Processing and Engineering, Springer.
- Mohsenin NN, 1986. Physical Properties of Plant and Animal Materials, Gordon & Breach Science.
- Bourne MC, 1981. Food Texture and Viscosity; Concept and Measurement, Academic Press. Steffe JF, 1992. Rheological Methods in Food Process Engineering, Freeman Press. Aguilera JM, 1999. Microstructure: Principles of Food Processing Engineering, Springer.
- Rahman MS, 2009. Food Properties Handbook, CRC Press.
- Serpil S & Sumnu SG, 2006. Physical Properties of Foods, Springer-Verlag.
- Pomeranz Y, 1991. Functional Properties of Food Components, Academic Press

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|------------|---------------------|----------|---|
| I | Course Title | : | Aseptic Processing and Packaging |
| II | Course Code | : | FPT 510 |
| III | Credit Hours | : | 3 (2+1) |

IV Theory :

Unit I

Introduction: present and future of aseptic processing, Advantages and disadvantages, processing of semi-solid and fluid and particulate foods. Aseptic processing operations: pre-sterilization, loss of sterility, water-to-product and product- to-water separation, cleaning, control, CIP.

Unit II

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

Unit III

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

Unit IV

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

V Practical

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

VI Suggested Reading

- Robertson GL, 2012. Food Packaging: Principles and Practices, CRC Press.
- David JRD, Graves RH and Szemplenski T, 2016. Handbook of Aseptic Processing and Packaging, CRC Press.
- Reuter H, 1993. Aseptic Processing of Foods, CRC Press.
- Willhoft EM, 1993. Aseptic Processing and Packaging of Particulate Foods, Springer

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|------------|---------------------|----------|---------------------------------------|
| I | Course Title | : | Food Ingredients and Additives |
| II | Course Code | : | FPT 514 |
| III | Credit Hours | : | 3 (2+1) |

IV Theory :

Unit I

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

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

Unit II

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

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

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

Unit III

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

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

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

Unit IV

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

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

V. Practical

- Determination of benzoic acid in food samples
- Estimation of sulphur dioxide in food samples
- Estimation of sorbic acid in cheese and yoghurt

- Determination of nitrate and nitrites in foods
- Detection and determination of aspartame by thin layer chromatography
- Liquid chromatographic determination of caffeine, benzoate and saccharin in soda beverage
- Identification of natural colours
- Isolation, identification and estimation of synthetic food colours
- TLC detection of antioxidants in fats and oils
- TLC detection of emulsifiers
- Detection of alginates in foods (chocolate, ice cream)
- GC determination of menthol in mentholated pan masala
- Isolation and modifications of protein, starch, lipids, fibres from the raw and processed food samples
- Estimation of various additives mentioned in unit IV

VI Suggested Reading

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

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|------------|---------------------|----------|---|
| I | Course Title | : | Engineering Properties of Food Materials |
| II | Course Code | : | FPE 502 |
| III | Credit Hours | : | 3 (2+1) |

IV Theory :

Unit I

Physical characteristics of different food grains, fruits and vegetables; shape and size, volume and density, porosity, surface area, water activity. Thermal properties: Specific heat, thermal conductivity, thermal diffusivity, phase transition, methods of determination, steady state, transient heat flow. Electrical properties; Dielectric loss factor, loss tangent, temperature dependent electrical conductivity and dielectric constant, method of determination, energy absorption from high-frequency electric field.

Unit II

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

Unit III

Contact stresses between bodies, hertz problems, firmness and hardness, mechanical damage, dead load and impact damage, vibration damage, friction, effect of load, sliding velocity and surface roughness. Friction in agricultural materials, rolling resistance, angle of internal friction, angle of repose, flow of bulk granular materials, aero dynamics of agricultural products, drag coefficients, terminal velocity.

Unit IV

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

Unit V

Rheology of semi-solid and solid food; Rheological characterization of foods in terms of stress-strain relationship; Viscoelasticity; Transient tests - Creep Compliance and Stress Relaxation; Mechanical models for viscoelastic foods: Maxwell, Kelvin, Burgers and generalized models and their application; Dynamic measurement of viscoelasticity.

Unit VI

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

Unit VII

Food structuring: traditional food structuring and texture improvement, approaches to food structuring, extrusion and spinning, structuring fat products, structure and stability, gels, gelation mechanisms, mixed gels, the microstructure of gels, structureproperty relations angels

Unit VIII

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

V Practical :

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

VI Suggested Reading

- Rao MA, Rizvi SS, Datta AK and Ahmed J. 2014. Engineering Properties of Foods. CRC press.
- Figura OL. and Teixeira AA. 2007. Food Physics: Physical Properties - Measurement and Applications. Springer Science & Business Media.
- Sahin S and Sumnu SG. 2006. Physical Properties of Foods. Springer Science and Business Media.
- Mohsenin NN. 1980. Thermal properties of foods and agricultural materials. New York. USA.
- Mohsenin NN. 1986. Physical properties of plant and animal materials. Gordon and Breach Science Publishers.
- Peleg M and Bagley EB. 1983. Physical Properties of Foods. In IFT basic symposium series (USA). AVI Pub. Co.

- Ronal J, Felix E, Bengt H, Hans F, Meffert Th., Walter EC and Gilbert V. 1983. Physical Properties of Foods. Applied Science Publishers.
- Bourne M. 2002. Food texture and viscosity: concept and measurement. Elsevier.
- Norton IT, Spyropoulos F and Cox P. 2010. Practical Food Rheology: an interpretive approach. John Wiley & Sons.

I Course Title : Numerical Techniques and Simulation
II Course Code : FPE 506
III Credit Hours : 2(1+1)

IV Theory :
Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

Computational fluid dynamics (CFD) applications in food processing

V Practical :

- Introduction to various features in different spreadsheet softwares
- Solving problems using functions and/or add-Ins and/or Analysis Tool pack in spreadsheets
- Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data
- Testing linearity and normality assumption, Testing the goodness of fit of different models
- Testing the hypothesis for one sample t-test, two sample t-test, paired t-test, test for large samples - Chi-squares test, F test, Analysis of variance
Practice on modelling and simulation softwares i.e. MATLAB, FLUENT, GAMBIT, EDEM, Solid works, ANSYS
- Practice on process optimization softwares i.e. SAS, SPSS, Origin Pro, Design Expert(DX), Minitab, Matlab
- Practice on design optimization softwares i.e. Solid works, ANSYS.

VI Suggested Reading

- Das H. 2005. Food Processing Operations Analysis. Asian Books Private Limited
- Denn MM. 1986. Process Modeling. Longman
- Holland CD. 1975. Fundamentals and Modeling of Separation Processes. Prentice Hall.
- Luyben WL. 1990. Process Modeling Simulation and Control for Chemical Engineers 2ed. McGraw Hill.
- Najim K. 1990. Process Modeling and Control in Chemical Engineering. CRC
- Aris R. 1999. Mathematical Modeling, Vol. 1: A Chemical Engineering Perspective (Process System Engineering). Academic Press.
- Kreyszig E. 2005. Advanced Engineering Mathematics. John Wiley & Sons publication
- Granato D and Ares G. 2014. Mathematical and statistical methods in food science and technology. IFT Press, Wiley Blackwell
- Standard software for modelling, analysis and simulations

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|------------|---------------------|----------|--|
| I | Course Title | : | Food Safety and Storage Engineering |
| II | Course Code | : | FPE 508 |
| III | Credit Hours | : | 3 (2+1) |

IV Theory :
Unit I

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

Unit II

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

Unit III

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

Unit IV

Predictive microbial modelling: classification of models: Kinetic & probability, Empirical & mechanistic models, Primary, secondary & tertiary models, Deterministic & stochastic models; Description of main models, Modelling growth curves, Modelling inactivation/survival curves, Secondary models, Probability models; Applications of predictive microbial modelling: Hazard analysis critical control point (HACCP) & quantitative risk assessment (QRA), Microbial shelf-life studies, Temperature function integration and temperature monitors, Product research and development, Design of experiments; Predictive microbial modelling and quantitative risk assessment.

Unit V

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

Unit VI

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

V Practical :

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

VI Suggested Reading

- Sun DW. 2015. Handbook of food safety engineering. Wiley Black Well Academic Press, Elsevier Ltd
- International Organization for Standardization. 2018. Food Safety Management Systems: Requirements for Any Organization in the Food Chain. ISO.
- Shejbal J. 1980. Controlled Atmosphere Storage of Grains. Elsevier.
- Vijayaraghavan S. 1993. Grain Storage Engineering and Technology. Batra Book Service
- Chakraverty A and Singh RP. 2014. Postharvest technology and food process engineering. CRC Press
- Chakraverty A, Mujumdar AS and Ramaswamy HS. 2002. Handbook of Postharvest Technology: Cereals, Fruits, Vegetables, Tea, and Spices. CRC Press
- ISO. 22000 Food safety management systems - Requirements for any organization in the food chain. Technical Committee ISO/TC 34, Food products and updates
- Case Studies and Field Reports - Food Safety Engineering

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|------------|---------------------|----------|------------------------------------|
| I | Course Title | : | Post-Harvest Management - I |
| II | Course Code | : | FBM 501 |
| III | Credit Hours | : | 3 (2+1) |

IV Theory :

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

V Practical :

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

fruits and vegetables.

- Preservation by drying and dehydration.
- Visit to local processing units.
- Visit to local market yards and cold storage units.
- Visit to local market and packing industries.

VI Suggested Reading

- Pantastico B. Post Harvest Physiology, Handling and Utilization of Tropical and Subtropical
- Fruits and Vegetables. The AVI Publishing Co. Inc, Westport
- Ryall, AL and Lipton WJ. Handling, Storage and Transportation of Fruits & Vegetables. Vol I. The AVI Pub. Company
- • Ryall AL and Peltzer WT. Handling, Storage and Transportation of Fruits and Vegetables – Vol II. The AVI Pub. Co.
- RydstmHeele S. Post Harvest Physiology and Pathology of Vegetables. Marcel Dekker

- I Course Title : Food Business Management - II**
- II Course Code : FBM 502**
- III Credit Hours : 2 (2+0)**

IV Theory :

Unit I

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

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

Unit II

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

Unit III

International trade; basics, classical theory, theory of absolute advantage. Theory of comparative, modern theory, free trade- protection, methods of protection, quotas, bounties, exchange control, devaluation, commercial treaties, terms of trade, balance of payments, EXIM policy, foreign exchange, mechanics of foreign exchange, GATT, WTO, role of WTO, International Trade in agriculture. World trade agreements related with food business, export trends and prospects of food products in India

Unit IV

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

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightges |
|-----------------|--|-----------|
| 1-2 | Business management; introduction, theories and functions, food industry management; marketing management and human resource development, personal management. Sectors in food industry and scale of operations in India | 3.0% |
| 3-6 | Human resource management, study the basics about HR and related policies and capacity mapping approaches for better | 15.0% |

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|-------|--|------------|
| | management. Consumer Behavior towards food consumption, consumer surveys by various institutes and agencies, Various journals on consumer behaviour and market research, Internet based data search | |
| 7-8 | Materials management – types of inventories, inventory costs, managing the inventories, economic order quantity (EOQ). | 6.0% |
| 9-12 | Personnel management – recruitment, selection and training, job specialization. Marketing management – definitions, planning the marketing programmes, marketing mix and four P's. Financial management – financial statements and ratios, capital budgeting | 13.0% |
| 13-14 | Project management – project preparation evaluation measures | 3.0% |
| 15-19 | International trade; basics, classical theory, theory of absolute advantage. Theory of comparative, modern theory, free trade-protection, methods of protection, quotas, bounties, exchange control, devaluation, commercial treaties, terms of trade, balance of payments, EXIM policy, foreign exchange, mechanics of foreign exchange | 16.0% |
| 20-22 | GATT, WTO, role of WTO, International Trade in agriculture. World trade agreements related with food business, export trends and prospects of food products in India | 9.0% |
| 23-25 | World consumption of food; patterns and types of food consumption across the globe. Ethnic food habits of different regions. Govt. institutions related to international ad trade | 9.0% |
| 26-27 | APEDA, Tea board, spice board, wine board, MOFPI etc. management of export import organization, registration, documentation, export import logistics, case studies | 9.0% |
| 28-29 | Export and import policies relevant to horticultural sector | 7.0% |
| 30-32 | Project: Consumer Survey on one identified product - both qualitative and quantitative analysis (say, Consumer behavior towards Pickles and Chutneys). | 10.0% |
| | Total | 100 |

V Suggested Readings

- David D and Erickson S. 1987. Principles of Agri Business Management. Mc Graw Hill Book Co., New Delhi.
- Acharya SS and Agarwal NL. 1987. Agricultural Marketing in India. Oxford & ISH Publishing Co., New Delhi.
- Cundiff Higler. 1993. Marketing in the International Environment, Prentice Hall of India, New Delhi.
- Batra GS and Kumar N. 1994. GAD Implications of Denkel Proposals - Azmol Publications Pvt., New Delhi.
- Phill Kottler. 1994. Marketing Management - Prentice Hall of India, New Delhi

- I Course Title : Food Processing Entrepreneurship and Start-up**
- II Course Code : FBM 503**
- III Credit Hours : 1(0+1)**

IV Practical :

- Study of a regulated market,
- Study of a fruit and vegetable market,
- Study of State and Central Warehousing Corporation
- Study of functioning of a regional rural bank and commercial bank for loan.
- Study of food processing enterprise,
- Formulation of project reports for financing food Industry,
- Working out repayment plans,
- Legal Issues in Product Development, Marketing and Market Segments
- Case studies: Innovations in Dairy industry, Bakery industry, fats and oils industry, fruit and vegetable industry, primary and secondary processing of cereals, brewing industry.

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

Practical

| Sr. No. | Topic | No. of Practicals |
|--------------|--|-------------------|
| 1 | Study of a regulated market, | 1 |
| 2 | Study of a fruit and vegetable market, | 1 |
| 3 | Study of State and Central Warehousing Corporation | 1 |
| 4 | Study of functioning of a regional rural bank and commercial bank for loan. | 1 |
| 5 | Study of food processing enterprise, | 1 |
| 6 | Formulation of project reports for financing food Industry, | 1 |
| 7 | Working out repayment plans, | 1 |
| 8 | Legal Issues in Product Development, Marketing and Market Segments | 1 |
| 9 | Case studies: Innovations in Dairy industry, Bakery industry, fats and oils industry, fruit and vegetable industry, primary and secondary processing of cereals, brewing industry. | 8 |
| Total | | 16 |

V Suggested Readings

- Hu, R. 2005. Food Product Design A Computer-Aided Statistical Approach, Technomic Publishers.
- Moskowitz H R, Saguy S. and Straus T. 2006. An Integrated Approach to New Food Product Development, CRC Press

- Moskowitz H R, Porretta S. and Silcher M. 2006. Concept Research in Food Product Design And Development, Blackwell Publishing Ltd.
- Peters MS and Timmerhaus KD. 2005. Plant Designs and Economics for Chemical Engineers, McGraw Hill, 5th Edition,
- Ahmad T. 2009. Dairy Plant Engineering and Management., Kitab Mahal, 8th Edition.

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|------------|---------------------|----------|-----------------------------|
| I | Course Title | : | Research Methodology |
| II | Course Code | : | BSH 501 |
| III | Credit Hours | : | 2 (2+0) |

IV Theory :

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

V Suggested Reading

- Creswell JW. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Sage publications, 2013.
- Kumar R. Research Methodology: A Step by Step Guide for Beginners, 2nd Edition, SAGE,2005.
- Kothari CR, Garg G. Research Methodology Methods and Techniques, New Age International publishers, Fourth Edition.
- Bower JA. 2009. Statistical Methods for Food Science, Blackwell Publishing
- Wilson A. Handbook of Science Communication, 1998, CRC Press
- Montgomery DC. 2017. Design and Analysis of Experiments, Willey
- Snecdecor GW and Cochran WG. 1991. Statistical Methods, 8th Edition, Wiley-Blackwell
- Saguy PI. Computer aided techniques in Food Technology, 1983, Taylor and Francis

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|------------|---------------------|----------|-------------------------|
| I | Course Title | : | Food Informatics |
| II | Course Code | : | BSH 502 |
| III | Credit Hours | : | 2 (2+0) |

IV Theory :

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

V Suggested Reading

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

I Course Title : Operation Research
II Course Code : FPE 510
III Credit Hours : 3 (2+1)

IV Theory :

Unit I

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

Unit II

Linear programming problem: Mathematical formulation of the linear programming problem and its graphical solution, Simplex method.

Unit III

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

Unit IV

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

Unit V

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

Unit VI

Queuing theory: Introduction and classification of queues, Solution of queuing models.

Unit VII

Project planning and network analysis: Introduction and basic definitions in Network Analysis, Rules for drawing network analysis, Critical path method (CPM), Project evaluation and review technique (PERT).

V Practical :

- Studies on application of Linear Programming on food product standardization
- Studies on use of Transportation and Assignment Problems in food plant operations
- Studies on Economic Order Quantity and Replacement Model
- Studies on Sequencing of food plant operations; Studies on Queuing Model
- Network Analysis using CPM and PERT.

VI Suggested Reading

- Ackoff RK and Sassioni MW. 1978. Fundamentals of Operations Research. Wiley Eastern, New Delhi
- Wagner HM. 1978. Principles of Operations Research, with Applications to Management Decisions. Prentice Hall of India, New Delhi
- Taha HA. 2007. Operations Research: An Introduction. Pearson Prentice Hall, New Jersey
- Goel BS and Mittal SK. 1985. Operations Research. Pragati Prakashan, Meerut
- Panneerselvam R. 2012. Operations Research. PHI Learning Pvt. Ltd.
- Prasanna C. 2009. Projects. Tata McGraw-Hill Publication, New Delhi.
- Nicolas JM. 2003. Project Management for Business and Technology – Principles and Practices. Pearson Prentice Hall
- Kerzner H and Kerzner HR. 2017. Project Management: a Systems Approach to Planning, Scheduling, and Controlling. John Wiley & Sons.
- Gopalakrishnan P and Ramamoorthy VE. 2005. Textbook of Project Management. Macmillan.

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|------------|---------------------|----------|--|
| I | Course Title | : | Energy Management and Auditing in Food Industry |
| II | Course Code | : | FPE 505 |
| III | Credit Hours | : | 3 (2+1) |

IV Theory :

Unit I

General Aspects of Energy Management & Energy Audit: Energy scenario, basics of energy and its various forms, material and energy balance, monitoring and targeting and financial management

Unit II

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

Unit III

Energy Accounting and Analysis: Energy Accounting and Analysis, The energy use index, Conditioned area, electricity costs, Thermal energy costs, Energy-using systems, Commercial energy use profiles, Identifying potential measures, Industrial audit Opportunities, Industrial Energy Use Profiles.

Unit IV

Energy economics: Simple payback, time value of money, job simulation experience, making decisions for alternate investments, depreciation, taxes and the tax credit, impact of fuel inflation on life cycle costing

Unit V

Measurements, Survey instrumentation, and data Collection: General audit instrumentation; CO₂, temperature, pressure, fluid and fuel flow, combustion gas composition, electrical and light measurement, measuring building losses, application of IR thermograph, infrared radiation and its measurement, measuring electrical system performance.

Unit VI

Energy and Water Conservation Technologies Applied to Food Processing Facilities: Conservation in steam generation and consumption system, energy conservation in heat exchangers, conservation in compressed air system, conservation in power and electrical systems, waste-heat recovery and thermal energy storage in food processing facilities, building envelope audit, energy consumption and saving opportunities.

V Practicals

- Study and practice with energy assessment and auditing instruments
- Performance assessment of motors and variable speed drives
- Performance assessment of pump, fans and blowers
- Performance assessment of refrigeration system
- Performance assessment of heat exchangers
- Performance assessment of furnace
- Performance assessment of boilers
- Conservation possibilities in dairy processing facilities
- Conservation possibilities in grains and oilseeds milling plants

- Conservation possibilities in sugar and confectionary processing facilities
- Conservation possibilities in fruit and vegetable processing facilities
- Conservation possibilities in bakery processing facilities
- Conservation possibilities in meat processing facilities
- Case studies & field reports.

VI Suggested Reading

- Wang L. 2009. Energy Efficiency and Management in Food Processing Facilities. CRC Press
- Thumann A, Niehus T and Younger WJ. 2013. Handbook of Energy Audits 9e. Fairmont Press
- Klemes J, Smith R and Kim JK. 2008. Handbook of water and energy management in food processing. Elsevier.
- Christopher CS. 2007. Electric Water: The Emerging Revolution in Water and Energy. New Society Publishers
- BEE-NPC Cases studies

Course Syllabus and Content of Doctoral Degree in Food Safety and Quality

- I Course Title : Food Quality and Safety Assessment**
- II Course Code : FSQ 601**
- III Credit Hours : 3(1+2)**

IV Theory :

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

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

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

V Practical :

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

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage |
|-----------------|--|-----------|
| 1-3 | Physical quality - Advances in Quantitative Evaluation of Physical Characteristics of Food as an indicator of quality, modern approaches for colour, texture and microstructure of food | 19.0% |
| 4-8 | Chemical Quality - Advances in instrumentation used for chemical analysis of foods and methods developed for rapid analytical methods, modern non-destructive testing methods, newer biomarkers for food authenticity, and approaches for using an analyte protectant in gas chromatographic analysis. | 31.0% |

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|-------|--|-------|
| 9-10 | Review of recent updates on the chemical safety threats such as contaminants from agrochemicals, process, packaging materials and environment | 12.0% |
| 11-14 | Biological Quality - Updates in molecular biological approaches for rapid detection, Relevance of metabolomics, transcriptomics and proteomics in food analysis and quality evaluations and current food industry applications | 25.0% |
| 15-16 | Emerging microbial and other macro-biological threats for foods: mitigation and detection | 13.0% |
| Total | | 100 |

Practical

| Sr. No. | Topic | No. of Practicals |
|---------|--|-------------------|
| 1. | Lab exercises on food microstructures | 4 |
| 2. | Food authentication, newer approaches in food analysis | 3 |
| 3. | Complex culture isolation and identification | 6 |
| 4. | Molecular methods to detect pathogens | 4 |
| 5. | Individual exercise on design of experiments in food analysis and inter learner parity. | 4 |
| 6. | Protein based detection of genetic modification ingredient | 4 |
| 7 | Detection of 3-monochloropropane-1,2-diol (MCPD) esters, mineral oil saturated hydrocarbons (MOSH) or mineral oil aromatic hydrocarbons (MOAH), or polyfluorinated alkyl substances (PFAS) | 5 |
| 8 | Species differentiation in meat - tryptic digestion of myosine by LC-MS/MS | 2 |
| Total | | 32 |

VI Suggested Reading

- Donna R and Unnevehr L, International Trade and Food Safety ed. Sy J. Buzby. Agricultural Economics Report 828. Washington: Economic Research Service. USDA. 2002.
- Josling T, Roberts D and Orden D, Food Regulation and Trade: Towards a Safe and Open Global System. Institute for International Economics. 2004.

- I Course Title : Food Toxicology and Risk Assessment**
- II Course Code : FSQ 602**
- III Credit Hours : 3 (3+0)**

IV Theory :

Food Allergies and Sensitivities, Immunological Food Hypersensitivities (True Food Allergies), Non immunological Food Sensitivities. Dietary Estrogens and Antiestrogens. Non nutrient Antitoxicants in Foods. Safety of Genetically Engineered Foods. Microbial Toxins in Foods: Algal, Fungal, and Bacterial. Natural Toxins and Chemo preventives in Plants. Pesticide Residues in the Food Supply. Antibiotic and Hormone Residues in Foods and their Significance. Heavy Metals. Food Additive Regulations, Specific Food Additives Under Scrutiny. Analysis of Chemical Toxicants and Contaminants in Foods. Toxic Components of Food Packaging Materials.

Introduction to Risk Analysis: Background, changing food safety environment, evolving food safety systems, an abundant array of hazards, Increasing demands on national food safety authorities. Risk Analysis: Components of risk analysis, carrying out risk analysis, Risk analysis at the international and national levels, Essential characteristics of risk analysis, Benefits for national governments of using food safety risk analysis. Risk management: Introduction, perspectives on risk, generic risk management framework, Understanding risk management, Preliminary risk management activities, Selection of risk management options, Implementation of the risk management decision, Monitoring and review. Risk Assessment: Introduction, Scientific approaches for assessing risks, Responsibilities of risk managers in commissioning & administering a risk assessment, Time and resources, Risk assessment, Integrating risk assessment and economic assessment. Risk Communication: Introduction, Understanding risk communication, Key communication elements of food safety risk analysis.

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage |
|-----------------|---|-----------|
| 1-5 | Food Allergies and Sensitivities, Immunological Food Hypersensitivities (True Food Allergies), Non immunological Food Sensitivities. Dietary Estrogens and Antiestrogens. Nonnutrient Antitoxicants in Foods. | 12.0% |
| 6-7 | Safety of Genetically Engineered Foods | 4.0% |
| 8-11 | Microbial Toxins in Foods: Algal, Fungal, and Bacterial. Natural Toxins and Chemo preventives in Plants | 8.0% |
| 12-15 | Pesticide Residues in the Food Supply. Antibiotic and Hormone Residues in Foods and their Significance | 8.0% |
| 16-20 | Heavy Metals. Food Additive Regulations, Specific Food Additives Under Scrutiny. Analysis of Chemical Toxicants and Contaminants in Foods. Toxic Components of Food Packaging Materials. | 12.0% |
| 21-25 | Introduction to Risk Analysis: Background, changing food | 13.0% |

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|-------|---|-------|
| | safety environment, evolving food safety systems, an abundant array of hazards, Increasing demands on national food safety authorities. | |
| 26-31 | Risk Analysis: Components of risk analysis, carrying out risk analysis, Risk analysis at the international and national levels, Essential characteristics of risk analysis, Benefits for national governments of using food safety risk analysis | 12.0% |
| 32-37 | Risk management: Introduction, perspectives on risk, generic risk management framework, Understanding risk management, Preliminary risk management activities, Selection of risk management options, Implementation of the risk management decision, Monitoring and review. | 13.0% |
| 38-43 | Risk Assessment: Introduction, Scientific approaches for assessing risks, Responsibilities of risk managers in commissioning & administering a risk assessment, Time and resources, Risk assessment, Integrating risk assessment and economic assessment. | 12.0% |
| 44-48 | Risk Communication: Introduction, Understanding risk communication, Key communication elements of food safety risk analysis | 10.0% |
| Total | | 100 |

V Suggested Reading

- William Helferich and Carl K. Winter, Food Toxicology. CRC, Press, New York, 2000
- John De Vries, Food Safety and Toxicity. by CRC Press, 1996.
- M. Dabrowski, Toxins In Food. T&F India. 2016.
Ahmed E. Yousef, Vijay K. Juneja. Microbial Stress Adaptation and Food Safety
- Vijay K. Juneja, John N. Sofos. Pathogens and Toxins in Food: Challenges and Interventions

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|------------|---------------------|----------|---|
| I | Course Title | : | Food and Nutraceutical Chemistry |
| II | Course Code | : | FSQ 605 |
| III | Credit Hours | : | 3 (3+0) |

IV Theory :

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

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

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage |
|-----------------|---|------------|
| 1-10 | Recent advances in mechanism of action and chemical properties of potential and established nutraceutical compounds and their applications in functional foods | 20.0% |
| 11-24 | Updates in chemistry of Nutraceuticals with diseases modifying indications modifying potential for Allergy, Alzheimer’s disease and nutraceuticals, Cardiovascular diseases, Cancer, Diabetes, Eye disorders, Immune system, Inflammation, Obesity, Parkinson’s, Alzhaimaretc | 30.0% |
| 25-35 | Complications and toxicity potential of nutraceuticals, Modern approaches regulatory clearance and ban of nutraceutical | 20.0% |
| 36-48 | Regulatory developments in health claims. Disease risk reduction claims and proprietary claims – recent protocols for phytosterols, digestible starch, slowly digestible starch, flavanols, grain/millet fibre, glucomannan, guar gum and hydroxypropyl methylcellulose and fructose etc. | 30.0% |
| Total | | 100 |

V Suggested Readings

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

- I Course Title : Food Microbiology and Safety**
- II Course Code : FSQ 606**
- III Credit Hours : 3(3+0)**

IV Theory :

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

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage |
|-----------------|---|-----------|
| 1-10 | Technological advances in starter cultures, Prospective application of food-grade microorganisms and fermentor for food preservation and food safety | 20.0% |
| 10-20 | Newer approaches on molecular techniques for detection of food borne pathogens, Safety evaluation of novel technologies of processing and food-surface disinfection | 40.0% |
| 21-32 | Latest software tools for predictive microbiology and microbial risk assessment in foods, Use of next generation sequencing for improving food safety | 20.0% |
| 32-40 | Role of nanotechnology in microbial food safety, New rapid detection methods including immune chromatographic or “dipstick” assays, commercial kits for indicator and pathogenic bacteria | 14.0% |
| 40-48 | Microbial bio-sensors and detector system in monitoring of food pathogens and antibiotic/pesticide residues | 6.0% |
| | Total | 100 |

V Suggested Reading

- Fratamico, PM and Bayles DO in Food Borne.
- Verma DK. Microbiology for Food and Health, Technological Developments and Advances.
- Sofos J. Advances in Microbial Food Safety, 1st Edition, Woodhead Publishing

| | | | |
|------------|---------------------|----------|---|
| I | Course Title | : | Quality Assurance in Food Supply Chain |
| II | Course Code | : | FSQ 603 |
| III | Credit Hours | : | 3 (3+0) |

IV Theory :

An exploration of food, food quality and food qualities, Quality and Value, Assurance safety and quality – General Guidelines; Understanding the food consumer, Emerging issues and challenges in Agri- food supply chain, A support-design procedure for sustainable food product-packaging systems. Designing advanced food packaging systems and technologies through modeling and virtualization. Design- support methodologies for job shop production system in the food industry. The storage of perishable products: a decision – support tool to manage temperature – sensitive products warehouses. Cool chain and temperature- controlled transport- An overview of concepts, challenges and technologies. Food transport requirements traceability and temperature monitoring. Quality of food grains and their analysis, water hygiene, quality of fresh and processed foods , quality and safety of tropical tuber crops, plantation crops, Food safety in Milk poultry, egg and meat products, Aqua products, fats and oils, bakery foods, proprietary foods, food additives etc.

V Suggested Reading

- Sudheer, Bindu Lakshmanan (2021). Safety And Quality Assurance In Food Supply Chain: Emerging Technologies and challenges, Published by Nipabooks, New Delhi
- Monika J.A. Schröder (2003). Food Quality and Consumer Value: Delivering Food that Satisfies. Springer Science & Business Media, New York
- Riccardo Accorsi, Riccardo Manzini (2019). Sustainable Food Supply Chains: Planning, Design, and Control through interdisciplinary methodologies. Academic press

I Course Title : Formulation of standards of Food Products, Packaging and Labeling

II Course Code : FSQ 604

III Credit Hours : 2(2+0)

IV Theory :

Key requirements for successful product development, Managing and improving product development, Standards developments, testing of physical, chemical and microbial characteristics, clinical testing, toxicological evaluation of foods and validation of quality parameters. Packaging and labeling requirements of different foods, Labelling of Pre-packaged Foods,. Nutritional information, USFDA regulations, FSSAI regulations, EU regulations, Codex regulations, Product specific requirements for packaging of different foods, “Health claims, Declaration regarding Food Additives, Specific Requirements/ Restrictions on manner of labelling

V Suggested Reading

- By Mary Earle, Richard Earle and Allan Anderson (2009).Food Product Development. Published by Woodhead Publishing Limited.
- USFDA regulations- <https://www.fda.gov/>
- FSSAI regulations- <https://www.fssai.gov.in/>
- EU regulations- https://food.ec.europa.eu/horizontal-topics/general-food-law_en
- Codex regulations.

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|------------|--|---|------------------------------------|
| I | Course Title | : | Sensory Evaluation of Foods |
| II | Course Code | : | FSQ 607 |
| III | Credit Hours | : | 2(2+0) |
| IV | Theory | : | |
| | Advances in rheological and texture measurement, Current sensory evaluation approaches, Applications and limitations of n e-nose, e-tongue, Data Analysis for Electronic sensory judgment and validation approaches. Computer-aided sensory evaluation of foods, statistical analysis of sensory data. | | |
| V | Suggested Reading | | |
| | <ul style="list-style-type: none"> • Rao ES. 2013. Food Quality Evaluation, Variety Books. • Meilgard. 1999. Sensory Evaluation Techniques, CRC Press • Maslowitz H. 2000. Applied Sensory Analysis of Foods. Vols. I, II. CRC Press | | |

| | | | |
|------------|---------------------|----------|--|
| I | Course Title | : | Special Problem / Industrial Attachment |
| II | Course Code | : | FSQ 608 |
| III | Credit Hours | : | 2(0+2) |

IV Practical's

- Summer internships will be usually of eight to twelve weeks duration, where the students will be attached with the special problem for skill development and first hand experience of working in Industry.
- Student will be asked to work on special problem either at college or any academic institute or industrial firms

Suggestive Problems

- Microbial Quality Control and Testing in Food
- Recent Advances in Food Processing Technology & Applications
- Recent Advances in Food Drying Technologies
- Methods of Food Analysis
- Methods of Food Preservation
- Quality Management System ISO 9001
- Food Storage, Transpiration and Marketing

- I Course Title : Novel Technologies for Food Processing and Shelf Life Extension**
II Course Code : FPT 601
III Credit Hours : 3 (3+0)

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

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage |
|-----------------|---|-----------|
| 1-3 | Recent advances in novel food processing technology | 10.0% |
| 4-8 | Membrane processing | 10.0% |
| 9-14 | Supercritical fluid extraction | 10.0% |
| 15-19 | Microwave and radio frequency processing | 10.0% |
| 20-24 | High Pressure processing | 10.0% |
| 21-25 | Ultrasonic processing | 10.0% |
| 26-30 | Ozonization | 10.0% |
| 31-35 | Plasma Technique | 8.0% |
| 36-41 | Novel drying techniques | 10.0% |
| 42-48 | Various techniques to increase shelf life and shelf life prediction | 12.0% |
| | Total | 100 |

V Suggested Reading

- Gould GW. 2000. New Methods of Food Preservation, CRC Press.
- Barbosa-Canovas, 2002. Novel Food Processing Technologies, CRC Press.
- Dutta AK and Anantheswaran RC, 1999. Hand Book of Microwave Technology for Food Applications, CRC Press.
- Sun DW. 2015. Emerging Technologies for Food Processing, Elsevier Ltd.
- Kudra T and Mujumbar AS. 2009. Advanced Drying Technologies, CRC Press.
- Killkast D and Subramaniam P. 2000. The Stability and Shelf Life of Food. CRC Press.
- Doona C J and Feeherry F E. 2007. High Pressure Processing of Foods. Blackwell Publishing Ltd.

- I Course Title : Food Handling and Storage Engineering**
- II Course Code : FPE 606**
- III Credit Hours : 3 (3+0)**

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

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage |
|-----------------|---|-----------|
| 1-3 | Recent development in handling and storage | 10.0% |
| 4-8 | Bulk storage structure, silos | 10.0% |
| 9-14 | Cold storages | 10.0% |
| 15-20 | CA storages | 10.0% |
| 21-25 | Modified atmosphere storage | 10.0% |
| 26-30 | Transportation and cold chain systems | 10.0% |
| 31-35 | Handling and storage low and ambient temperatures | 10.0% |
| 36-40 | During supply chain, codes and standards | 10.0% |
| 41-48 | Problem solving and case studies | 20.0% |
| | Total | 100 |

V Suggested Reading

- Guineè RPF, Correia PMR. 2013. Engineering Aspects of Cereal and cereal-based Products. Taylor & Francis
- Mascheroni RH. 2012. Operations in Food Refrigeration. CRC Press
- Farid MM. 2010. Mathematical Modeling of Food Processing. CRC Press
- Teixeira JA and Vicente AK. 2014. Engineering Aspects of Food Biotechnology. CRC Press
- Varzakas T, Tzia C. 2014. Food Engineering Handbook. CRC Press
- Saravacos GD, Maroulis ZB. 2011. Food Process Engineering Operations. CRC Press
- Ron BH Wills, Golding JB. 2015. Advances in Postharvest Fruit and Vegetable Technology. CRC Press
- Petr D, Marilyn R. 2015. Engineering Aspects of Food Emulsification and Homogenization. CRC Press
- Constantina T, Theodoros V. 2016. Handbook of Food Processing: Food Safety, Quality, and Manufacturing Processes. CRC Press.

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|------------|---------------------|----------|---|
| I | Course Title | : | Food Process Modeling and Scale up |
| II | Course Code | : | FPT 605 |
| III | Credit Hours | : | 3 (3+0) |

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

V Suggested Reading

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

| | | | |
|------------|---------------------|----------|---|
| I | Course Title | : | Concentration and Drying Engineering |
| II | Course Code | : | FPE 602 |
| III | Credit Hours | : | 3 (3+0) |

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

V Suggested Reading

- Anandharamakrishnan C and Padma IS. 2015. Spray Drying Techniques for Food Ingredient Encapsulation. Wiley-Blackwell•
- Oetjen GW, Haseley P. 2018. Freeze-Drying, 3e. Wiley-VCH
- Krokida M. 2018. Thermal and Nonthermal Encapsulation Methods. CRC Press
- Anandharamakrishnan C. 2017. Handbook of Drying for Dairy Products. Wiley-Blackwell
- Zhang M, Bhandari B, Fang Z. 2017. Handbook of Drying of Vegetables and Vegetable Products. CRC Press
- Prakash O, Kumar A. 2017. Solar Drying Technology: Concept, Design, Testing, Modeling, Economics and Environment. Springer Singapore
- Karim A, Law CL. 2017. Intermittent and Nonstationary Drying Technologies: Principles and Applications. CRC Press
- Vasile M. 2016. Advances in Heat Pump-Assisted Drying Technology. CRC Press
- MengWai W. 2016. Computational Fluid Dynamics Simulation of Spray Dryers: An Engineer's Guide. CRC Press
- Reis FR. 2014. Vacuum Drying for Extending Food Shelf-Life. Springer International Publishing
- Rodrigues S. 2008. Advances in Fruit Processing Technologies. CRC Press
- Angela M and Meireles A. 2008. Extracting Bioactive Compounds for Food Products Theory and Applications. CRC Press
- Rivas EO. 2009. Processing Effects on Safety and Quality of Foods. CRC Press
- Lebovka NI, Vorobiev E, Cheimat F. 2012. Enhancing Extraction Processes in the Food Industry. CRC Press

I Course Title : Food Analytical Techniques
II Course Code : FPE 605
III Credit Hours : 3 (1+2)

IV Theory :

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

V Practical

- Practice on UV-Visible, IR, Raman, & Mass spectroscopy.
- Practice on Fluorescence, Turbidimetric and related techniques.
- Practice on NMR/ESR spectroscopy.
- Practice on general and advanced chromatographic (HPLC, GC, Paper, TLC/HPTLC, Ion, Flash etc.) techniques.
- Practice on biological techniques such as Electrophoresis, PCR/RT-PCR, Immunoassays etc
- Practice on Immuno based analytical techniques such as ELISA & Lateral flow assay.
- Determination of common adherents, colour, flavours and composition using specified methods.
- Separation of selected biomolecules (protein, colour, amino acids, fat, colour, flavours, peptides, anti/ nutritional factors, casein etc) using different techniques.
- Gel-filtration of biomolecules.
- SDS gel electrophoresis and molecular weight determination.
- Measurement of size and zeta potential of colloidal solution or emulsion using dynamic light scattering/ particle size analyser.
- Practice on purification of selected biomolecules.
- Estimation of minerals using AAS.
- Determination of specific and non-specific antimicrobial factors of selected biomolecules.
- Determination of health benefits of selected biomolecules/ products.
- Correlation of offline with online assessment of selected parameters.
- Correlation among industrial, national and international methods of selected concerned parameters.

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage |
|-----------------|---|-----------|
| 1-4 | Hands on experience on advance methods | 25.0% |
| 5-8 | Equipment and instruments used for analysis of raw material | 20.0% |
| 9-12 | Food products and confirmation of standards | 25.0% |

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|-------|--|-------|
| 13-16 | Offline and online assessment of food properties | 30.0% |
| 16 | Total | 100 |

Practical

| Sr. No. | Topic | No. of Practical |
|---------|--|------------------|
| 1. | Practice on UV-Visible, IR, Raman, & Mass spectroscopy. | 2 |
| 2. | Practice on Fluorescence, Turbidimetric and related techniques. | 2 |
| 3. | Practice on NMR/ESR spectroscopy. | 1 |
| 4. | Practice on general and advanced chromatographic (HPLC, GC, Paper, TLC/HPTLC, Ion, Flash etc.) techniques | 4 |
| 5. | Practice on biological techniques such as Electrophoresis, PCR/RTPCR, Immunoassays etc . | 3 |
| 6. | Practice on Immuno based analytical techniques such as ELISA & Lateral flow assay | 2 |
| 7 | Determination of common adherents, colour, flavours and composition using specified methods. | 5 |
| 8 | Separation of selected biomolecules (protein, colour, amino acids, fat, colour, flavours, peptides, anti/ nutritional factors, casein etc) using different techniques. | 3 |
| 9 | Gel-filtration of biomolecules. | 1 |
| 10 | SDS gel electrophoresis and molecular weight determination. | 1 |
| 11 | Measurement of size and zeta potential of colloidal solution or emulsion using dynamic light scattering/ particle size analyser. | 1 |
| 12 | Practice on purification of selected biomolecules. | 1 |
| 13 | Estimation of minerals using AAS. | 2 |
| 14 | Determination of specific and non-specific antimicrobial factors of selected biomolecules | 1 |
| 15 | Determination of health benefits of selected biomolecules/ products. | 1 |
| 16 | Correlation of offline with online assessment of selected parameters. | 1 |
| 17 | Correlation among industrial, national and international methods of selected parameters. | 1 |
| | Total | 32 |

VI Suggested Reading

- Boziaris IS. 2014. Novel Food Preservation and Microbial Assessment Techniques. CRC Press.
- Renfu L. 2016. Light scattering technology for food property, quality and safety assessment. CRC Press

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|------------|--|----------|------------------------------------|
| I | Course Title | : | Sensory Evaluation of Foods |
| II | Course Code | : | FSQ 607 |
| III | Credit Hours | : | 2 (2+0) |
| IV | Theory | : | |
| | Advances in rheological and texture measurement, Current sensory evaluation approaches, Applications and limitations of n e-nose, e-tongue, Data Analysis for Electronic sensory judgment and validation approaches. Computer-aided sensory evaluation of foods, statistical analysis of sensory data. | | |

Teaching Schedule

Theory

| No. of Lectures | Topic | Weightage |
|-----------------|---|-----------|
| 1-6 | Advances in rheological and texture measurement | 20.0% |
| 7-12 | Current sensory evaluation approaches | 20.0% |
| 13-16 | Applications and limitations of n e-nose, e-tongue | 10.0% |
| 17-23 | Data Analysis for Electronic sensory judgment and validation approaches | 25.0% |
| 24-28 | Computer-aided sensory evaluation of foods | 13.0% |
| 29-32 | Statistical analysis of sensory data. | 12.0% |
| 32 | Total | 100 |

V Suggested Reading

- Rao ES. 2013. Food Quality Evaluation, Variety Books.
- Meilgard. 1999. Sensory Evaluation Techniques, CRC Press
- Maslowitz H. 2000. Applied Sensory Analysis of Foods. Vols. I, II. CRC Press

E Resources and List of Journals

| S.No | Titles | ISSN |
|------|---|-----------|
| 1 | Bioscience of Microbiota Food and Health | 2186-6953 |
| 2 | Comprehensive Reviews in Food Science and Food Safety | 1541-4337 |
| 3 | Critical Reviews in Food Science and Nutrition | 1040-8398 |
| 4 | Current Opinion in Food Science | 2214-7993 |
| 5 | Food Additives and Contaminants: Part A (Food Additives and Contaminants) | 1944-0049 |
| 6 | Food Additives and Contaminants: Part B (Food Additives and Contaminants) | 1939-3210 |
| 7 | Food Analytical Methods | 1936-9751 |
| 8 | Food Biophysics | 1557-1858 |
| 9 | Food Bioscience | 2212-4292 |
| 10 | Food Biotechnology | 0890-5436 |
| 11 | Food Chemistry | 0308-8146 |
| 12 | Food Control | 0956-7135 |
| 13 | Food Engineering Reviews | 1866-7910 |
| 14 | Food Microbiology | 0740-0020 |
| 15 | Food Packaging and Shelf Life | 2214-2894 |
| 16 | Food Quality and Preference | 0950-3293 |
| 17 | Food Research International | 0963-9969 |
| 18 | Food Reviews International | 8755-9129 |
| 19 | Food Science & Technology - Lebensmittel-Wissenschaft& Tech | 0023-6438 |
| 20 | Food Security | 1876-4517 |
| 21 | Food and Bioprocess Technology | 1935-5130 |
| 22 | Food and Bioproducts Processing | 0960-3085 |
| 23 | Food and Chemical Toxicology | 0278-6915 |
| 24 | Food and Function | 2042-6496 |
| 25 | Foodborne Pathogens and Disease | 1535-3141 |
| 26 | Foods | 2304-8158 |
| 27 | GM Crops & Food-Biotechnology in Agriculture and the Food Chain | 2164-5698 |
| 28 | Innovative Food Science and Emerging Technologies | 1466-8564 |
| 29 | International Journal of Food Engineering | 2194-5764 |
| 30 | International Journal of Food Microbiology | 0168-1605 |
| 31 | International Journal of Food Properties | 1094-2912 |
| 32 | International Journal of Food Science and Technology | 0950-5423 |

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| 33 | Journal of Consumer Protection and Food Safety | 1661-5751 |
| 34 | Journal of Food Composition and Analysis | 0889-1575 |
| 35 | Journal of Food Engineering | 0260-8774 |
| 36 | Journal of Food Measurement and Characterization | 2193-4126 |
| 37 | Journal of Food Process Engineering | 0145-8876 |
| 38 | Journal of Food Quality | 0146-9428 |
| 39 | Journal of Food Safety | 0149-6085 |
| 40 | Journal of Food and Drug Analysis | 1021-9498 |
| 41 | Journal of Functional Foods | 1756-4646 |
| 42 | Journal of Medicinal Food | 1096-620X |
| 43 | Molecular Nutrition and Food Research | 1613-4125 |
| 44 | Nutrition | 0899-9007 |
| 45 | Nutrition Research | 0271-5317 |
| 46 | Nutrition Reviews | 0029-6643 |
| 47 | Nutrition Research Reviews | 0954-4224 |
| 48 | Plant Foods for Human Nutrition | 0921-9668 |
| 49 | Quality Assurance and Safety of Crops & Foods | 1757-8361 |
| 50 | Trends in Food Science and Technology | 0924-2244 |