भाकृअनुप
ICAR

SIXTH
DEANS' COMMITTEE
REPORT

AGRICULTURAL EDUCATION DIVISION
Indian Council of Agricultural Research
Krishi Anusandhan Bhawan-II
Pusa, New Delhi-110012

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FOOD TECHNOLOGY

Course Curricula for Undergraduate Programs in Food Technology UG-Certificate (Food Technology) UG-Diploma (Food Technology) B. Tech. (Food Technology)

INTRODUCTION

In an era marked by rapid population growth, changing dietary patterns, and environmental concerns, the significance of food technology cannot be overstated. Food Technology course is designed to address the multifaceted challenges facing the food industry today. It recognizes the need for a holistic approach to food technology education that encompasses theoretical knowledge, practical skills, and ethical considerations. At its core, the course aims to produce graduates who are well-equipped to address issues such as food security, safety, new product development, sustainability, and innovation.

The National Education Policy (NEP) serves as a guiding framework aimed at revolutionizing education in this critical field. This comprehensive policy not only emphasizes theoretical knowledge but also underscores the importance of practical application, interdisciplinary learning, innovation, and critical thinking.

In view of these, the restructuring of under-graduate programs in Food Technology have been carried out. More emphasis has been given on basic skill enhancement courses, exposure visits and case studies, industry attachments, flexibility in choice of courses through electives and also through online courses. Provision has also been made for advanced skill development through project work or experiential learning/ incubation, etc. These activities have been intended at conceptual learning than rote learning as well as for inculcating ingenuity and analytical thinking. Besides, as per NEP-2020, provision for multiple exit and entry options have also been included.

One of the fundamental pillars of the program on Food Technology course is the emphasis on practical application. Recognizing the importance of hands-on learning experiences, laboratory work, and industry internships, the course has been designed to provide students with real-world exposure to the complexities of food processing, preservation, and quality assurance. By integrating practical training into the curriculum, students can develop essential skills that are crucial for success in the food industry. Two exit options, one after first year as a Certificate and the other after the second year

as Diploma in Food Technology, have been provided, so that the students can look for employment at any point of their career.

The course on Food Technology advocates for an interdisciplinary approach to education. It recognizes that food technology is inherently multidisciplinary, drawing upon principles from fields such as biology, chemistry, microbiology, engineering, and nutrition. By incorporating elements from these diverse disciplines, students gain a comprehensive understanding of food science and are better equipped to tackle complex challenges in the field.

This modified Food Technology course has far-reaching implications for the future of food. By equipping students with comprehensive knowledge, practical skills, and ethical principles, the syllabus lays the foundation for a sustainable, resilient, and equitable food system. Graduates of the program are poised to make meaningful contributions to the food industry, driving innovation, promoting food security, and ensuring the safety and integrity of the global food supply.

Entrepreneurship in food technology is an aspect that is characterized by a spirit of innovation and disruption. Entrepreneurs in this field leverage cutting-edge technologies, scientific advancements, and creative thinking to develop novel solutions that revolutionize the way we produce, process, and consume food. These entrepreneurs are driving forward-thinking initiatives that have the potential to reshape the future of food.

The details of the course structure for the Undergraduate courses in Food Technology (UG-Certificate, UG-Diploma and B. Tech.) have been prepared after having multistage in-depth deliberations and discussions with the Deans' and faculty members of the Food Technology discipline of different SAUs, stakeholders from related industries and alumni. It is expected that the course curriculum will strengthen the knowledge and skill base of the students and meet the expectations of the NEP-2020.

This course on Food Technology represents a landmark initiative aimed at transforming education in this critical field. By emphasizing practical application, interdisciplinary learning, innovation, and food safety, the program seeks to empower students with the knowledge and skills needed to address the complex challenges facing the food industry. As we look towards the future, the course curricula on Food Technology holds immense promise for shaping a more sustainable, resilient, and equitable food system for generations to come.

HIGHLIGHTS

- The B. Tech. (Food technology) Program will be of 4 years, covering 182 credits, which has 176 credits (inclusive of four credits of two non-gradial courses i.e (Deeksharambh (Induction-cum-Foundation course): 2 credits and Study tour: 2 credits), offered by the parent institute. Additionally, 6 credits of online courses are to be taken by the student as per his/ her choice.
- More weightage has been given to skill development courses in first two years, semesters 1 to 4. Students have been given flexibility and choice in selection of skill development courses from a basket of multiple skill development modules offered in all the four semesters of first two years.
- The UG Certificate is being offered in three domains viz., Food Plant Operations, Food Manufacturing and Food Quality Testing for which a bouquet of courses has been offered to enhance their skill in the particular domain.
- Students will be given 4 credits of skill-based courses each in first, second, and 2 each in third and fourth semesters so that they will acquire enough knowledge and skill through hands-on training in related domain.
- The students will have flexibility and choice in selection of skill areas from a bouquet of skill enhancement modules to be offered/ listed by the parent institute. After three days common orientation on different skill enhancement modules, students will take up either one or more modules as per the local needs and gain complete hands-on experience on these modules. In addition to the modules proposed in this report, the SAUs can formulate other modules relevant to the respective regions or modify the titles of the proposed modules.
- An institution is at liberty to (and in fact it should) work in partnership with capable organizations/ companies/ NGOs/ progressive entrepreneurs for running the Skill Enhancement courses. In such cases, a detailed content should be prepared in consultation with the industry/ organization and the institution should have a regular monitoring for the learning process. The evaluation can be done jointly by the institute and collaborating partners.
- In first year, after completing the course requirement of 45 credits of both the semesters, there is provision of extra 10 credits Internship of two months period for Industry placement/ Industry exposure/ Hands-on with local food processors/equipment manufacturers, etc. in related domain of skill acquired to get first-hand experience to become eligible for the award of UG-Certificate on exit.
- The second year has been designed with the basic engineering courses as well as fundamental courses in food technology with adequate theory and practical components, enabling the student to get acquainted with the basic principles and applications of Food Technology. After satisfactory completion of the courses of 2nd year and subsequent satisfactory completion of 10 credits (10 weeks) of industry/ institute training/ internship, the student will become eligible for the award of UG-Diploma in Food Technology on exit. The students continuing the study further, would not have to attend the internship after 2nd year.
- These students are expected to acquire competency and confidence to start their own enterprise, as well as will have adequate competency for getting jobs.
- More emphasis has been given in proper amalgamation of theory and practical to provide them hard core knowledge of the B. Tech. (Food Technology) discipline as well. In third year, the student will be taught Intensive core courses of Food Technology.

- Six credits of online courses are at the discretion of students. Students have the choice of taking online courses to groom their passion to enhance their knowledge and competency beyond prescribed courses. Student also has flexibility to complete these Non-credit elective courses of 6 credits any time during the 3rd and 4th years. These courses are to be completed with satisfactory grade.
- In eighth semester of the degree program students will be offered Internship of 20 credits.
- On successfully completing the four years degree requirement, the student will be given undergraduate degree of B. Tech. (Food Technology).

Entry and Exit Options

The entry and exit options for the UG programs in Food Technology are shown in the figure 1. below.

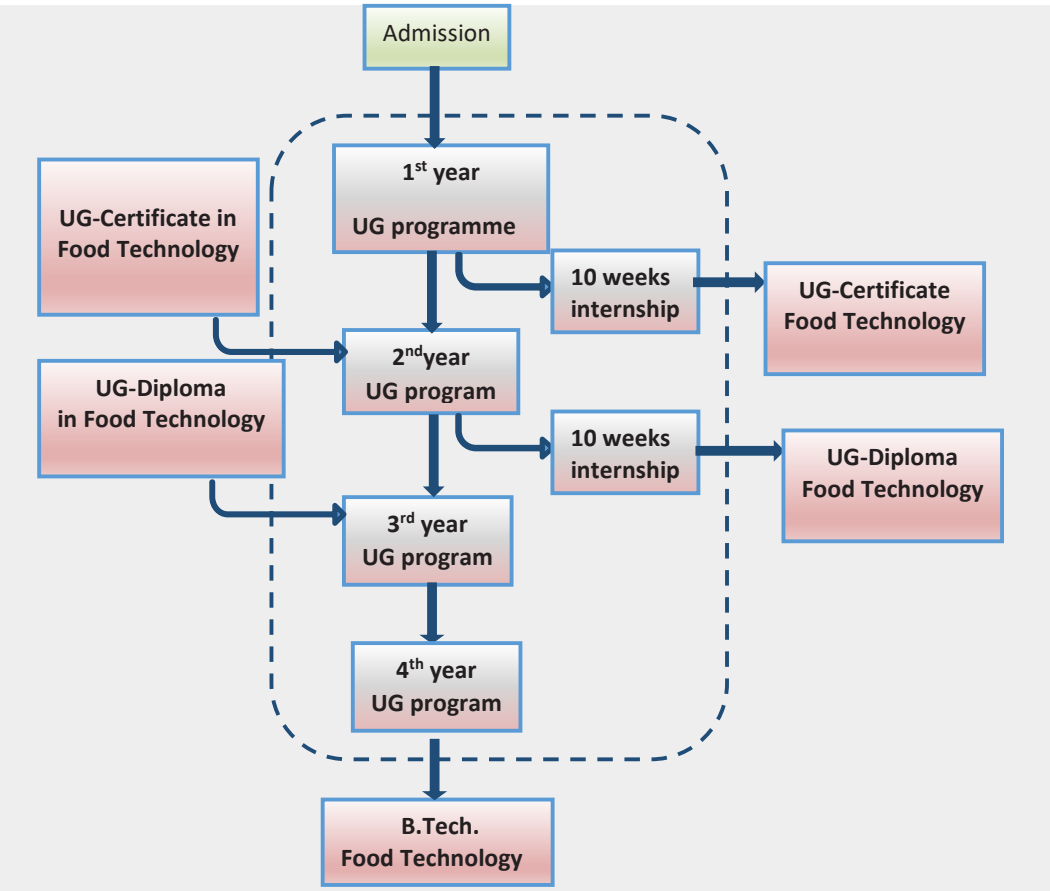

Fig.1 Entry and Exit options for the UG programs in Food Technology

1. **Eligibility for Entry into 1st year UG program:** +2 Science with Mathematics as one subject or as per the criteria decided by the ICAR/ SAU.

Exit options

UG-Certificate in Food Technology (exit after first year and completion of 10 weeks' internship) with following specialization e.g. UG certificate in Food technology (Food Plant Operations)

a. Food Plant Operations
b. Food Manufacturing
c. Food Quality Testing

2. **UG-Diploma in Food Technology** (exit after second year and completion of 10 weeks' internship)

3. **B.Tech. (Food Technology)** (on successful completion of four-year degree requirements)

The Universities may consider allowing lateral entry for the candidates having Diploma in Food Technology (as such courses are available in many states and lateral entry is practiced in some Universities). In such cases, the candidates having Diploma in Food Technology (with minimum 3 years course program after 10th or equivalent as approved by UGC/ICAR as per the provisions to be notified by the respective AU from time to time.

ACADEMIC PROGRAM

Semester wise course distribution

S. No.	Course Title	Credit hours	Total Credit hours
	First Year		
	Semester-I		
1.	*Deeksharambh* (Induction-cum-Foundation Course of 2 weeks)	2 (0+2) Non-Gradial	22 (10+12) +2 (Non-Gradial)
2.	Fundamentals of Food Processing	3 (2+1)	
3.	Workshop Technology	3 (1+2)	
4.	Basic Electrical Engineering	3 (2+1)	
5.	General Microbiology	3 (2+1)	
6.	Farming Based Livelihood System	3 (2+1)	
7.	Communication Skills	2 (1+1)	
8.	NCC-I/ NSS-I	1 (0+1)	
9.	Skill Enhancement Course- I***	2 (0+2)	
10.	Skill Enhancement Course - II***	2 (0+2)	
	Semester-II		
1.	Post-Harvest Engineering	3 (2+1)	23 (11+12)
2.	Food Chemistry I	3 (2+1)	
3.	Unit Operations in Food Processing	3 (2+1)	
4.	Food Thermodynamics	3 (2+1)	
5.	Engineering Drawing and Graphics	3 (1+2)	

S. No.	Course Title	Credit hours	Total Credit hours
6.	Environmental Studies and Disaster Management	3 (2+1)	
7.	NCC-II/NSS-II	1 (0+1)	
8.	Skill Enhancement Course - III***	2 (0+2)	
9.	Skill Enhancement Course - IV***	2 (0+2)	

Proposed Basket of Skill Enhancement Course Modules for Semester I to VI++

Discipline/ Department		Course Title	Credit hours
Food Technology	1	Introduction to Drying Technology and Dryers	2 (0+2)
	2	Introduction to Processing of Extruded Foods	2 (0+2)
	3	Introduction to Milling (Rice, Dal, Spices, etc.)	2 (0+2)
Food Quality	1	Introduction to Food Safety and Sanitation	2 (0+2)
	2	Introduction to Good Laboratory Practices	2 (0+2)
	3	Basic Food Analysis Laboratory Techniques	2 (0+2)
Food Engineering	1	Introduction to Electrical and Control Systems in Food Industry	2 (0+2)
	2	Introduction to Mechanical Systems in Food Industry	2 (0+2)
	3	Introduction to AutoCAD	2 (0+2)
Food Plant Operations	1	Maintenance of Food Processing Equipment	2 (0+2)
	2	Introduction to Bottling and Canning Line	2 (0+2)
	3	Introduction to Manufacturing of Bakery Products	2 (0+2)

++From Basket of Skill enhancement course modules, only one course from each discipline is to be selected per the semester as per the selected specialization of certificate. However, at least one course of other specialization viz. Food Technology, Food Engineering and Food Quality is to be taken for the Diploma course.

Student taking various SKILL ENHANCEMENT COURSES will be eligible to get a Certificate with Nomenclature as follows provided the student has selected courses as mentioned against the nomenclature of the UG-Certificate.

Nomenclature of Certificate	Skill Enhancement Courses to be selected from the respective disciplines	
	Semester-I	Semester-II
UG-Certificate in Food Technology (Food Plant Operations)	Food Engineering	Food Plant Operations
UG-Certificate in Food Technology (Food Manufacturing)	Food Technology	Food Plant Operations
UG-Certificate in Food Technology (Food Quality Testing)	Food Quality Assurance	Food Plant operations

In case a student wishes to exit at this point,

Post- II SEMESTER

Course Title	Credit hours
Internship only for exit option for award of UG-Certificate) 10 weeks	**10 (0+10)***

There is no need to do the internship if the student wishes to continue further study.

Second Year			
SEMESTER-III			
1.	Food Chemistry II	3 (2+1)	**23 (13+10)**
2.	Fluid Mechanics	3 (2+1)	
3.	Heat and Mass Transfer in Food Processing	3 (2+1)	
4.	Basic Electronic Engineering	2 (1+1)	
5.	Food Microbiology	3 (2+1)	
6.	Engineering Mathematics- I	2 (2+0)	
8.	Agricultural Informatics and Artificial Intelligence	3 (2+1)	
9.	Physical Education, First Aid, Yoga Practices and Meditation	2 (0+2)	
7.	Skill Enhancement Course-V***	2 (0+2)	
SEMESTER-IV			
1.	Fundamentals of Food Engineering	3 (2+1)	**20 (13+7)**
2.	Food Plant Sanitation	3 (2+1)	
3.	Food Quality, Safety Standards and Certification	2 (2+0)	
4.	Engineering Mathematics- II	2 (2+0)	
5.	Food Plant Utilities and Services	3 (2+1)	
6.	Entrepreneurship Development and Business Management	3 (2+1)	
7.	Personality Development	**2 (1+1)**	
8.	Skill Enhancement Course-VI***	2 (0+2)	
Student taking various SKILL ENHANCEMENT COURSES can exit here to get a UG-Diploma in Food Technology			

Post- IV SEMESTER

Course Title	Credit hours
Internship (only for exit option for award of UG- Diploma)	**10 (0+10)***

There is no need to do the internship if the student wishes to continue further study.

Third Year			
SEMESTER-V			
1.	Food Biochemistry and Nutrition	3 (2+1)	**22 (14+8) +2** (Non-Gradial)
2.	Processing Technology of Cereals	3 (2+1)	
3.	Processing Technology of Fruits and Vegetables	3 (2+1)	
4.	Food Packaging Technology and Equipment	2 (1+1)	
5.	Processing of Spices and Plantation Crops	3 (2+1)	
6.	Food Storage Engineering	3 (2+1)	
7.	Project Preparation and Management	2 (1+1)	
8.	Agricultural Marketing and Trade	3 (2+1)	
9.	Study tour (10-12 days during the semester)	2 (0+2) NG	

SEMESTER-VI			
1.	Food Additives and Preservatives	2 (1+1)	**21 (13+8)**
2.	Sensory Evaluation of Food Products	2 (1+1)	
3.	Processing Technology of Legumes and Oilseed	3 (2+1)	
4.	Food Refrigeration and Cold Chain	3 (2+1)	
5.	Processing of Meat, Fish and Poultry Products	3 (2+1)	
6.	Processing Technology of Beverages	3 (2+1)	
7.	Bakery, Confectionary and Snack Products	3 (2+ 1)	
8.	Processing Technology of Liquid Milk	2 (1+1)	
Fourth Year			
SEMESTER-VII			
1.	Food Process Equipment Design	3 (2+1)	**20**
2.	Processing Technology of Dairy Products	3 (2+1)	
3.	ICT Applications in Food Industry	3 (1+2)	
4.	Seminar	1 (0+1)	
5.	Elective Courses	10	

Student has to complete 20 credits in this semester. Courses 1-4 (10 credits) are compulsory. (Minimum 10 credit hours from this Suggestive list of courses should be opted as Elective Courses)

ELECTIVE COURSES

1.	Design and Formulation of Foods	3 (2+1)
2.	Industrial Microbiology	3 (2+1)
3.	Introduction to Food Biotechnology	3 (2+1)
4.	Business Management and Economics	2 (2+0)
5.	Statistical Methods and Numerical Analysis	2 (1+1)
6.	Instrumentation and Process Control in Food Industry	3 (1+2)
7.	Instrumental Techniques in Food Analysis	2 (1+1)
8.	Traditional Indian Dairy Products	2 (1+1)
9.	Ice-cream andFrozen Desserts	3 (2+1)
10.	Energy Conservation and Management	2 (1+1)
11.	Applications of Renewable Energy in Food Processing	2 (1+1)
12.	Food Plant Design and Layout	3 (2+1)
13.	Waste and By-Products Utilization	3 (2+1)

SEMESTER-VIII			
1	Student Ready / Internship (at Industry/ Research Institutes, etc.) (20 weeks)	20 (0+20)	**20 (0+20)**

#CNC-Compulsory non-gradial course

*** From the available basket of skill enhancement modules

Department wise course distribution

S. No.	Course Title	Credit hours
Department of Food Technology		
1	Fundamentals of Food Processing	3 (2+1)
2	Processing Technology of Fruits and Vegetables	3 (2+1)
3	Processing Technology of Liquid Milk	2 (1+1)
4	Food Packaging Technology and Equipment	2 (1+1)
5	Processing Technology of Cereals	3 (2+1)
6	Processing Technology of Legumes and Oilseed	3 (2+1)
7	Processing Technology of Dairy Products	3 (2+1)
8	Processing of Meat, Fish and Poultry Products	3 (2+1)
9	Bakery, Confectionary and Snack Products	3 (2+ 1)
10	Processing of Spices and Plantation Crops	3 (2+1)
16	Sensory evaluation of Food Products	2 (1+1)
11	Processing Technology of Beverages	3 (2+1)
12	Internship (at Industry/ Research Institutes, etc.) (20 weeks)	20 (0+20)
Skill Enhancement Courses		
1	Introduction to Drying Technology andDryers	2 (0+2)
2	Introduction to Processing of Extruded Foods	2 (0+2)
3	Introduction to Milling (Rice, Dal, Spices, etc.)	2 (0+2)
Department of Food Engineering		
1	Workshop Technology	3 (1+2)
2	Engineering Drawing and Graphics	3 (1+2)
3	Basic Electrical Engineering	3 (2+1)
4	Food Thermodynamics	3 (2+1)
5	Post-Harvest Engineering	3 (2+1)
6	Fluid Mechanics	3 (2+1)
7	Heat and Mass Transfer in Food Processing	3 (2+1)
8	Basic Electronic Engineering	2 (1+1)
9	Unit Operations in Food Processing	3 (2+1)
10	Fundamentals of Food Engineering	3 (2+1)
11	Food Refrigeration and Cold Chain	3 (2+1)
12	Food Storage Engineering	3 (2+1)
13	Food Process Equipment Design	3 (2+1)
14	Instrumentation and Process Control in Food Industry	3 (1+2)
Skill Enhancement Courses		
1	Introduction to Electrical and Control Systems in Food Industry	2 (0+2)
2	Introduction to Mechanical Systems in Food Industry	2 (0+2)
3	Introduction to AutoCAD	2 (0+2)

S. No.	Course Title	Credit hours
Department of Food Quality Assurance		
1	Food Chemistry I	3 (2+1)
2	Food Chemistry II	3 (2+1)
3	General Microbiology	3 (2+1)
4	Food Microbiology	3 (2+1)
5	Industrial Microbiology	3 (2+1)
6	Food Biochemistry and Nutrition	3 (2+1)
7	Food Plant Sanitation	3 (2+1)
8	Introduction to Food Biotechnology	3 (2+1)
9	Instrumental Techniques in Food Analysis	2 (1+1)
10	Food Additives and Preservatives	3 (2+1)
11	Food Quality, Safety Standards and Certification	2 (2+0)
	Skill Enhancement Courses	
1	Introduction to Food Safety and Sanitation	2 (0+2)
2	Introduction to Good Laboratory Practices	2 (0+2)
3	Basic Food Analysis Laboratory Techniques	2 (0+2)
Department of Food Business Management		
1	Business Management and Economics	2 (2+0)
2	Engineering Mathematics- I	2 (2+0)
3	Engineering Mathematics- II	2 (2+0)
4	Statistical Methods and Numerical Analysis	2 (1+1)
5	ICT Applications in Food Industry (Informatics)	3 (1+2)
6	Project Preparation and Management	2 (1+1)
	Common Courses	
1	Foundation Program (3 weeks)	4 (0+4) Non-Gradial
2	Farming Based Livelihood System	3 (2+1)
3	Communication Skills	2 (1+1)
4	Personality Development	
5	Environmental Science and Disaster Management	3 (2+1)
6	Entrepreneurship Development and Business Management	3 (2+1)
7	Agricultural Marketing and Trade	3 (2+1)
Department of Food Plant Operations		
1	Food Plant Utilities andServices	3 (2+1)
	Skill Enhancement Courses	

S. No.	Course Title	Credit hours
1	Maintenance of Food Processing Equipment	2 (0+2)
2	Introduction to Bottling andCanning Line	2 (0+2)
3	Introduction to Manufacturing of Bakery Products	2 (0+2)
4	Internship (only for exit option for award of UG-Certificate) 10 weeks	**10 (0+10)***
5	Internship (only for exit option for award of UG- Diploma)	**10 (0+10)***
6	Study tour (10-12 days during the semester)	2(0+2) Non-gradial

Summary of Credit Distributions

Categories of Courses		Credit Hours
Core Courses (Major and Minor)	:	117
Common Courses (MDC+VAC+AEC)	:	23
Skill Enhancement Courses (SEC)	:	12
Internship	:	20
MOOCs/Online Courses (Non-gradial)	:	6**
Grand Total	**:**	**172+6****

Table 1 Credits Allocation Scheme of UG programs B. Tech (Food Technology) (Credit Hours)

Semester	Core Courses (Major+ Minor)	Multi-Disciplinary Course (MDC)	Value Added Course (VAC)	Ability Enhancement Course (AEC)	Skill Enhancement Course (SEC)	Internship/ Project/ Student READY	Total Credits	Non-Gradial	Internship	Online Courses/ MOOC
I	12	3(2)		1(3) + 2(4)	4	-	22	2(1)		
II	15	---	3(6)	1(3)	4	-	23	-	10(12)	
III	16	----	3 (10)	2(8)	2	-	23			
IV	13	3(5)		2(7)	2	-	20	-	10(13)	**6**
V	19	3(9)	-	-	-	-	22	2(11)		
VI	21	-	-	-	-	-	21	-		
VII	20	-	-	-	-	-	20	-		
VIII		-	-	-	-	20	20	-		
Total	**116**	**9**	**6**	**8**	**12**	**20**	**171**	**4**		**6**

Note: The credit hours mentioned in the table includes both theory and practical.

(1) *Deeksharambh* (Induction-cum-Foundation Course) of 2 credits (2 weeks duration).
(2) Farming based Livelihood systems
(3) NCC/NSS
(4) Communication Skills
(5) Entrepreneurship Development and Business Management
(6) Environmental Studies and Disaster Management
(7) Personality Development
(8) Physical Education, First Aid, Yoga Practices and Meditation
(9) Agriculture Marketing and Trade
(10) Agriculture Informatics and artificial intelligence
(11) Study tour (10-14 days)
(12) Only for those opting for an exit with UG-Certificate
(13) Only for those opting for an exit with UG-Diploma

DETAILED SYLLABI

Semester I

Deeksharambh (2 weeks Program) 2 (0+2) NG

The activities to be taken under *Deeksharambh* shall aim at creating a platform for students to

- Help for cultural Integration of students from different backgrounds,
- Know about the operational framework of academic process in university
- Instilling life and social skills,
- Social Awareness, Ethics and Values, Team Work, Leadership, Creativity, etc.
- Identify the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenario.

The details of activities will be decided by the parent universities. The structure shall include, but not restricted to:

- Discussions on operational framework of academic process in university, as well as interactions with academic and research managers of the University
- Interaction with alumni, business leaders, perspective employers, outstanding achievers in related fields, and people with inspiring life experiences
- Students shall be made aware about the field of food processing, the industry, production systems, importance of nutrition, packaging, quality issues involved, shelf life and the legal standards available using simple day to day examples.
- In addition, the students shall be exposed to the job opportunities at various levels like production, product development, entrepreneurship opportunities and research opportunities that are existing in this area of food processing technology.
- The students will be encouraged to develop deep interest in the field in which now they have entered. It will also make it clear about the skill enhancement courses that they need to choose during the study to decide their future.
- Group activities to identify the strength and weakness of students (with expert advice for their improvement) as well as to create a platform for students to learn from each other's life experiences
- Activities to enhance cultural Integration of students from different backgrounds.
- Field visits to related fields/ establishments
- Sessions on personality development (instilling life and social skills, social awareness, ethics and values, team work, leadership, etc.) and communication skills

Fundamentals of Food Processing 3 (2+1)

Objectives

1. Gain an understanding of the perishability of food and causes for food spoilage
2. Have an idea of the basic methods of preservation of food
3. Knowledge about non thermal processing of food

Theory

Food: Definition and Functions, Classification of foods, sources, types and perishability of foods; Causes and types of food spoilage; Scope and benefit of food preservation.

Food processing: Introduction, levels and techniques; Methods of food preservation; Preservation by salt and sugar: Principle, method and effect on food quality.

Preservation by heat treatment: Principle, process and equipment for blanching, canning, pasteurization, sterilization.

Preservation by use of low temperature: Principle, methods, equipment.

Preservation by drying, dehydration and concentration: Principle, methods, equipment.

Preservation by irradiation: Principle, methods, equipment.

Preservation by chemicals- antioxidants, mould inhibitors, antibodies, acidulants, Hurdle technology etc.

Preservation by fermentation: Principles, methods, equipment.

Non-thermal preservation processes: Principles, equipment – Pulsed electric field and pulsed intense light, ultrasound, dielectric heating, ohmic and infrared heating, high pressure processing, microwave processing, Cold Plasma technology, etc.

Quality tests and shelf-life of preserved foods.

Practical

Demonstration of various perishable food items and degree of spoilage; Blanching of selected food items; Preservation of food by heat treatment- pasteurization; Preservation of food by high concentration of sugar: Jam; Preservation of food by using salt: Pickle; Preservation of food by using acidulants i.e. pickling by acid, vinegar or acetic acid; Preservation of food by using chemical preservatives; Preservation of bread, cake using mold inhibitors; Drying of fruit slices pineapple slices, apple slices in cabinet drier; Drying of green leafy vegetables; Drying of mango/ other pulp by foam-mat drying; Drying of semisolid foods using roller dryers; Drying of foods using freeze-drying process; Demonstration of preserving foods under cold vs. freezing process; Processing of foods using fermentation technique, i.e. preparation of sauerkraut; Study on effect of high pressure on microbe; Study on effect of pulse electric field on food.

Suggested Readings

1. Brennan, J.G. 2006. Food Processing Handbook. Wiley-VCH Verlag GmbH and Co. KGaA, Weinheim, Germany.
2. Desrosier N.W. and Desrosier, J.N. 1977. The Technology of Food Preservation. 4th edn. AVI Publishing Co., Connecticut, USA.
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5. Lal, G., Siddappa, G.S. and Tandon, G.L. 1959. Preservation of Fruits and Vegetables. ICAR, New Delhi.
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7. Rahman, M.S. 2007. Handbook of Food Preservation. 2nd edn. CRC Press, Boca Raton, FL, USA.
8. Stavros Y. 2008. Solving Problems in Food Engineering. Springer Science + Business Media, NY, USA.
9. Tewari, G. and Juneja, V.K. 2007. Advances in Thermal and Non-Thermal Food Preservation. Blackwell Publishing, Ames, Iowa, USA.
10. Zeuthen, P. and Bùgh-Sùrensen, L. 2003. Food Preservation Techniques. CRC Press LLC, Boca Raton, FL, USA.

Workshop Technology 3 (1+2)

Objectives

1. Gain an understanding about different type of material and their measurement
2. Have an idea of the basic methods involved in repair and maintenance of equipment
3. Knowledge about skills related to welding, blacksmith, carpentry, sheet metal, machining etc.

Theory

Introduction to basic materials: Ferrous and non-ferrous materials and important engineering materials such as timber, abrasive materials, silica, ceramics, glasses, graphite, diamond, plastic polymers and composite materials, their properties and applications.

Safety measures in workshop; Indian Factory Acts on safety; Measuring and Gauging: Basic measuring instruments and gauges.

Heat treatment processes: Introduction to hardening, tempering, annealing, normalizing, etc.

Welding: Introduction, types of welding, types of electrodes, types of flames, types of welding joints, edge preparation, welding techniques and equipment; Gas welding and cutting, arc welding; Introduction to soldering and brazing and their uses; Estimation of welding and soldering cost.

Smithy and forging: Introduction to different tools and their uses, different forging operations.

Carpentry: Introduction to various carpentry tools and materials; Type of woods and their characteristics, brief ideas about band saw, wooden lathe circular saw, wood planner, etc.

Machinery: Introduction to various workshop machines (1) Lathe, (2) power hacksaw, (3) Shaper and planner, (4) Drilling, (5) Grinder and (6) CNC machines; Length of cut, feed, depth of cut, RPM, cutting speed, time, time allowances; Estimation of machining time for different lathe operations; Estimation of machining time for shaping, slotting and planning operations, work holding and tool holding devices.

Sheet-metal: Introduction, different operations, sheet metal joints; Allowances for sheet metal, operations and joints, estimate of cost.

Practical

Identification of different materials of manufacture; Demonstration of different measuring instruments and measurement technique; Identification of various hand tools; Demonstration of various power tools and machine tools; Simple exercises in filing, fitting, chipping, hack sawing, chiseling, tapping, etc.; Introduction to welding machine, processes, tools, their use and precautions; Simple exercises on arc welding; Simple exercises in gas welding; Demonstration of various casting processes and equipment, tools and their use; Exercises on mould making using one piece pattern and two piece pattern; Demonstration of mould making using sweep pattern and match plate pattern; Simple exercises on turning: Step turning, taper turning, drilling and threading; Introduction to shaper and planner machine and preparations of various jobs on them; Introduction to drilling machines and preparation of a related jobs; Demonstration of other important operations and preparation of additional jobs.

Suggested Readings

1. Chapman, W.A.J. 1989. Workshop Technology. Parts I and II. Arnold Publishers (India) Pvt. Ltd., New Delhi.
2. Hazra Choudari, S.K. and Bose, S.K. 1982. Elements of Workshop Technology. Vols. I and II. Media Promoters and Publishers Pvt. Ltd., Mumbai.
3. Raghuwansi, B.S. 1996. A Course in Workshop Technology. Vols. I and II. Dhanpet Rai and Sons, New Delhi.

Basic Electrical Engineering 3 (2+1)

Objectives

1. Differentiate between single and three phase connection
2. Have an idea of the basic measuring electrical current and its quality
3. Knowledge about application of wiring and connections

Theory

AC Fundamentals: Definitions of cycle, frequency, time period, amplitude, Peak value, RMS value, Average value, Electro motive force, Magnetic circuits, composite magnetic circuits, magnetic leakage, hysteresis and eddy currents, phase relations and vector representation, AC through resistance, inductance and capacitance, AC series and parallel circuits, Simple R-L, R-C and R-L-C circuits; Engineering Circuit Analysis: Current, Voltage, Power, Circuit elements, Ohm's law.

3 Phase Systems: Star and Delta connections, Relationship between line and phase voltages and currents in Star and Delta connections, various methods of single and three phase power measurement.

Transformer: Principle of working, construction of single-phase transformer, core type, shell type transformer, emf equation, Phasor diagrams, Ideal transformer, transformer on no load, Transformer under load, Equivalent circuits, Transformer losses, efficiency, Regulation, Open and short circuit test.

Single phase induction motor: Double field revolving theory, characteristics, phase split, shaded pole motors.

Poly phase induction motor: Construction, operation, equivalent circuit, production of rotating field, effect of rotor resistance, torque equation, starting and speed control methods.

Alternators: Principle of operation, types of rotors, EMF equation.

D.C. Machine (generator and motor): Types, Construction and Operation, EMF equation, armature reaction, commutation of D.C. generator and their characteristics. D.C. Motors, their starting, speed controls and characteristics.

Electric Power Economics: Maximum demand charge, Load factor, Power factor and power factor improvement.

Measuring Equipment's: Classification, Characteristics of different electrical measuring systems and equipment's.

Electrical Wiring: system of wiring, domestic wiring installation, industrial electrification.

Protection devices: Earthing, Circuit protection devices, fuses, ELCB and relays.

Practical

Study of voltage resonance in L.C.R. circuits at constant frequency: (a) Star connection study of voltage and current relation. (b) Delta connection study of voltage and current relation. Measurement of Power in 3 phase circuit by wattmeter and energy meter: (a) for balanced loads, (b) for unbalanced loads. Polarity test, no-load test, efficiency and regulation test of single-phase transformer, starting of induction motors by; (a) D.O.L. (b) Manual star delta (c) Automatic star delta starts. Starting of slip ring induction motors by normal and automatic rotor resistance starters. Test on 3 phase induction motor- determination of efficiency, line current, speed slip and power factor at various outputs. Determination of relation between the induced armature voltage and speed of separately excited D.C. generator. Magnetization characteristics of D.C. generator. Study the starter connection and starting reversing and adjusting speed of a D.C. motor. Problems on Industrial Electrification. Study of various circuit protection devices. Study of various measuring instruments.

Suggested Readings

1. Theraja, B.L. and Theraja, A.K. 2005. A Textbook of Electrical Technology. Vol. II. S. Chand and Company Ltd., New Delhi.
2. Toro, V.D. 2000. Electrical Engineering Fundamentals. Prentice-Hall India Private Ltd., New Delhi.

General Microbiology 3 (2+1)

Objectives

1. Identify the micro-organisms, their structure and growth characteristics
2. Techniques for cultivation and preservation and control

Theory

Scope and history of microbiology: (notable contributions of Leeuwenhoek, Pasteur, Koch, etc.), Place of Microorganisms in living world; Groups of microorganisms; Applied area of microbiology,

Classification and identification of micro- organism; Major Characteristics of Microorganisms, Methods of classification of bacteria.

Microscopy: Introduction to microscope; Component of microscope; Types of microscope and Microscopic techniques.

Microbial Ultra Structure and Functions: Morphological features; Structures external to cell wall, Cell wall; Structures internal to cell wall.

Cultivation and preservation of micro-organisms: Nutritional requirements; Types of media. Physical condition required for the growth; Enumeration methods for micro-organisms.

Bacterial Metabolism and Growth: Reproduction of bacteria; Growth of bacteria: growth curve, continuous culture, synchronous culture; Methods of isolation of pure cultures; Maintenance and preservation of pure cultures; Culture collections.

Control of microorganisms: Physical and Chemical agents.

Bacterial genetics.

Structure and functions of DNA and RNA; Overview of replication and regulation.

Practical

Microscopy; Micrometry; Cleaning and sterilization of glassware and acquainting with equipment used in microbiology; Preparation of nutrient agar media and techniques of inoculation; Staining methods (monochrome staining, gram staining, negative staining, capsule- staining, flagella staining and endospore staining); Pure culture techniques (streak plate/pour plate/spread plate); Identification procedures (morphology and cultural characteristics); Growth characteristics of fungi: Determination of microbial numbers, direct plate count, generation time; Factors influencing growth: pH, temperature, growth curves for bacteria.

Suggested Readings

1. Pelczar Jr. M.J., Chan, E.C.S. and Krieg, N.R. 1998. Microbiology. 5th edn. Tata McGraw-Hill Education, New Delhi.
2. Tortora, G.J., Funke, B.R. and Case, C.L. 2014. Microbiology: An Introduction. 12th edn. Prentice-Hall, NY, USA.
3. Willey, J.M., Sherwood, L.M. and Woolverton, C.J. 2013. Prescott's Microbiology. 9th edn. McGraw-Hill Higher Education, NY, USA.

Farming based Livelihood Systems 3 (2+1)

Objectives

1. To make the students aware about farming based livelihood systems in agriculture
2. To disseminate the knowledge and skill how farming based systems can be a source of livelihood

Theory

Status of agriculture in India and different states, Income of farmers and rural people in India, Livelihood-Definition, concept and livelihood pattern in urban and rural areas, Different

indicators to study livelihood systems. Agricultural livelihood systems (ALS): Meaning, approach, approaches and framework, Definition of farming systems and farming based livelihood systems Prevalent Farming systems in India contributing to livelihood. Types of traditional and modern farming systems. Components of farming system/ farming-based livelihood systems- Crops and cropping systems, Livestock (dairy, piggery, goatry, poultry, duckry etc.), Horticultural crops, Agro--forestry systems, Aqua culture Duck/Poultry cum Fish, Dairy cum Fish, Piggery cum Fish etc., Small-, medium- and large- enterprises including value chains and secondary enterprises as livelihood components for farmers, Factors affecting integration of various enterprises of farming for livelihood. Feasibility of different farming systems for different agro-climatic zones, Commercial farming-based livelihood models by NABARD, ICAR and other organizations across the country, Case studies on different livelihood enterprises associated with the farming. Risk and success factors in farming-based livelihood systems, Schemes and programs by Central and State Government, Public and Private organizations involved in promotion of farming-based livelihood opportunities. Role of farming- based livelihood enterprises in 21st Century in view of circular economy, green economy, climate change, digitalization and changing life style.

Practical

Survey of farming systems and agricultural based livelihood enterprises, Study of components of important farming based livelihood models/ systems in different agro-climatic zones, Study of production and profitability of crop based, livestock based, processing based and integrated farming based livelihood models, Field visit of innovative farming system models. Visit of Agri-based enterprises and their functional aspects for integration of production, processing and distribution sectors and Study of agri-enterprises involved in industry and service sectors (Value Chain Models), Learning about concept of project formulation on farming-based livelihood systems along with cost and profit analysis, Case study of Start-Ups in agri-sectors.

Suggested Readings

1. Agarwal, A. and Narain, S. (1989). Towards Green Villages: A strategy for Environmentally, Sound and Participatory Rural Development, Center for Science and Environment, New Delhi, India
2. Ashley, C., Carney, D. (1999). Sustainable Livelihoods: Lessons from Early Experience; Department for International Development: London, UK; Volume 7. [Google Scholar].
3. Carloni, A. (2001). Global Farming Systems Study: Challenges and Priorities to 2030 – Regional Analysis: Sub-Saharan Africa, Consultation Document, FAO, Rome, Italy
4. Dixon, J. and A. Gulliver with D. Gibbon. (2001). Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World. FAO and World Bank, Rome, Italy and Washington, DC, USA.
5. Evenson, R.E. (2000). Agricultural Productivity and Production in Developing Countries. In FAO, The State of Food and Agriculture, FAO, Rome, Italy
6. Livelihood Improvement of Underprivileged Farming Community: Some Experiences from Vaishali, Samastipur, Darbhanga and Munger Districts of Bihar by B. P. Bhatt, Abhay Kumar, P.K. Thakur, Amitava Dey Ujjwal Kumar, Sanjeev Kumar, B.K. Jha, Lokendra Kumar, K. N. Pathak, A. Hassan, S. K. Singh, K. K. Singh and K. M. Singh ICAR Research Complex for Eastern Region ICAR Parisar, P.O. Bihar Veterinary College, Patna - 800 014, Bihar

7. Panwar et al. (2020). Integrated Farming System models for Agricultural Diversification, Enhanced Income and employment, Indian Council of Agricultural Research, New Delhi.
8. Reddy, S.R. (2016). Farming System and Sustainable Agriculture. Kalyani Publishers, New Delhi.
9. Singh, J.P., et al. (2015). Region Specific Integrated Farming System Models, ICAR-Indian Institute of Farming Systems Research, Modipuram.
10. Walia, S. S. and Walia, U. S. (2020). Farming System and Sustainable Agriculture, Scientific Publishers, Jodhpur, Rajasthan.

Communication Skills 2 (1+1)

Objective

To acquire competence in oral, written and non-verbal communication, develop strong personal and professional communication and demonstrate positive group communication

Theory

Communication Process: The magic of effective communication; Building self-esteem and overcoming fears; Concept, nature and significance of communication process; Meaning, types and models of communication; Verbal and non-verbal communication; Linguistic and non-linguistic barriers to communication and reasons behind communication gap/ miscommunication.

Basic Communication Skills: Listening, Speaking, Reading and Writing Skills; Precis writing/ Abstracting/Summarizing; Style of technical communication Curriculum vitae/resume writing; Innovative methods to enhance vocabulary, analogy questions.

Structural and Functional Grammar: Sentence structure, modifiers, connecting words and verbals; phrases and clauses; Case: subjective case, possessive case; objective case; Correct usage of nouns, pronouns and antecedents, adjectives, adverbs and articles; Agreement of verb with the subject: tense, mood, voice; Writing effective sentences; Basic sentence faults.

Practical

Listening and note taking; Writing skills: precis writing, summarizing and abstracting; Reading and comprehension (written and oral) of general and technical articles; Micro-presentations and Impromptu Presentations: Feedback on presentations; Stage manners: grooming, body language, voice modulation, speed; Group discussions; Public speaking exercises; vocabulary building exercises; Interview Techniques; organization of events.

Suggested readings

1. Allport, G W, 1937, Personality: A Psychological Interpretation. Holt, New York.
2. Brown Michele and Brandreth, Gyles, 1994, How to Interview and be Interviewed. Sheldon Press, London.
3. Carnegie Dale, 1997, The Quick and Easy Way to Effective Speaking. Pocket Books, New York.
4. Francis Peter S J, 2012, Soft Skills and Professional Communication. Tata McGraw Hill, New Delhi.

5. Kumar S and Pushpa Lata, 2011, Communication Skills. Oxford University Press.
6. Neuliep James W, 2003, Intercultural Communication A Contextual Approach. Houghton Mifflin Co Boston.
7. Pease, Allan, 1998, Body Language. Sudha Publications, Delhi.
8. Raman M and Singh P, 2000, Business Communication. Oxford University Press.
9. Seely J, 2013, Oxford Guide to Effective Writing and Speaking. Oxford University Press.
10. Thomson A J and Martinet A V, 1977, A Practical English Grammar. Oxford University.

National Cadet Corps (NCC-I) 1 (0+1)

- Aims, objectives, organization of NCC and NCC song. DG's cardinals of discipline.
- Drill- aim, general words of command, attention, stands at ease, stand easy and turning.
- Sizing, numbering, forming in three ranks, open and close order march, and dressing.
- Saluting at the halt, getting on parade, dismissing, and falling out.
- Marching, length of pace, and time of marching in quick/slow time and halt. Side pace, pace forward and to the rear. Turning on the march and wheeling. Saluting on the march.
- Marking time, forward march, and halt. Changing step, formation of squad and squad drill.
- Command and control, organization, badges of rank, honors, and awards
- Nation Building- cultural heritage, religions, traditions, and customs of India. National integration. Values and ethics, perception, communication, motivation, decision making, discipline and duties of good citizens. Leadership traits, types of leadership. Character/ personality development. Civil defense organization, types of emergencies, firefighting, protection. Maintenance of essential services, disaster management, aid during development projects.
- Basics of social service, weaker sections of society and their needs, NGO's and their contribution, contribution of youth towards social welfare and family planning.
- Structure and function of human body, diet and exercise, hygiene and sanitation. Preventable diseases including AIDS, safe blood donation, first aid, physical and mental health. Adventure activities. Basic principles of ecology, environmental conservation, pollution and its control.

National Service Scheme (NSS-I) 1 (0+1)

Evoking social consciousness among students through various activities viz., working together, constructive, and creative social work, to be skilful in executing democratic leadership, developing skill in program, to be able to seek self-employment, reducing gap between educated and uneducated, increasing awareness and desire to help sections of society.

All the activities related to the National Service Scheme are distributed under four different courses viz., National Service Scheme I, National Service Scheme II, National Service Scheme III and National Service Scheme IV each having one credit load.

The entire four courses should be offered continuously for two years.

A student enrolled in NSS course should put in at least 60 hours of social work in different activities in a semester other than five regular one day camp in a year and one special camp for duration of 7 days at any semester break period in the two years. Different activities will include

orientation lectures and practical works. Activities directed by the Central and State Government have to be performed by all the volunteers of NSS as per direction.

Introduction and Basic Components of NSS

- Orientation: history, objectives, principles, symbol, badge; regular programs under NSS.
- organizational structure of NSS, Code of conduct for NSS volunteers, points to be considered by NSS volunteers' awareness about health.
- NSS program activities. Concept of regular activities, special camping, day camps, basis of adoption of village/slums, conducting survey, analyzing guiding financial patterns of scheme, youth program/ schemes of GOI, coordination with different agencies and maintenance of diary. Understanding youth. Definition, profile, categories, issues and challenges of youth; and opportunities for youth who is agent of the social change.
- Community mobilization. Mapping of community stakeholders, designing the message as per problems and their culture; identifying methods of mobilization involving youth-adult partnership. Social harmony and national integration.
- Indian history and culture, role of youth in nation building, conflict resolution and peace-building. Volunteerism and *shramdaan*. Indian tradition of volunteerism, its need, importance, motivation, and constraints; shaman as part of volunteerism.
- Citizenship, constitution, and human rights. Basic features of constitution of India, fundamental rights and duties, human rights, consumer awareness and rights and rights to information. Family and society. Concept of family, community (PRIs and other community-based organizations) and society.

Semester II

Post-Harvest Engineering 3 (2+1)

Objectives

1. To understand the basic post-harvest operations
2. Gain an understanding of various engineering properties
3. Differentiate between different types of material handling systems

Theory

Overview of Post-Harvest Technology.

Concept and science, Introduction to different agricultural crops, their cropping pattern, production, harvesting and post-harvest losses, reasons for losses, importance of loss reduction, Post-Harvest Handling operations.

Water Activity; Water binding and its effect on enzymatic and non-enzymatic reactions and food texture, control of water activity and moisture.

Engineering Properties of Food Materials; physical, thermal, aerodynamic, optical, mechanical, rheological and electromagnetic properties and their measurement.

Cleaning; Cleaning of grains, washing of fruits and vegetables, types of cleaners, screens, types of screens, rotary screens, vibrating screens, machinery for cleaning of fruits and vegetables (air cleaners, washers), cleaning efficiency, care and maintenance; Peeling.

Sorting, grading, methods of grading; Grading- Size grading, colour grading, specific gravity grading; screening, equipment for grading of fruits and vegetables, grading efficiency, care and maintenance

Magnetic separator, destoners, electrostatic separators, pneumatic separator.

Decorticating and Shelling; Principles of working, design and constructional details, operating parameters, maintenance, etc. of various decorticators/dehullers/shellers, description of groundnut decorticators, maize shellers, etc.

Milling, polishing, grinding, milling equipment, de-huskers, polishers (abrasion, friction, water jet), flour milling machines, pulse milling machines, grinders, cutting machines, oil expellers, machine efficiency and power requirement.

Materials Handling; Introduction to different conveying equipment used for handling of grains; Scope and importance of material handling devices.

Study of different Material Handling systems; Classification, principles of operation, conveyor system selection/design; Belt conveyor: Principle, characteristics, design, relationship between belt speed and width, capacity, inclined belt conveyors, idler spacing, belt tension, drive tension, belt tripper; Chain conveyor: Principle of operation, advantages, disadvantages, capacity and speed, conveying chain; Screw conveyor: Principle of operation, capacity, power, troughs, loading and discharge, inclined and vertical screw conveyors; Bucket elevator: Principle, classification, operation, advantages, disadvantages, capacity, speed, bucket pickup, bucket discharge, relationship between belt speed, pickup and bucket discharge, buckets types, power requirement; Pneumatic conveying system: types, air/product separators; Gravity conveyor design considerations, capacity and power requirement.

Practical

Study of cleaners for grains; Study of washers for fruits and vegetables; Study of graders for grains; Study of graders for fruits and vegetables; Study of decorticators; Study of a maize/ sunflower sheller; Study of crop dryers; Study of a RF/MW/tray dryer; Study of hot air dryer and modelling drying kinetics; Study of vacuum dryer and modelling drying kinetics; Study of working principle of spray dryer and spray drying process; Study of drum dryer and liquid food dehydration using drum drying; Study of fluidized bed dryer and drying process; Study of freeze dryer and freeze drying process; Study of rice milling machines; Study of pulse milling machines; Study of different components of flour mill; Study of different materials handling equipment.

Suggested Readings

1. Boumans, G. 1985. Grain Handling and Storage. Elsevier Science Publishers, Amsterdam, The Netherlands.
2. Brennan, J.G. 2006. Food Processing Handbook. Wiley-VCH Verlag GmbH and Co. KGaA, Weinheim, Germany.
3. Chakraverty, A. 2008. Post Harvest Technology of Cereals, Pulses and Oilseeds, 3rd edn. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
4. Chakraverty, A. and Singh, R.P. 2014. Post Harvest Technology and Food Process Engineering.

CRC Press, Boca Raton, FL, USA.

5. Dash, S K, Bebartta, J P and Kar, A. 2012. Rice Processing and Allied Activities. Kalyani Publishers.
6. Earle, R.L. 1983. Unit operations in Food Processing. Pergamon Press, New York, USA.
7. Green, D.W. and Perry, R.H. 2008. Perry's Chemical Engineers' Handbook. McGraw-Hill Co., Inc., NY, USA.
8. Hall, C. W. and Davis, D. C. 1979. Processing Equipment for Agricultural Products. The AVI Publishing Company, Inc., Connecticut, MA, USA.
9. Henderson, S.M. and Perry, R.L. 1966. Agricultural Process Engineering, 2nd Ed. The AVI Publishing Company, Inc., Connecticut, MA, USA.
10. Mohsenin, N.N. 1980. Thermal Properties of Foods and Agricultural Materials. Gordon and Breach Science Publishers, New York.
11. Mohsenin, N.N. 1984. Electromagnetic Radiation Properties of Foods and Agricultural Products. Gordon and Breach Science Publishers, New York.
12. Mohsenin, N.N. 1986. Physical Properties of Plant and Animal Materials: Structure, Physical Characteristics and Mechanical properties, 2nd edn. Gordon and Breach Science Publishers, NY.
13. Pandey, H. Sharma, H.K., Chauhan, R.C., Sarkar, B.C. and Bera, M.B. 2010. Experiments in food process engineering. New Delhi: CBS Publisher and Distributors Pvt Ltd.
14. Sahay, K.M. and Singh, K.K. 2001. Unit Operations of Agricultural Processing. Vikas Publishing House Pvt. Ltd., Noida, UP.

Food Chemistry I 3 (2+1)

Objectives

1. Learn the chemical aspects of food and bio- materials and its importance in food processing
2. Gain an understanding of various water and macro- molecules
3. Have an idea of about the effect of processing on these biomolecules

Theory

Water; Moisture in foods, role and type of water in foods, functional properties of water, water activity and sorption isotherm, molecular mobility and foods stability; Dispersed systems of foods: Physicochemical aspects of food dispersion system (Sol, gel, foam, emulations); Rheology of diphase systems.

Carbohydrates; Monosaccharaides, disaccharides and polysaccharides, modification of carbohydrates, dietary fibres and carbohydrates digestibility; Enzymatic and chemical reactions of carbohydrates.

Proteins in foods: Proteins: Classification, structure and properties, Proteins and nutrition, Functional properties of proteins, Processing induced, physical, chemical and nutritional changes in protein, chemical and enzymatic modification of protein.

Lipids in foods: Classification, structure and properties of lipids; Role and use of lipids/ fat, crystallization and consistency, chemical aspects of lipids, lipolysis, auto-oxidation, thermal

decomposition, chemistry of frying technology of fat and oil; Oil processing: Refining, hydrogenations, inter esterification, use of oils and fats in food formulation.

Enzymatic and chemical reactions of fats; Rancidity and its types, detection techniques, chemical aspects of lipids, antioxidants.

Practical

Determination of moisture content of foods using different methods; Studies of sorption isotherms of different foods; Swelling and solubility characteristics of starches; Rheological properties of food systems; Determination of crude proteins by micro-Kjeldhal method; Determination of essential amino acids i.e. lysine, tryptophan, methionine, etc.; Isolation of egg and milk protein; Preparation of protein isolate and concentrate of proteins; Determination of acid value, saponification value and iodine number of fat/oil; Assay of amylases, papain and lipases.

Suggested Readings

1. Brady, J.W. 2013. Introductory Food Chemistry. Comstock Publishing Associates, Cornell University Press, Ithaca, USA.
2. Belitz, H. D., Grosch, W. and Schieberle, P. 2009. Food Chemistry, 4th edn. Springer-Verlag Berlin Heidelberg.
3. Fennema, O.R. 1996. Food Chemistry, 3rd edn. Marcel Dekker, Inc., New York, USA.
4. Meyer, L.H. 1974. Food Chemistry. The AVI Publishing Co Inc., Connecticut, MA, USA.

Unit Operations in Food Processing 3 (2+1)

Objectives

1. To familiarize with Commonly involved unit operations in food processing
2. Differentiate between blanching, pasteurization and sterilization
3. Application of these unit operations in food product development

Theory

Evaporation: Principles of evaporation, mass and energy balance, factors affecting rate of evaporation, thermodynamics of evaporation (phase change, boiling point elevation, Dühring plot; Heat and mass transfer in evaporator, factors influencing the overall heat transfer coefficient, influence of feed liquor properties on evaporation.

Evaporation equipment: Natural circulation evaporators, horizontal/vertical short tube, natural circulation with external calandria, long tube, forced circulation; Evaporator ancillary plant, design of evaporation systems, single effect, multiple effect evaporators, feeding methods of multiple effect evaporation systems, feed preheating, vapour recompression systems; Fouling of evaporators and heat exchangers; Recompression heat and mass recovery and vacuum creating devices.

Food freezing: Introduction, freezing point curve for food and water, freezing points of common food materials, Principles of food freezing, Freezing time calculation by using Plank's equation; Freezing systems; Direct contact systems, air blast immersion; Changes in foods; Frozen

food properties; freezing time, factors influencing freezing time, freezing/thawing time; Freeze concentration: Principles, process, methods; Frozen food storage: Quality changes in foods during frozen storage; Freeze drying: Heat mass transfer during freeze drying, equipment and practice.

Expression and Extraction: liquid-liquid extraction processes, types of equipment and design for liquid-liquid extraction, continuous multistage counter current extraction; Leaching: process, preparation of solids, rate of leaching, types of equipment, equilibrium relations.

Crystallization and dissolution: Theory and principles, kinetics, applications in food industry, equipment for crystallization.

Distillation: Principles, vapour-liquid equilibrium, continuous flow distillation, batch/ differential distillation, fractional distillation, steam distillation, distillation of wines and spirits.

Baking: Principles, baked foods, baking equipment; Roasting: Principles of roasting, roasting equipment.

Frying: theory and principles, shallow or contact frying and deep fat frying, heat and mass transfer in frying, frying equipment; Puffing: Puffing methods, puffing equipment.

Blanching: Principles and equipment; Pasteurization: Purpose, microorganisms and their reaction to temperature and other influences, Methods of heating, design and mode of operation of heating equipment, vat, tubular heat exchanger, plate heat exchanger.

Sterilization: Principles, process time, T-evaluation, design of batch and continuous sterilization, different methods and equipment; UHT sterilization, in the package sterilization, temperature and pressure patterns, equipment for sterilizing goods in the package.

Aseptic processing: principles, analysis of thermal resilience, duration mathematics of conduction heating; Thermal processing and microbial death curves; Homogenization, Emulsification.

Practical

Study of working principle open pan and vacuum evaporator and estimation of heat/mass balance during concentration of liquid foods; Study of single effect evaporator and estimation of heat/mass balance during concentration of liquid foods; multiple effect evaporator and estimation of heat/mass balance during concentration of liquid foods; Effect of sample particle size and time on solvent extraction process; Effect of temperature on crystallization rate of sugar.

Study of freezers/ Design problems on freezers; To study freezing of foods by different methods IQF freezing; Determination of freezing time of a food material; To study simple distillation process and determine the rate of distillation; To study the process of roasting/ To study the effect of time-temperature combination on roasting; Determination of oil uptake by the food product during frying.

To determine the efficacy of a blanching process; time-temperature combination for a blanching process; efficacy of a sterilization process; Determination of F value for a product in can/ retortable pouch; Study of sterilizer /blancher/ pasteurizers/ fryers/ homogenizers/ irradiators.

Suggested Readings

1. Earle, R.L. 2004. Unit Operations in Food Processing. The New Zealand Institute of Food Science and Technology, New Zealand.
2. Fellows, P. 2000. Food Processing Technology: Principles and Practice, 2nd edn. CRC Press, Boca Raton, FL, USA.
3. Geankoplis, C.G. 2003. Transport Processes and Separation Process Principles (Includes Unit Operations), 4th edn. Prentice-Hall, NY, USA.
4. Ibarz, A. and Barbosa-Cánovas, G. V. 2003. Unit Operations in Food Engineering. CRC Press, Boca Raton, FL, USA.
5. McCabe, W.L., Smith, J. and Harriott, P. 2004. Unit Operations of Chemical Engineering, 7th edn. McGraw-Hill, Inc., NY, USA.
6. Pandey, H. Sharma, H.K., Chauhan, R.C., Sarkar, B.C. and Bera, M.B. 2010. Experiments in food process engineering. New Delhi: CBS Publisher and Distributors Pvt Ltd.
7. Richardson, J F., Harker, J.H. and Backhurst, J.R. 2002. Coulson and Richardson's Chemical Engineering, Vol. 2, Particle Technology and Separation Processes, 5th edn. Butterworth–Heinemann, Oxford, UK.
8. Saravacos, G.D. and Kostaropoulos, A.E. 2002. Handbook of Food Processing Equipment. Springer Science andBusiness Media, New York, USA.
9. Singh, R.P. and Heldman, D.R. 2014. Introduction to Food Engineering, 5th edn. Elsevier, Amsterdam, The Netherlands.
10. Sinnott, R.K. 1999. Chemical Engineering, Vol. 6, Chemical Engineering Design, 3rd edn. Butterworth-Heinemann, Oxford, UK.
11. Treybal, R.E. 1980. Mass Transfer Operations, 3rd edn. McGraw-Hill Book Company, Auckland, USA.
12. Valentas, K.J., Rotstein, E. and Singh, R.P. 1997. Handbook of Food Engineering Practice. CRC Press, Boca Raton, FL, USA.

Food Thermodynamics 3 (2+1)

Objectives

1. Have an idea about basic concepts of energy and laws of thermodynamics
2. Knowledge about thermodynamic cycles and their application
3. Knowledge about psychrometric properties of air and its application in drying and other food applications

Theory

Basic concepts: definitions, approaches, thermodynamic systems, thermodynamic properties and equilibrium, state of a system, state diagram, path and process, different modes of work, Zeroth law of thermodynamics, concept of temperature, heat.

First law of thermodynamics: Energy, enthalpy, specific heats, applications of first law, steady and unsteady flow analysis.

Second law of thermodynamics: Kelvin-Planck and Clausius statements, reversible and irreversible processes, entropy, availability and irreversibility.

Properties of Pure Substances: Thermodynamic properties of pure substances in solid, liquid and vapor phases, P-V-T behaviour of simple compressible substances, phase rule.

Thermodynamic cycles: Carnot vapor power cycle, ideal Rankine cycle, air standard Otto cycle, air standard Diesel cycle, vapor-compression refrigeration cycle.

Psychometry: thermodynamic properties of moist air, perfect gas relationship, absolute humidity, relative humidity, percentage humidity, humid volume, total heat, enthalpy, dry bulb temperature, wet bulb temperature, dew point temperature, adiabatic processes, wet bulb depression, humid heat, specific volume, heating, cooling, dehumidifying, sorption isotherms.

Three stages of water, phase diagram for water, vapour pressure-temperature curve for water, heat requirement for vaporization, measurement of humidity.

Boilers and steam generation: fuels for boilers and steam generation, boiler types, boiler mountings and accessories, Introduction to Indian Boiler Regulation Act. Layout of steam pipe-line and expansion joints. Boiler Draught: Definition, importance and classification of draught, Natural and artificial draught, Calculation of Height of chimney, draught analysis; Properties of steam: Wet, dry saturated, superheated steam, use of steam tables.

Practical

Demonstration and application of zeroth law of thermodynamics; first law of thermodynamics; and second law of thermodynamics. Study of different types of boilers; boiler mounting and accessories; various types of burners and fuels; Determination of calorific values of different fuels. Study of vapour compression refrigeration test rig; heat pump; properties of wet, dry, saturated and superheated steam; Use of steam tables and Moiler charts; dryness fraction of steam; use of psychometric chart for humidification, dehumidification, heating and drying; Determination of thermodynamic properties on psychrometric charts; study of steam trap and steam line layouts; Visit to food plant with steam utilization.

Suggested Readings

1. Brooker, D.B., Bakker-Arkema, F.W. and Hall, C.W. 1976. Drying Cereal Grains. The AVI Publishing Company, Inc., Connecticut, MA, USA.
2. Geankoplis, C. J. 2003. Transport Processes and Separation Process Principles (Includes Unit Operations), 4th edn. Prentice-Hall, NY, USA.
3. McCabe, W.L., Julian Smith, Peter Harriott. 2004. Unit Operations of Chemical Engineering, 7th edn. McGraw-Hill, Inc., NY, USA.
4. Nag, P.K. 2005. Engineering Thermodynamics, 3rd edn. Tata-McGraw-Hill Education, New Delhi.
5. Pandey, H., Sharma, H.K., Chauhan, R.C., Sarkar, B.C. and Bera, M.B. 2010. Experiments in food process engineering. New Delhi: CBS Publisher and Distributors Pvt Ltd.
6. Rajput, R.K. 2007. Engineering Thermodynamics, 3rd edn. Laxmi Publications (P) Ltd., Bangalore.

7. Smith, J.M., Van Ness, H.C. and Abbott, M.M. 2005. Introduction to Chemical Engineering Thermodynamics, 7th edn. McGraw-Hill, Inc., NY, USA.

Engineering Drawing and Graphics 3 (1+2)

Objectives

1. To gain an understanding about drawing as per engineering requirement
2. Have an idea of the isometric, orthographic views and projection
3. Knowledge about Computer Aided Design

Theory

Definition of projection, Principle of projection, Methods of projections, Orthographic projection, plane of projection, First and third angle of projection.

Different methods of dimensioning; Isometric scale, Isometric axes, Isometric projection, Preparation of working drawing from models and isometric views.

Concept of sectioning; Revolved and oblique section; Sectional drawing of simple machine parts; Types of rivet heads and riveted joints, Symbols for different types of welded joints; Processes for producing leak proof joints.

Nomenclature, thread profiles, multi-start threads, left and right-hand thread; Square headed and hexagonal nuts and bolts; Conventional representation of threads; Different types of lock nuts, studs, machine screws, cap screws and wood screws; Foundation bolts; Drawing of missing views. Application of computers for design, definition of CAD, benefits of CAD, CAD system components; Computer hardware for CAD.

Practical

Introduction of drawing scales; Principles of orthographic projections; References planes; Points and lines in space and traces of lines and planes; Auxiliary planes and true shapes of oblique plain surface; True length and inclination of lines; Projections of solids: Change of position method, alteration of ground lines; Section of solids and interpenetration of solid-surfaces; Development of surfaces of geometrical solids; Isometric projection of geometrical solids; Preparation of manual drawings with dimensions from models and isometric drawings of objects and machine components; Preparation of sectional drawings of simple machine parts; Drawing of riveted joints and thread fasteners; Demonstration on computer graphics and computer aided drafting use of standard software; Sectional drawings of engineering machines; Computer graphics for food engineering applications; Interpretation of sectional views of food equipment and components; Practice in the use of basic and drawing commands on AutoCAD; Generating simple 2-D drawings with dimensioning using AutoCAD; Small Projects using CAD/CAM.

Suggested Readings

1. Bhat, N.D. and Panchal, V.M. 1995. Machine Drawing. Charotar Publishing House, Anand.
2. Bhat, N.D.1995. Elementary Engineering Drawing. Charotar Publishing House, Anand.
3. Lee, K. 1999. Principles of CAD/CAM/CAE Systems. Prentice-Hall, USA.
4. Zeid, I. 2004. Mastering CAD/CAM. McGraw-Hill Book Co., NY, USA.

Environmental Studies and Disaster Management 3 (2+1)

Objective

To expose and acquire knowledge on the environment and to gain the state-of-the-art - skill and expertise on management of disasters

Theory

Introduction to Environment - Environmental studies - Definition, scope and importance - Multidisciplinary nature of environmental studies - Segments of Environment - Spheres of Earth - Lithosphere - Hydrosphere - Atmosphere - Different layers of atmosphere. Natural Resources: Classification - Forest resources. Water resources. Mineral resources Food resources. Energy resources. Land resources. Soil resources. Ecosystems - Concept of an ecosystem - Structure and function of an ecosystem - Energy flow in the ecosystem. Types of ecosystem. Biodiversity and its conservation: Introduction, definition, types. Biogeographical classification of India. Importance and Value of biodiversity. Biodiversity hot spots. Threats and Conservation of biodiversity.

Environmental Pollution: Definition, cause, effects and control measures of: (i) Air pollution. (ii) Water pollution. (iii) Soil pollution. (vi) Marine pollution. (v) Noise pollution. (vi) Thermal pollution h. light pollution. Solid Waste Management: Classification of solid wastes and management methods, Composting, Incineration, Pyrolysis, Biogas production, Causes, effects and control measures of urban and industrial wastes. Social Issues and the Environment: Urban problems related to energy. Water conservation, rain water harvesting, watershed management. Environmental ethics: Issues and possible solutions, climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Environment Protection Act. Air (Prevention and Control of Pollution) Act. Water (Prevention and control of Pollution) Act. Wildlife Protection Act. Forest Conservation Act. Human Population and the Environment: Environment and human health: Human Rights, Value Education. Women and Child Welfare. Role of Information Technology in Environment and human health.

Disaster management - Disaster definition - Types - Natural Disasters - Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, Heat and cold waves. Man Made Disasters - Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire, oil fire, road accidents, rail accidents, air accidents, sea accidents. International and National strategy for disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, community-based organizations and media in disaster management. Central, state, district and local administration in disaster control; Armed forces in disaster response; Police and other organizations in disaster management.

Practical

Visit to a local area to document environmental assets river/ forest/ grassland /hill /mountain. Energy: Biogas production from organic wastes. Visit to wind mill / hydro power / solar power generation units. Biodiversity assessment in farming system. Floral and faunal diversity assessment in polluted and un polluted system. Visit to local polluted site - Urban/Rural/Industrial/Agricultural to study of common plants, insects and birds. Environmental sampling and preservation. Water quality analysis: pH, EC and TDS. Estimation of Acidity, Alkalinity. Estimation of water hardness.

Estimation of DO and BOD in water samples. Estimation of COD in water samples. Enumeration of E. coli in water sample. Assessment of Suspended Particulate Matter (SPM). Study of simple ecosystem – Visit to pond/river/hills. Visit to areas affected by natural disaster.

Suggested Readings

1. De. A.K. 2010. Environmental chemistry. Published by New Age International Publishers, New Delhi. ISBN:13–978 81 224 2617 5. 384 pp
2. Dhar Chakrabarti. P.G. 2011. Disaster management - India's risk management policy frameworks and key challenges. Published by Centre for Social Markets (India), Bangalore. 36 pp.
3. Erach Bharucha, Text book for Environmental studies. University Grants Commission, New Delhi.
4. Parthiban, K.T. Vennila, S. Prasanthrajan, M. Umesh Kanna, S. 2023. Forest, Environment, Biodiversity and Sustainable development. Narendra Publishing House, New Delhi, India (In Press).
5. Prasanthrajan M, Mahendran, P. P. 2008. A text book on Ecology and Environmental Science. ISBN 81-8321-104-6. Agrotech Publishing Academy, Udaipur - 313 002. First Edition.
6. Prasanthrajan M. 2018. Objective environmental studies and disaster management. ISBN 9789387893825. Scientific publishers, Jodhpur, India. Pp. 146.
7. Sharma, P.D. 2009, Ecology and Environment, Rastogi Publications, Meerut, India
8. Tyler Miller and Scot Spoolman. 2009. Living in the Environment (Concepts, Connections, and Solutions). Brooks/cole, Cengage learning publication, Belmont, USA.

National Cadet Corps (NCC-II) 1 (0+1)

- Arms Drill- Attention, stand at ease, stand easy. Getting on parade. Dismissing and falling out. Ground/take up arms, examine arms. Shoulder from the order and vice-versa, present from the order and vice-versa. Saluting at the shoulder at the halt and on the march. Short/long trail from the order and vice- versa. Guard mounting, guard of honor, Platoon/Coy Drill.
- Characteristics of rifle (.22/.303/SLR), ammunition, fire power, stripping, assembling, care, cleaning, and sight setting. Loading, cocking, and unloading. The lying position and holding.
- Trigger control and firing a shot. Range Procedure and safety precautions. Aiming and alteration of sight. Theory of groups and snap shooting. Firing at moving targets. Miniature range firing. Characteristics of Carbine and LMG.
- Introduction to map, scales, and conventional signs. Topographical forms and technical terms.
- The grid system. Relief, contours, and gradients. Cardinal points and finding north. Types of bearings and use of service protractor. Prismatic compass and its use. Setting a map, finding north and own position. Map to ground and ground to map. Knots and lashings, Camouflage and concealment, Explosives and IEDs.
- Field defence obstacles, mines and mine lying. Bridging, waterman ship. Field water supplies, tracks and their construction. Judging distance. Description of ground and indication of landmarks. Recognition and description of target. Observation and concealment. Field signals. Section formations. Fire control orders. Fire and movement. Movement with/without arms. Section battle drill. Types of communication, media, latest trends and developments.

National Service Scheme (NSS-II) **1 (0+1)**

- Importance and role of youth leadership.
- Meaning, types and traits of leadership, qualities of good leaders; importance and roles of youth leadership, Life competencies.
- Definition and importance of life competencies, problem-solving and decision-making, interpersonal communication. Youth development programs.
- Development of youth programs and policy at the national level, state level and voluntary sector; youth-focused and youth-led organizations.
- Health, hygiene and sanitation. Definition needs and scope of health education; role of food, nutrition, safe drinking water, water borne diseases and sanitation (Swachh Bharat Abhiyan) for health; national health programs and reproductive health. Youth health, lifestyle, HIV AIDS and first aid. Healthy lifestyles, HIV AIDS, drugs and substance abuse, home nursing and first aid. Youth and yoga. History, philosophy, concept, myths, and misconceptions about yoga; yoga traditions and its impacts, yoga as a tool for healthy lifestyle, preventive and curative method

Semester III

Food Chemistry II **3 (2+1)**

Objectives

1. Study chemical aspects of food and bio- materials and their importance in food processing
2. Gain an understanding of chemicals responsible for flavour, pigments and colorants
3. Have an idea of about the effect of processing on these biomolecules
4. Gain the knowledge about role of enzymes in food processing

Theory

Philosophy and definitions of flavour, Chemistry of food flavour; flavourmatics/ flavouring compounds, sensory assessment of flavour, technology for flavour retention.

Pigments in animal and plants kingdoms: Heme pigments, chlorophyll, carotenoids, phenolic and flavonoids, betalins, effect of processing on pigment behaviour; Technology for retention of natural colours of food stuffs.

Popular colors used in food and their fictional properties; Regulatory use of regulatory dyes; Colour losses during thermal processing.

Vitamin functions in body and deficiency conditions, Requirements, allowances, enrichment, restorations, fortifications, losses of vitamins, optimization and retention of vitamins.

Important minerals and their function in body and deficiency conditions, Requirements, allowances, enrichment, restorations, fortifications, losses of minerals, optimization and retention of minerals.

Various anti-nutritional factors their mode of action and inactivation.

Enzymes in Food Processing: Carbohydrases, proteasase, lipases; Modification of food using enzymes: Role of endogenous enzymes in food quality, enzymes use as processing aid, enzyme specificity, Michaelis-Menten equation, regulation mechanism.

Practical

Preparation of mineral solution by using ash and tri-acid method (dry and wet oxidations); Estimation of calcium; Determination of phosphorus; Determination of iron; Estimation of magnesium; Estimation of tannins and phytic acid from food; Determination of vitamin A (Total carotenoids), C, E; Determination of ascorbic acid by dye method; Determination of thiamin and riboflavin; Determination of food colors; Assessment of hydrocolloids as food additives; Assessment of various pectinases from fruits and vegetables.

Suggested Readings

1. Belitz, H.-D., Grosch, W. and Schieberle, P. 2009. Food Chemistry, 4th edn. Springer-Verlag Berlin Heidelberg.
2. Fennema, O.R. 1996. Food Chemistry, 3rd edn. Marcel Dekker, Inc., New York, USA.

Fluid Mechanics 3 (2+1)

Objectives

1. Get idea about types of fluids and their properties
2. Gain knowledge about the flow behaviour of the fluids
3. Differentiate about various types of pumps and their use in food processing

Theory

Units and dimensions; Properties of fluids; Static pressure of liquids: Hydraulic pressure, absolute and gauge pressure, pressure head of a liquid; Pressure on vertical rectangular surfaces, Flow behavior of viscous fluids; Compressible and non-compressible fluids; Surface tension, capillarity, Pressure measuring devices: Simple, differential, micro-, inclined manometer, mechanical gauges, piezometer; Floating bodies: Archimedes principle, stability of floating bodies; Equilibrium of floating bodies, metacentric height; Fluid flow: Classification, steady, uniform and non-uniform, laminar and turbulent, continuity equation; Bernoulli's theorem and its applications; Navier-Stokes equations in cylindrical co-ordinates, boundary conditions; Simple application of Navier-Stokes equation: Laminar flow between two straight parallel boundaries; Flow through pipes: Loss of head, determination of pipe diameter; Determination of discharge, friction factor, critical velocity; Flow through orifices, mouthpieces, notches and weirs; Vena contracta, hydraulic coefficients, discharge losses; Time for emptying a tank; Loss of head due to contraction, enlargement at entrance and exit of pipe; External and internal mouthpieces, types of notches, rectangular and triangular notches, rectangular weirs; Venturimeters, pitot tube, rotameter; Water level point gauge, hook gauge; Dimensional analysis: Buckingham's theorem application to fluid flow phenomena, Froude Number, Reynolds number, Weber number and hydraulic similitude; Pumps: classification, centrifugal pumps, submersible pumps, reciprocating pumps, positive displacement pump; Centrifugal pumps: Pumps in series and parallel, basic equations applied to centrifugal pump, loss of head due to changed discharge, static head, total head, manometric head, manometer efficiency, operating characteristics of centrifugal pumps, Submersible pumps; Reciprocating pumps: Working of reciprocating pump, double acting pump, instantaneous rate of discharge, acceleration of piston and water, gear pump; Pressure variation, work efficiency; Pressure requirements for viscous foods to lift them to different heights and selection of pumps.

Practical

Study of different tools and fittings; Study on flow rate versus pressure drop with U-tube manometer; Verification of Bernoulli's theorem; Determination of discharge co-efficient for venturi, orifice, V-notch; Verification of emptying time formula for a tank; Determination of critical Reynold's number by Reynold apparatus; Study of reciprocating, centrifugal and gear pump; Calibration of rotameter; Study of different types of valves; Study of pumps for viscous fluid; Floating bodies, liquid flow, venturimeter, orifice, weir, flow through pipes; Study and operation of centrifugal and other pumps used in dairy and food processing plants.

Suggested Readings

1. Bird, R.B., Stewart, W.E. and Lightfoot, E.N. 2002. Transport Phenomena, 2nd edn. John Wiley and Sons, Inc., New York, USA.
2. Çengel, Y. A. and Cimbala, J.M. 2006. Fluid Mechanics: Fundamentals and Applications. McGraw-Hill, Inc., New York, USA.
3. Finnemore, E.J. and Franzini, J.B. 2002. Fluid Mechanics with Engineering Applications, 10th edn. McGraw-Hill, Inc., New York, USA.
4. Munson, B.R., Young, D.R. and Okiishi, T.H. 2002. Fundamentals of Fluid Mechanics, 4th edn. John Wiley and Sons, Inc., New York, USA.
5. Nevers, N.D. 1991. Fluid Mechanics for Chemical Engineers. McGraw-Hill, Inc., New York, USA.
6. Pandey, H., Sharma, H.K., Chauhan, R.C., Sarkar, B.C. and Bera, M.B. 2010. Experiments in food process engineering. New Delhi: CBS Publisher and Distributors Pvt Ltd.
7. Streeter, V.L. 1962. Fluid Mechanics, 3rd edn. McGraw-Hill Book Co., Inc., Boston, USA.
8. White, F.M. 2010. Fluid Mechanics, 7th edn. McGraw-Hill Book Co., Inc., Boston, USA.

Heat and Mass Transfer in Food Processing 3 (2+1)

Objectives

1. Have knowledge about the mechanism of heat and mass transfer
2. Get knowledge of dimensionless numbers involved in heat and mass transfer
3. Differentiate between different types of heat exchangers

Theory

Basic heat transfer processes, heat transfer coefficients, properties related to heat transfer, food properties measurements and errors; One-dimensional steady state conduction: Theory of heat conduction, Fourier's law and its derivation, Concept of electrical analogy and its application for thermal circuits, heat transfer through composite walls and insulated pipelines; One-dimensional steady state heat conduction with heat generation: Heat flow through slab, hollow sphere and cylinder with linear heat transfer, uniform/non-uniform heat generation, development of equations of temperature distribution with different boundary conditions; Steady-state heat conduction with heat dissipation to environment: Introduction to extended surfaces (fins) of uniform area of cross-section and with Equation of temperature distribution with different boundary conditions; Effectiveness and efficiency of the fins; Introduction to unsteady state heat conduction: System with

negligible internal resistance and in various geometries; Convection: Forced and free convection, use of dimensional analysis for correlating variables affecting convection heat transfer; Dimensionless numbers: Concept of Nusselt number, Prandtl number, Reynolds number, Grashoff number, some important empirical relations used for determination of heat transfer coefficient; Heisler charts and calculations; Heat transfer to flowing fluids; Radiation: Heat radiation, emissivity, absorptivity, transmissivity, radiation through black and grey surfaces, determination of shape factors; Heat Exchangers: General discussion, fouling factors, jacketed kettles, LMTD, parallel and counter flow heat exchangers, shell and tube and plate heat exchangers, heat exchanger design; Efficiency and NTU analysis; Application of different types of heat exchangers in dairy and food industry; Mass transfer: Fick's law of diffusion, steady state diffusion of gases and liquids through solids, equimolal diffusion, isothermal evaporation of water into air, mass transfer coefficient, application in dairy and food industry.

Practical

Heat transfer analysis during conduction and convection; Study on various types of heat exchangers used in food industry; Preparation and calibration of thermocouples; Determination of thermal conductivity of different food products; Study of working principle and constructional details of plate heat exchanger; Study of working principle and constructional details of shell and tube heat exchanger. Determination of overall heat transfer coefficient of shell and tube, plate heat exchangers, jacketed kettle used in food industry; Studies on heat transfer through extended surfaces; Studies on temperature distribution and heat transfer in HTST pasteurizer; mass transfer coefficient in foods; glass transition temperature of food sample; mass transfer during leaching process.

Suggested Readings

1. Cao, E. 2010. Heat Transfer in Process Engineering. The McGraw-Hill Companies, Inc., New York, USA.
2. Don W. Green and Robert H. Perry. 2008. Perry's Chemical Engineers' Handbook. McGraw-Hill Co., Inc., NY, USA.
3. Geankoplis, C. J. 2003. Transport Processes and Separation Process Principles (Includes Unit Operations), 4th edn. Prentice-Hall, NY, USA.
4. Holman, J.P. 2010. Heat Transfer, 10th edn. McGraw-Hill Book Co., Boston, USA.
5. Lienhard IV, J.H. and Lienhard V, J.H. 2008. A Heat Transfer Textbook. Phlogiston Press, Cambrige, MA, USA.
6. McCabe, W.L., Julian Smith, Peter Harriott. 2004. Unit Operations of Chemical Engineering, 7th edn. McGraw-Hill, Inc., NY, USA.
7. Özişik, M.N. 1993. Heat Conduction, 2nd edn. John Wiley and Sons, NY, USA.
8. Pandey, H., Sharma, H.K., Chauhan, R.C., Sarkar, B.C. and Bera, M.B. 2010. Experiments in food process engineering. New Delhi: CBS Publisher and Distributors Pvt Ltd.
9. Rajput, R.K. 2008. Heat and Mass Transfer. S. Chand and Co., New Delhi
10. Richardson, J F., Harker, J.H. and Backhurst, J.R. 1999. Coulson and Richardson's Chemical Engineering, Vol. 1, Fluid Flow, Heat Transfer and Mass Transfer, 6th edn. Butterworth–Heinemann, Oxford, UK.

11. Treybal, R.E. 1980. Mass Transfer Operations, 3rd edn. McGraw-Hill Book Company, Auckland, USA.

Basic Electronics Engineering 2 (1+1)

Objectives

1. Study basic concepts of electronics and their relevance in food industry
2. Get idea about various electronic components
3. Knowledge about electronic device and their concept in measurement

Theory

Semiconductors, P-n junction, V-I characteristics of P-n junction, diode as a circuit element, rectifier; Diode circuits for OR and AND (both positive and negative logic); voltage multiplier, filter circuits; Bipolar junction transistor: Operating point, classification (A, B and C) of amplifier, various biasing methods (fixed, self, potential divider); Ideal OP-AMP characteristics, linear and non-linear applications of OP-AMP integrator, active rectifier, comparator, differentiator, differential, instrumentation amplifier and oscillator), Zener diode voltage regulator, transistor series regulator, current limiters, OP-AMP voltage regulators; Basic theorem of Boolean algebra; Combinational logic circuits (basic gates, SOP rule and K-map) and sequential logic circuits binary ladder D/A converter and A/D converter; Transducers: Classification, selection criteria, characteristics, sensors and actuators construction, working principles, applications of following transducers- Potentiometers RTD, thermocouples, thermistors, LVDT, strain gauges, capacitive and inductive transducers, piezoelectric transducers, photoelectric transducers, self-generating transducers, variable parameter type, digital, actuating and controlling devices.

Practical

Study of diode characteristics; Study of triode characteristics; Study of Zener diode; Study of V-I characteristics of P-n junction diode; Study of RC coupled amplifier; Study of RC phase shift oscillator; Study of full wave rectifier; Verification of logic gates; Determination of energy gap in a junction diode; Study of transistor characteristics in CE configuration; Study of OP-Amp IC 741 as differential amplifier; Study of half wave rectifier; Study of OP-AMP IC 741 as an active rectifier; Study of transistor characteristics; Study of temperature characteristics of resistor; Study of diode as clipper and clamper.

Suggested Readings

1. Anand Kumar. 2014. Fundamentals of Digital Circuits. PHI Pvt. Ltd., New Delhi.
2. Gupta, S. 2002. Electronic Devices and Circuits. Dhanpat Rai Publications (P) Limited, New Delhi.
3. Mehta, V.K. and Mehta, R. 2008. Principles of Electronics. S. Chand and Co., New Delhi.
4. Roy, D.C. 2003. Linear Integrated Circuits. John Wiley International, NY.
5. Sawhney, A.K. 2010. Course in Electrical and Electronics Measurements and Instrumentation. Dhanpat Rai Publications (P) Limited, New Delhi.

Food Microbiology 3 (2+1)

Objectives

1. Microbiology of different foods
2. Food borne toxins
3. Understand spoilage of food

Theory

Importance and significance of microbes in food science; Sources of microorganisms in foods and their effective control; Factors affecting growth and survival of microorganisms in foods; Intrinsic factors i.e., pH, water activity, nutrients, redox potential, oxygen etc., Extrinsic factors: Relative humidity, temperature, gaseous atmosphere etc. Normal Microbiological quality of Foods and its significance: milk and milk products, fruits and vegetables, cereals and cereal products, meat and meat products, fish and other sea foods, poultry and eggs; sugar and sugar products, slats and spices and canned foods; Chemical changes caused by microorganisms: Changes in nitrogenous organic compounds, non-nitrogenous organic compounds, organic acids, other compounds, lipids, pectic substances; Shelf life: Calculation of shelf life, Shelf-life requirements, deteriorative reactions, accelerated testing; Simulations of product: Package environment interaction, shelf-life simulation for moisture, oxygen, and light sensitive products; Microbial toxins; Bacterial toxins, fungal toxins, algal toxins and mushroom toxins; Food borne intoxications and infections: types of food involved, toxicity and symptoms, chemical properties, environmental conditions; Food borne viruses: types of food involved, noroviruses, rota viruses, prion diseases, toxicity and symptoms.

Practical

Isolation of bacteria and molds from foods; Microbial examination of cereal and cereal products: Identification, isolation and confirmation; Microbial examination of vegetable and fruits: Identification, isolation and confirmation; Microbial examination of meat and meat products: Identification, isolation and confirmation; Microbial examination of fish and other sea foods: Identification, isolation and confirmation; Microbial examination of eggs and poultry: Identification, isolation and confirmation; Microbial examination of milk and milk products: Identification, isolation and confirmation; Microbial examination of sugar, salts and spices: Microbial examination of canned products: Identification, isolation and confirmation; Determination and enumeration of pathogenic and indicator organisms in foods (Coliform/ Enterococcus); Thermal death time determination; Detection of Salmonella from food sample; Detection of coliforms from water by MPN method; Detection of *Staphylococcus aureus* from food sample.

Suggested Readings

1. Adams, M.R. and Moss, M.O. 2008. Food Microbiology, 3rd edn, The Royal Society of Chemistry, Cambridge, UK.
2. Banwart, G.J. 1989. Basic Food Microbiology, 2nd edn. Chapman and Hall, New York, USA.
3. Frazier, W.C. and Westfoff, D.C. 1987. Food Microbiology, 4th edn. Tata McGraw-Hill Education, New Delhi.
4. Jay, J.M. 2000. Modern Food Microbiology, 6th edn. Aspen Publishers, Inc., Gaithersburg, Maryland, USA.

5. Ray, B. and Bhunia, A. 2008. Fundamental Food Microbiology, 4th edn., CRC press, Taylor and Francis Group, USA.

Engineering Mathematics-I 2 (2+0)

Objectives

1. Gain knowledge about curves and their expression in mathematical form
2. Develop equations for a process and its integration

Theory

Taylor's and Maclaurin's expansions, indeterminate form: Curvature, asymptotes, tracing of curves function of two or more independent variables, partial differentiation, homogeneous functions and Euler's theorem, composite functions, total derivatives, derivative of an implicit function, change of variables, Jacobians, error evaluation, maxima and minima; Reduction formulae, Gamma and Beta functions: Rectification of standard curves, volumes and surfaces of revolution of curves Double and triple integrals, change of order of integration, application of double and triple integrals to find area and volume; Exact and Bernoulli's differential equations, equations reducible to exact form by integrating factors, equations of first order and higher degree, Clairaut's equation; Differential equations of higher orders, methods of finding complementary functions and particular integrals, Method of variation of parameters simultaneous linear differential equations with constant coefficients, Cauchy's and Legendre's linear equations, Bessel's and Legendre's differential equations series solution techniques; Differentiation of vectors, scalar and vector point functions, vector differential operator Del: Gradient of a scalar point function, Divergence and Curl of a vector point function and their physical interpretations, Identities involving Del, second order differential operator Line, Surface and volume integrals, Stoke's, divergence and Green's theorems.

Suggested Readings

1. Grewal, B.S. 2004. Higher Engineering Mathematics. Khanna Publishers Delhi.
2. Narayan, S. 2004. Differential Calculus. S. Chand and Co. Ltd., New Delhi.
3. Narayan, S. 2004. Integral Calculus. S. Chand and Co. Ltd. New Delhi.
4. Narayan, S. 2004. A Textbook of Vector Calculus. S. Chand and Co. Ltd. New Delhi

Agricultural Informatics and Artificial Intelligence 3 (2+1)

Objectives

1. To acquaint students with the basics of computer applications in agriculture, multimedia, database management, application of mobile app and decision- making processes, etc.
2. To provide basic knowledge of computer with applications in agriculture
3. To make the students familiar with Agricultural-Informatics, its components and applications in agriculture

Theory

Introduction to Computers, Anatomy of Computers, Memory Concepts, Units of Memory, Operating System: Definition and types, Applications of MS-Office for creating, Editing and Formatting a document, Data presentation, Tabulation and graph creation, Statistical

analysis, Mathematical expressions, Database, concepts and types, creating database, Uses of DBMS in Agriculture, Internet and World Wide Web (WWW): Concepts and components.

Computer programming: General concepts, Introduction to Visual Basic, Java, Fortran, C/ C++, etc. concepts and standard input/output operations.

e-Agriculture, Concepts, design and development, Application of innovative ways to use information and communication technologies (IT) in Agriculture, Computer Models in Agriculture: Statistical, weather analysis and crop simulation models, concepts, structure, inputs-outputs files, limitation, advantages and application of models for understanding plant processes, sensitivity, verification, calibration and validation, IT applications for computation of water and nutrient requirement of crops, Computer-controlled devices (automated systems) for Agri-input management, Smartphone mobile apps in agriculture for farm advice: Market price, postharvest management etc., Geospatial technology: Concepts, techniques, components and uses for generating valuable agri-information, Decision support systems: Concepts, components and applications in Agriculture, Agriculture Expert System, Soil Information Systems etc. for supporting farm decisions. Preparation of contingent crop-planning and crop calendars using IT tools, Digital India and schemes to promote digitalization of agriculture in India.

Introduction to artificial intelligence, background and applications, Turing test. Control strategies, Breadth-first search, Depth-first search, Heuristics search techniques: Best-first search, A* algorithm, IoT and Big Data; Use of AI in agriculture for autonomous crop management, and health, monitoring livestock health, intelligent pesticide application, yield mapping and predictive analysis, automatic weeding and harvesting, sorting of produce, and other food processing applications; Concepts of smart agriculture, use of AI in food and nutrition science etc.

Practical

Study of computer components, accessories, practice of important DoS Commands, Introduction of different operating systems such as Windows, Unix/ Linux, creating files and folders, File Management. Use of MS-WORD and MS Power-point for creating, editing and presenting a scientific document, MS- EXCEL - Creating a spreadsheet, Use of statistical tools, writing expressions, Creating graphs, Analysis of scientific data, Handling macros. MS-ACCESS: Creating Database, preparing queries and reports, Demonstration of Agri- information system, Introduction to World Wide Web (WWW) and its components, Introduction of programming languages such as Visual Basic, Java, Fortran, C, C++, Hands on practice on Crop Simulation Models (CSM), DSSAT/Crop-Info/Crop Syst/ Wofost, Preparation of inputs file for CSM and study of model outputs, computation of water and nutrient requirements of crop using CSM and IT tools, Use of smart phones and other devices in agro-advisory and dissemination of market information, Introduction of Geospatial Technology, Hands on practice on preparation of Decision Support System, Preparation of contingent crop planning, India Digital Ecosystem of Agriculture (IDEA).

Suggested Readings

1. Concepts and Techniques of Programming in C by Dhabal Prasad Sethi and Manoranjan, Wiley India.
2. Fundamentals of Computer by V. Rajaroman.

3. Introduction to Information Technology by Pearson.
4. Introduction to Database Management System by C. J. Date.
5. Introductory Agri Informatics by Mahapatra, Subrat Ketal, Jain Brothers Publication.

Physical Education, First Aid,Yoga Practices and Meditation 2 (0+2)

Objectives

1. To make the students aware about Physical Education, First Aid and Yoga Practices
2. To disseminate the knowledge and skill how to perform physical training, perform first aid and increase stamina and general wellbeing through yoga

Practical

Physical education; Training and Coaching - Meaning and Concept; Methods of Training; aerobic and aerobic exercises; Calisthenics, weight training, circuit training, interval training, Fartlek training; Effects of Exercise on Muscular, Respiratory, Circulatory and Digestive systems; Balanced Diet and Nutrition: Effects of Diet on Performance; Physiological changes due to ageing and role of regular exercise on ageing process; Personality, its dimensions and types; Role of sports in personality development; Motivation and Achievements in Sports; Learning and Theories of learning; Adolescent Problems andits Management; Posture; Postural Deformities; Exercises for good posture.

Yoga; History of Yoga, Types of Yoga, Introduction to Yoga.

- Asanas (Definition and Importance) Padmasan, Gaumukhasan, Bhadrasan, Vajrajasan, Shashankasan, Pashchimotasan, Ushtrasan, Tadasan, Padhastasan, Ardhchandrasan, Bhujangasan, Utanpadasan, Sarvangasan, Parvatasan, Patangasan, Shishupalanasan – left leg-right leg, Pavanmuktasan, Halasan, Sarpasan, Ardhdhanurasan, Sawasan
- Suryanamskar Pranayama (Definition and Importance) Omkar, Suryabhedan, Chandrabhedan, Anulom Vilom, Shitali, Shitkari, Bhastrika, Bhramari
- Meditation (Definition and Importance), Yogic Kriyas (Kapalbhati), Tratak, Jalneti and Tribandh
- Mudras (Definition and Importance) Gyanmudra, Dhyanmudra, Vayumudra, Akashmudra, Pruthvimudra, Shunyamudra, Suryamudra, Varunmudra, Pranmudra, Apanmudra, Vyanmudra, Uddanmudra.
- Role of yoga in sports.
- Teaching of Asanas – demonstration, practice, correction and practice.

History of sports and ancient games, Governance of sports in India; Important national sporting events; Awards in Sports; History, latest rules, measurements of playfield, specifications of equipment, skill, technique, style and coaching of major games (Cricket, football, table Tennis, Badminton, Volleyball, Basketball, Kabaddi and Kho-Kho) and Athletics.

Need and requirement of first aid. First Aid equipment and upkeep. First AID Techniques, First aid related with respiratory system. First aid related with Heart, Blood and Circulation. First aid

related with Wounds and Injuries. First aid related with Bones, Joints Muscle related injuries. First aid related with Nervous system and Unconsciousness. First aid related with Gastrointestinal Tract. First aid related with Skin, Burns. First aid related with Poisoning. First aid related with Bites and Stings. First aid related with Sense organs, Handling and transport of injured traumatized persons. Sports injuries and their treatments.

Semester IV

Fundamentals of Food Engineering 3 (2+1)

Objectives

1. Understand basic concepts of engineering principals applied to food
2. Differentiate between drying and dehydration and different types of dryers
3. knowledge about basic operations like size reduction, mixing, separation

Theory

Drying and dehydration: Basic drying theory, heat and mass transfer in drying, drying rate curves, calculation of drying times, dryer efficiencies; classification and selection of dryers; tray, vacuum, osmotic, fluidized bed, pneumatic, rotary, tunnel, trough, bin, belt, microwave, IR, heat pump and freeze dryers; dryers for liquid: Drum or roller dryer, spray dryer and foam-mat dryers. Size reduction: Benefits, classification, determination and designation of the fineness of ground material, sieve/screen analysis, principle and mechanisms of comminution of food, Rittinger's, Kick's and Bond's equations, work index, energy utilization; Size reduction equipment: Principal types, crushers (jaw crushers, gyratory, smooth roll), hammer mills and impactors, attrition mills, buhr mill, tumbling mills, tumbling mills, ultra fine grinders, fluid jet pulverizer, colloid mill, cutting machines (slicing, dicing, shredding, pulping). Mixing: theory of solids mixing, criteria of mixer effectiveness and mixing indices, rate of mixing, theory of liquid mixing, power requirement for liquids mixing; Mixing equipment: Mixers for low- or medium-viscosity liquids (paddle agitators, impeller agitators, powder-liquid contacting devices, other mixers), mixers for high viscosity liquids and pastes, mixers for dry powders and particulate solids. Mechanical Separations: Theory, centrifugation, liquid-liquid centrifugation, liquid-solid centrifugation, clarifiers, desludging and decanting machine. Filtration: Theory of filtration, rate of filtration, pressure drop during filtration, applications, constant-rate filtration and constant-pressure filtration, derivation of equation; Filtration equipment; plate and frame filter press, rotary filters, centrifugal filters and air filters, filter aids. Membrane separation: General considerations, materials for membrane construction, ultra-filtration, microfiltration, concentration, polarization, processing variables, membrane fouling, applications of ultra-filtration in food processing, reverse osmosis, mode of operation, and applications; Membrane separation methods, demineralization by electro-dialysis, gel filtration, ion exchange, per-evaporation and osmotic dehydration.

Practical

Determination of fineness modulus and uniformity index; Determination of mixing index of a feed mixer; Power requirement in size reduction of grain using Rittinger's law, Kick's law and Bond's law. Performance evaluation of hammer mill; Performance evaluation of attrition mill; Study of centrifugal separator; Study of freeze dryer and freeze-drying process; Study on osmosis in fruits;

Determination of solid gain and moisture loss during osmosis; Study of reverse osmosis process; Study of ultra-filtration/membrane separation process.

Suggested Readings

1. Earle, R.L. 1983. Unit operations in Food Processing. Pergamon Press, New York, USA.
2. Geankoplis, C. J. 2003. Transport Processes and Separation Process Principles (Includes Unit Operations), 4th edn. Prentice-Hall, NY, USA.
3. McCabe, W.L., Julian Smith, Peter Harriott. 2004. Unit Operations of Chemical Engineering, 7th Ed. McGraw-Hill, Inc., NY, USA.
4. Mohsenin, N. N. 1986. Physical Properties of Plant and Animal Materials: Structure, Physical Characteristics and Mechanical properties, 2nd edn. Gordon and Breach Science Publishers, New York.
5. Mohsenin, N. N. 1984. Electromagnetic Radiation Properties of Foods and Agricultural Products. Gordon and Breach Science Publishers, New York.
6. Mohsenin, N. N. 1980. Thermal Properties of Foods and Agricultural Materials. Gordon and Breach Science Publishers, New York.
7. Pandey, H., Sharma, H.K., Chauhan, R.C., Sarkar, B.C. and Bera, M.B. 2010. Experiments in food process engineering. New Delhi: CBS Publisher and Distributors Pvt Ltd
8. Richardson, J F., Harker, J.H. and Backhurst, J.R. 2002. Coulson and Richardson's Chemical Engineering, Vol. 2, Particle Technology and Separation Processes, 5th edn. Butterworth–Heinemann, Oxford, UK.
9. Saravacos, G.D. and Kostaropoulos, A.E. 2002. Handbook of Food Processing Equipment. Springer Science and Business Media, New York, USA.

Food Plant Sanitation 3 (2+1)

Objectives

1. Importance of sanitation and hygiene and its application to food
2. Gain knowledge of Hazard Analysis and Critical Control Point
3. Learn good manufacturing practices

Theory

Sanitation and food industry: Sanitation, sanitation laws, regulations, and guidelines, establishment of sanitary Practices. Foodborne bioterrorism: Potential risks and protection measures for bioterrorism. The Relationship of microorganisms to sanitation: Microbial growth in relation to spoilage and food borne out breaks and its control measures. The Relationship of allergens to sanitation: Food allergens and its control measures. Food contamination sources: Sources of contamination, contamination of foods, protection against contamination. Personal hygiene and sanitary food handling: Personal hygiene, employee hygiene, sanitary food handling, role of employee supervision, employee responsibility. Cleaning compounds and sanitizers: Classification, selection of cleaning compounds and sanitizers, CIP and COP, handling and storage, precautions. Pest and Rodent Control: Insect infestation, cockroaches, insect destruction, rodents, birds, use of pesticides, integrated pest management. Sanitary design and construction for food processing: Site selection,

site preparation, building construction considerations, processing and design considerations, pest control design. Waste product handling: solid waste and liquid waste management. Role of HACCP in sanitation: Good manufacturing practices, current good manufacturing practices; Standard operating procedures, good laboratory practices.

Practical

Estimation of BOD (Biological Oxygen Demand); Estimation of COD (Chemical Oxygen Demand); Determination of hardness of water; Good Manufacturing Practices (GMPs) and personal hygiene; Sewage treatment: Primary, secondary, tertiary and quaternary; Aerobic and anaerobic sludge treatment; Lab demonstration on state of water; Study of CIP plant; Isolation and identification of Actinomycetes; Enrichment and isolation of cellulose degrading bacteria; Biodegradation of phenol compounds; Bacteriological examination of water: Coliform MPN test; Sampling of airborne microorganisms; Sampling of surfaces - equipment and physical plant; Aerosol sampling and measurement guidelines.

Suggested Readings

1. Cramer, M.M. 2013. Food Plant Sanitation: Design, Maintenance, and Good Manufacturing Practices. CRC Press, Boca Raton, FL, USA.
2. Hui, Y.H., Bruinsma, B.L., Gorham, J.R., Nip, W.-K., Tong, P.S., and Ventresca, P. 2003. Food Plant Sanitation. Marcel Dekker, Inc., NY, USA.
3. Mitchell, R. and Gu, J. D. 2010. Environmental Microbiology, 2nd edn. John Wiley and Sons, Inc., Hoboken, New Jersey, USA.
4. Marriott, N.G. and Gravani, R.B. 2006. Principles of Food Sanitation, 5th edn. Springer Science and Business Media, Inc., NY, USA.
5. Pepper, I.L. and Gerba, C.P. 2005. Environmental Microbiology: Laboratory Manual, 2nd edn. Elsevier Academic Press, Amsterdam.

Food Quality, Safety Standards and Certification 2 (2+0)

Objectives

1. To familiarize the students with quality and safety of food and the standards and certification available
2. Understand quality and its assessment
3. Learn different food laws and FSMS 22000

Theory

Introduction: Definition, its role in food industry, Quality attributes; Quality Defects: Classification, Genetic-physiological defects: Structural, off color, character; Entomological defects: Holes, scars, lesions, off coloring, curled aves, pathological defects; Mechanical defects, extraneous or foreign material defects. Measurement of defects by different techniques; Quality Assessment; Quality assessment of food materials on the basis of sensory evaluation, Physical, chemical microbiological methods; Quality of products during processing and after processing; Factors influencing the food qualities: Soil, field practices, harvesting practices, procedures, packaging, transportation, storage, conditions, processing conditions, packaging and storage conditions of finished products. Role of

QC and QA Quality: Quality Control, Quality Assurance, Concepts of quality control and quality assurance functions in food industries; Quality Improvement Total Quality management: Quality evolution, quality gurus, defining TQM, principals of TQM, stages in implementation, TQM road map. Quality improvement tools, customer focus, cost of quality.

Food Laws; Food Laws and Standards: National and International food laws. Mandatory and voluntary food laws. Indian Food Regulations and Certifications: Food Safety and Standards Act FSSAI Rules, food adulteration, misbranding, common adulterants in foods, Duties and responsibilities of Food Safety Authorities. AGMARK, BIS, FPO, Weights and Measures Act, CODEX; Agricultural Marketing and Grading Standards (AGMARK), Bureau of Indian Standards (BIS) and their certification, FPO –standards and certification process Weights and Measures Act and Packaged commodity rules; Role of CODEX in food safety and standards, Food safety issues and risk analysis; FSMS 22000, Food Safety Management Systems, ISO 22000 – 2005 and other Global Food safety management systems. Principles, implementation; documentation, types of records; Auditing, certification procedures, certifying bodies, accrediting bodies.

Suggested Readings

1. Alli, I. 2004. Food Quality Assurance: Principles and Practices. CRC Press, Boca Raton, FL, USA.
2. Hester, R.E. and Harrison, R.M. 2001. Food Safety and Food Quality. Royal Society of Chemistry, Cambridge, UK
3. Schmidt, R.H. and Rodrick, G.E. 2003. Food Safety Handbook. John Wiley and Sons, Inc., Hoboken. New Jersey, USA.

Engineering Mathematics-II 2 (2+0)

Objectives

1. To familiarize the students with basic concept of mathematics
2. Gain knowledge about matrix and their transformation
3. Develop partial differential equations and their applications

Theory

Elementary transformation and rank of a matrix, reduction to normal form, Gauss-Jordan method to find inverse of a matrix; Consistency and solution of linear equations; Eigen value and vectors, Cayley-Hamilton theorem; Linear and orthogonal transformations; Diagonalization of matrices, Bilinear, Quadratic forms; Limit, continuity, derivative of function of complex variable; Analytical function, C-R equations, conjugate function, harmonic functions; Fourier series: Infinite series and its convergence, periodic function, Euler's formulae for calculating Fourier coefficients, Dirichlet's conditions; Fourier series of functions with arbitrary period; Fourier series of odd and even functions; Half range sine and cosine series, Harmonic analysis; Formation of partial differential equations; Lagrange's linear equation; Higher order linear partial differential equation with constant coefficients; Solution of non-linear partial differential equation (Charpit's method); Application of partial differential equations: One dimensional wave e.g., one dimensional heat equation, two dimensional steady state heat equation i.e. Laplace equation.

Suggested Readings

1. Ramana, B.V. 2008. Engineering Mathematics. Tata McGraw-Hill Book Co., New Delhi.
2. Grewal, B.S. 2004. Higher Engineering Mathematics. Khanna Publishers, Delhi.
3. Narayan, S. 2004. A Textbook of Matrices. S. Chand and Co. Ltd., New Delhi.

Food Plant Utilities and Services 3 (2+1)

Objectives

1. Gain knowledge of various Utilities and services required in a food processing plant
2. Understanding working of different services
3. Understand cleaning, maintenance and trouble shooting

Theory

Classification of Various Utilities and Services in food Plant/ industry. Commercial energy Pricing; Electrical System- Introduction to electric power supply systems, electrical billing, electrical load management and maximum demand control, power factor improvement and benefits, transformers, system distribution losses, harmonics, trouble shooting of electrical power system. Electrical motors- Types, losses in Introduction motor, motor efficiency, factors affecting motor performers, performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors. Compressed air system - Requirement, types, compressor efficiency, efficient compressor operation, compressed air system components, capacity assessment, leakage test, factors affecting the performance and efficiency. HVAC and Refrigeration system - Requirement, vapor compression refrigeration cycle, refrigerants, coefficient of performance, capacity, factors affecting refrigeration and air conditioning system performance and saving opportunities. Vapor absorption refrigeration system: Working principle, types and comparison with VCR system, saving potential; Fans and blowers - Requirement, types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities, Pumps and pumping systems- Requirement, types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities. DG set system- Requirement, introduction, factors affecting selection; Fuels and combustion - Introduction to fuels; properties of fuel oil, coal and gas; storage; handling and preparation of fuels; principles of combustion, combustion of oil, coal and gas; draft system. Boilers- Boiler specification, Indian boiler regulation, system components, types, combustion in boilers, performance terms, analysis of losses, feed water treatment, blow down, energy conservation opportunities; Steam system - Properties of steam, assessment of steam distribution losses, steam leakage, steam trapping, condensate and flash steam recovery system, opportunities for energy savings; Waste heat recovery - Classification, advantages and application, commercially viable waste heat recovery devices, saving potential; Other utilities and services - Lighting, CIP system, waste water/drainage, water treatment, dust removal, fire protection and maintenance system.

Practical

Study on energy basic, types, forms, terms and measuring instruments used in food plant utilities.; electrical power supply system, billing and load estimation; Motors and variable speed drives specification, selection, performance terms and definitions; compressed air system components and

performance terms and definitions; refrigeration and HVAC system components, performance terms and definitions and load estimation of a plant; fans and blowers, types, specification, performance terms and definitions. Pumps types, specification, selection, performance terms and definitions; plant lighting system and their components; DG system their specification and selection; combustion of oil, gas and coal; boiler performance terms and assessment. Study on cost of steam; waste heat recovery devices. Recuperates, Regenerators, Heat wheel, Heat pipes, Economizers, Heat exchanger (Shell and tube, PHE, run around coil exchanger, direct contact HX), Waste heat recovery boilers, Heat pumps and Thermo compressor. ClP system components; water treatment plant; effluent treatment plant; fire control operations and use of fire extinguishers.

Suggested readings

1. Energy Efficiency and Management in Food Processing Facilities by Lijun Wang. Published by CRC Press, 2008.
2. Energy-saving Techniques for the Food Industry by M. E. Casper. Published by Noyes Data Corp., 1977.
3. Chilton's Food Engineering. Published by Chilton Co., 1979.
4. A Survey of Water Use in the Food Industry by W. E. Whitman, S. D. Holdsworth. Published by British Food Manufacturing Industries Research Association.

Entrepreneurship Development and Business Management 3 (2+1)

Objectives

1. To provide student an insight into the concept and scope of entrepreneurship.
2. To expose the student to various aspects of establishment and management of a small business unit.
3. To enable the student to develop financially viable agribusiness proposal.

Theory

Development of entrepreneurship, motivational factors, social factors, environmental factors, characteristics of entrepreneurs, entrepreneurial attributes/competencies. Concept, need for and importance of entrepreneurial development. Evolution of entrepreneurship, objectives of entrepreneurial activities, types of entrepreneurs, functions of entrepreneurs, importance of entrepreneurial development, and process of entrepreneurship development. Environment scanning and opportunity identification need for scanning–spotting of opportunity-scanning of environment– identification of product / service – starting a project; factors influencing sensing the opportunities. Infrastructure and support systems- good policies, schemes for entrepreneurship development; role of financial institutions, and other agencies in entrepreneurship development. Steps involved in functioning of an enterprise. Selection of the product / services, selection of form of ownership; registration, selection of site, capital sources, acquisition of manufacturing know how, packaging and distribution. Planning of an enterprise, project identification, selection, and formulation of project; project report preparation, Enterprise Management. Production management – product, levels of products, product mix, quality control, cost of production, production controls, Material management. Production management – raw material costing, inventory control. Personal management – manpower planning, labour turn over, wages / salaries. Financial management /

accounting – funds, fixed capital and working capital, costing and pricing, long term planning and short-term planning, book keeping, journal, ledger, subsidiary books, annual financial statement, taxation. Marketing management- market, types, marketing assistance, market strategies. Crisis management- raw material, production, leadership, market, finance, natural etc.

Practical

Visit to small scale industries/agro-industries, Interaction with successful entrepreneurs/ agric-entrepreneurs. Visit to financial institutions and support agencies. Preparation of project proposal for funding by different agencies.

Suggested Readings

1. Charantimath P.M. 2009. Entrepreneurship Development and Small Business Enterprises. Pearson Publications, New Delhi.
2. Desai,Vasant. 1997. Small Scale Industries and Entrepreneurship. Himalaya Publ. House
3. Desai V. 2015. Entrepreneurship: Development and Management, Himalaya Publishing House.
4. Grover, Indu. 2008. Handbook on Empowerment and Entrepreneurship. Agrotech Public Academy.
5. Gupta CB. 2001. Management Theory and Practice. Sultan Chand and Sons.
6. Khanka SS. 1999. Entrepreneurial Development. S. Chand and Co.
7. Mehra P. 2016. Business Communication for Managers. Pearson India, New Delhi.
8. Pandey M. and Tewari D. 2010. The Agribusiness Book. IBDC Publishers, Lucknow.
9. Singh D. 1995. Effective Managerial Leadership. Deep and Deep Publ.
10. Singhal R.K. 2013. Entrepreneurship Development and Management, Katson Books.
11. Tripathi PC and Reddy PN. 1991. Principles of Management. Tata McGraw Hill.

Personality Development 2 (1+1)

Objectives

1. To make students realize their potential strengths
2. To cultivate their inter-personal skills and improve employability

Theory

Personality Definition, Nature of personality, theories of personality and its types. The humanistic approach - Maslow's self-actualization theory, shaping of personality, determinants of personality, Myers-Briggs Typology Indicator, Locus of control and performance, Type A and Type B Behaviours, personality and Organizational Behaviour. Foundations of individual behavior and factors influencing individual behavior, Models of individual behavior, Perception and attributes and factors affecting perception, Attribution theory and case studies on Perception and Attribution. Learning: Meaning and definition, theories and principles of learning, Learning and organizational behavior, Learning and training, learning feedback. Attitude and values, Intelligence- types of Intelligence, theories of intelligence, measurements of intelligence, factors influencing intelligence, intelligence and Organizational behavior, emotional intelligence. Motivation- theories and principles, Teamwork and group dynamics.

Practical

MBTI personality analysis, Learning Styles and Strategies, Motivational needs, Firo-B, Interpersonal Communication, Teamwork and team building, Group Dynamics, Win-win game, Conflict Management, Leadership styles, Case studies on Personality and Organizational Behavior.

Suggested readings

1. Andrews, Sudhir, 1988, How to Succeed at Interviews. 21st (rep.) New Delhi. Tata McGraw-Hill.
2. Heller, Robert, 2002, Effective Leadership. Essential Manager series. DK Publishing.
3. Hindle, Tim, 2003, Reducing Stress. Essential Manager series. DK Publishing.
4. Kumar, Pravesh, 2005, All about Self- Motivation. New Delhi. Goodwill Publishing House.
5. Lucas, Stephen, 2001, Art of Public Speaking. New Delhi. Tata - Mc-Graw Hill.
6. Mile, D.J., 2004, Power of Positive Thinking. Delhi. Rohan Book Company.
7. Smith, B, 2004, Body Language. Delhi: Rohan Book Company.
8. Shaffer, D. R.,2009, Social and Personality Development (6th edn). Belmont, CA: Wadsworth

Semester V

Food Biochemistry and Nutrition 3 (2+1)

Objectives

1. Gain an understanding of nutrition and diets
2. Understand and learn metabolic pathways for different biomolecules in human body

Theory

Concepts of Food and Nutrition; Functions of food; Basic food groups; nutrients supplied by food; Water and energy balance, water intake and losses, basal metabolism; Formulation of diets, classification of balanced diet, preparation of balanced diet for various groups; Recommended dietary allowances for various age groups; Malnutrition; Assessment of nutritional status; Food fad and faddism; Potentially toxic substance in human food; Mechanism of Enzyme action; Introduction to enzyme and characteristics, coenzymes, kinetics and mechanism of enzyme action; Derivation of Michaelis- Menten Equation, Enzyme inhibition by pH, allosteric enzymes; Nucleic acids, structures of various components of DNA and RNA.

Nutrients; Functions, sources, digestion, absorption, assimilation, transport of carbohydrates; Functions, sources, digestion, absorption, assimilation, transport of proteins; Functions, sources, digestion, absorption, assimilation, transport of fats; Metabolism of carbohydrates.

Introduction to carbohydrates metabolism, glycolysis, TCA cycle; Electron transport chain, oxidative and substrate level phosphorylation; Metabolism of Lipids; Introduction to lipid metabolism, β-oxidation of long chain fatty acids, Ketosis, breakdown of phospholipids; Biosynthesis of fatty acids, triglycerides and phospholipids; Introduction to protein metabolism, transamination; Deamination and decarboxylation; Fixation of Nitrogen, Urea Cycle; Functions, sources, absorption, deficiency of macrominerals, microminerals and trace minerals; Functions, sources, absorption,

deficiency of Vitamins A &D, Vitamins E and K and water-soluble vitamins Information about hormones and relation between vitamins and hormones.

Practical

Preparation of various solutions and buffers; Qualitative and quantitative determination of carbohydrates; Qualitative and quantitative determination of amino acids; Qualitative and quantitative determination of proteins; Qualitative and quantitative determination of lipids; Qualitative and quantitative determination of vitamins; Isolation of enzymes from various sources; Measurement of energy using bomb calorimeter; Determination of pka of acid; Determination of pI for casein; Estimation of sugars by Anthrone method; Estimation of protein by Lowry method; Estimation of amino acid using Biuret reaction; Separation of amino acids using paper chromatography; Separation of amino acids using thin layer chromatography; Separation of amino acids using electrophoresis; Estimation of phosphorus in food sample. Estimation of iron content in foods; Determination of calcium in food samples; Estimation of β-carotene using column chromatography; Estimation of ascorbic acid using dye method; Effects of acids and alkali on pigments.

Suggested Readings

1. Berdanier, C.D., Feldman, E.B. and Dwyer, J. 2008. Handbook of Nutrition and Food, 2nd edn. CRC Press, Boca Raton, FL, USA.
2. Berg, J.M., Tymoczko, J.L., Stryer, L. and Gatto Jr., G.J. 2002. Biochemistry, 7th edn. W.H. Freeman and Company, NY, USA.
3. Buchanan, B.B., Gruissem W. and Jones, R.L. 2002. Biochemistry and Molecular Biology of Plants. John Wiley and Sons, Inc., NY, USA.
4. Moe, G., Kelley, D., Berning, J. and Byrd-Bredbenner, C. 2013. Wardlaw's Perspectives in Nutrition: A Functional Approach. McGraw-Hill, Inc., NY, USA.
5. Nelson, D.L. and Cox, M.M. 2012. Lehninger Principles of Biochemistry, 6th edn. Macmillan Learning, NY, USA.
6. Voet, D. and Voet, J.G. 2011. Biochemistry, 4th edn. John Wiley and Sons, Inc., NY, USA.

Processing Technology of Cereals 3 (2+1)

Objectives

1. Learn milling technology of rice, wheat, corn and barley
2. Get knowledge about breakfast cereals and their processing

Theory

Present status and future prospects of cereals and millets; Morphology, physico-chemical properties of cereals, major and minor millets Chemical composition and nutritive value; Paddy processing and rice milling: Conventional milling, modern milling; Milling operations, milling machines, milling efficiency; Quality characteristics influencing final milled product; Parboiling; Rice bran stabilization and its methods; Ageing of rice; Enrichment of rice – methods of enrichment; Rice fortification; Wheat milling: Break system, purification system and reduction system; extraction rate and its effect on flour composition; Quality characteristics of flour and their suitability for baking; Corn milling: Dry and wet milling of corn, starch and gluten separation, milling fractions

and modified starches; Barley: Malting and milling; Oat/Rye: Processing, milling; Sorghum: Milling, malting, pearling; Millets (Pearl millets, finger millets): Processing of millets for food uses; Secondary and tertiary products processing of cereals and millets; By-products processing of cereals and millets; Processing of infant foods from cereals and millets; Breakfast cereal foods: Flaked, puffed, expanded, extruded and shredded.

Practical

Morphological characteristics of cereals; Physical properties of cereals; Chemical properties of cereals; Parboiling of paddy; Cooking quality of rice; Milling of rice; Conditioning and milling of wheat; Production of sorghum flakes; Production of popcorns, flaked rice, puffed rice, noodles; Preparation of sorghum malt; Determination of gelatinization temperature by amylograph; Processing of value added products from millets; Visit to Cereal processing unit.

Suggested Readings

1. Araullo, E.V., De Padua, D.B. and Graham, M. 1976. Rice Post Harvest Technology. IDRC, Canada.
2. Chakraverty, A. and Singh, R.P. 2014. Post Harvest Technology and Food Process Engineering. CRC Press, Boca Raton, FL, USA.
3. Chakraverty, A., Mujumdar, A.S., Vijaya Raghavan G.S. and Ramaswamy, H. S. 2003. Handbook of Post Harvest Technology: Cereals, Fruits, Vegetables, Tea, and Spices. Marcel Dekker, Inc., NY, USA.
4. Champagne, E.T. 2004. Rice: Chemistry and Technology, 3rd edn. AACC International, Inc., St. Paul, MN, USA.
5. David, A.V. Dendy and Dobraszczyk, B.J. 2001. Cereal and Cereal Products: Technology and Chemistry. Springer-Verlag, US.
6. Kent, N.L. and Evers, A.D. 1994. Kent's Technology of Cereals: An Introduction for Students of Food Science and Agriculture, 4th edn. Elsevier Science Ltd., Oxford, UK.
7. Khan, K. and Shewry, P.R. 2009. Wheat: Chemistry and Technology, 4th edn. AACC International, Inc., St. Paul, MN, USA.
8. Matz, S.A. 1991. The Chemistry and Technology of Cereals as Food and Feed, 2nd edn. Springer Science + Business Media, NY, USA.
9. Wrigley, C. 2004. Encyclopedia of Grain Science. Academic Press, London, UK.
10. White, P. J. and Johnson. L. Lawrence A. 2003. Corn: Chemistry and Technology, 2nd edn. AACC International, Inc., St. Paul, MN, USA.

Processing Technology of Fruits and Vegetables 3 (2+1)

Objectives

1. Understand methods of preservation of fruits and vegetables
2. Get knowledge of FSSAI specifications of fruits and vegetables products

Theory

Production and processing scenario of fruits and vegetables in India and world; Scope of fruit and vegetable processing industry in India; Overview of principles and preservation methods of

fruits and vegetables; Supply chain of fresh fruits and vegetables; Primary processing and pack house handling of fruits and vegetables; Peeling, slicing, cubing, cutting and other size reduction operations for fruits and vegetables; Minimal processing of fruits and vegetables; Blanching- operations and equipment; Canning: - Definition, processing steps, and equipment.

Cans and containers, quality assurance and defects in canned products; FSSAI specifications and preparation and preservation of juices, squashes, syrups, sherbets, nectars, cordials, etc.; Processing and equipment for above products; FSSAI specifications of crystallized fruits and preserves, jam, jelly and marmalades, candies; Preparation, preservation and machines for manufacture of above products; Preparation, preservation and machines for manufacture of chutney, pickles, sauce, puree, paste, ketchup; toffee, cheese, leather, dehydrated, wafers and papads, soup powders; Production of pectin and vinegar; Commercial processing technology of selected fruits and vegetables for production of various value added processed products; By-products of fruit and vegetable processing industry.

Practical

Primary processing of selected fruits and vegetables; Canning of Mango/Guava/ Papaya; Preparation of jam from selected fruits; Preparation of jelly from selected fruits; Preparation of fruit marmalade; Preparation of RTS; Preparation of squash; Preparation of syrup; Preparation of raisins, dried fig and dried banana; Preparation of anardana; Preparation of papain; Preparation of pickles; Preparation of dried ginger; Preparation of dried onion and garlic; Preparation of banana and potato wafers; Preparation of dehydrated leafy vegetables; Visit to fruits and vegetables pack house, canning plant, vegetable dehydration plant.

Suggested Readings

1. Chavan, U.D. and Patil, J.V. 2013. Industrial Processing of Fruits and Vegetables. Astral International Pvt. Ltd., New Delhi.
2. Chakraverty, A. Mujumdar, A.S. Vijaya Raghavan, G.S. and Ramaswamy, Hosahalli S. 2003. Handbook of Post Harvest Technology: Cereals, Fruits, Vegetables, Tea, and Spices. Marcel Dekker, Inc., NY, USA.
3. Cruess, W.V. 2004. Commercial Fruit and Vegetable Products. Agrobios India, Jodhpur.
4. Dauthy, M. E. 1995. Fruit and Vegetable Processing. FAO Agricultural Services Bulletin No.119. FAO of UN, Rome.
5. EIRI Board of Consultants and Engineers. Manufacture of Snacks, Namkeen, Papads and Potato Products. EIRI, New Delhi.
6. Hui, Y.H. 2006. Handbook of Fruits and Fruit Processing. Blackwell Publishing Ltd., Oxford, UK.
7. Hui, Y.H., Chazala, S., Graham, D.M., K.D. Murrell and Wai-Kit Nip. 2004. Handbook of Vegetable Preservation and Processing. Marcel Dekker, Inc., NY, USA.
8. Lal, G., Siddappa, G.S. and Tandon, G.L. 1959. Preservation of Fruits and Vegetables. ICAR, New Delhi.
9. Pandey, P.H. 1997. Post Harvest Technology of Fruits and Vegetables. Saroj Prakashan, Allahabad.

10. Rajarathnam, S. and Ramteke, R.S. 2011. Advances in Preservation and Processing Technologies of Fruits and Vegetables. New India Publishing Agency, New Delhi.
11. Srivastava, R.P. and Kumar, S. 2002. Fruit and Vegetable Preservation: Principles and Practices, 3rd edn. International Book Distribution Co., Delhi.
12. Thompson, A.K. 2003. Fruit and Vegetables: Harvest, Handling and Storage, 2nd edn. Blackwell Publishing Ltd., Oxford, UK.

Food Packaging Technology and Equipment 2 (1+1)

Objectives

1. Understand concept of packaging, its type and properties of packaging materials
2. Gain knowledge about intelligent, smart and active packaging
3. Learn labelling requirement and regulations

Theory

Packaging situations in World and India; Need of packaging; Package requirements, package functions; Properties of different packaging materials; Package materials: Classification of packages, paper as package material, its manufacture, types, advantages of corrugated and paper board boxes, etc.; Glass as package material, manufacture, advantages, disadvantages; Metal (Aluminum/ tin/ SS) as package material-manufacture, advantages, disadvantages, Plastic as package material, classification of polymers, properties of each plastics, uses of each plastics; Lamination: Moulding-Injection, blow, extrusion; Coating on paper and films; Aseptic packaging: Need, advantages, process, comparison of conventional and aseptic packaging, system of aseptic packaging and materials used in aseptic packaging; Permeability: Theoretical considerations, permeability of gases and vapours; Permeability of multilayer materials; Permeability in relation to packaging requirement of foods; Intelligent/Smart/Active packaging systems and their food applications, CAP/MAP; Retort structure and packaging; Edible packaging- Types and sources; Microwavable packaging - Types and applications. Transport properties of barriers; Simulations of product: Package environment interaction; Packaging of specific foods, mechanical and functional tests on package. Packaging practices followed for fruits and vegetables and their products, packaging machines, Filling machines, vacuum packaging machines. Bottle fillers, fillers for dry mixers, ice-cream fillers, Form fill and seal (FFS) machines, vacuum packaging machine, shrink wrap packaging machine, Aseptic tetra pack system; Labelling requirements, methods of coding and regulation and standards of labelling of food packages.

Practical

Classification of various packages based on material and rigidity; Measurement of thickness of paper, paper boards; Measurement of basic weight and grammage of paper and paperboards; Measurement of water absorption of paper, paper boards; Measurement of bursting strength of paper, paper boards; Measurement of tear resistance of papers; Measurement of puncture resistance of paper and paperboard; Measurement of tensile strength of paper, paper boards; Measurement of grease resistance of papers; Determination of gas and water transmission rate of package films; Determination of laquer integrity test; Drop test, Box compression test; Identification of plastic films; Determination of seal integrity, ink adhesion; packaging practices followed for packing fruits

and vegetables; Shelf life calculations for food products; Head space analysis of packaged food; Study of vacuum packaging machines, bottle filling machines and form-fill-seal machines, shrink wrap packaging machine, Aseptic tetra pack system.

Suggested Readings

1. Ahvennainen, R. 2003. Novel Food Packaging Techniques. CRC-Woodhead Publishing Ltd., Cambridge, England.
2. Coles, R., McDowell, B. and Kirwan, M.J. 2003. Food Packaging Technology. Blackwell Publishing Ltd., Oxford, UK
3. Han, J. H. 2007. Packaging for Nonthermal Processing of Food. Blackwell Publishing Ltd., Oxford, UK.
4. Han, J.H. 2005. Innovations in Food Packaging. Elsevier Science and Technology Books, UK.
5. Lee, D. S. 2008. Food Packaging Science and Technology. CRC Press, Boca Raton FL, USA.
6. Robertson, G. L. 2014. Food Packaging: Principles and Practice, 3rd edn. CRC Press, Boca Raton, FL, USA.
7. Robertson, G. L. 2010. Food Packaging and Shelf Life – A Practical Guide. CRC Press, Boca Raton, FL, USA.

Processing of Spices and Plantation Crops 3 (2+1)

Objectives

1. Learn processing technology of different spices
2. Understand post-harvest technology of tea, coffee, cocoa etc.

Theory

Production and processing scenario of spice, flavour and plantation crops and its scope; Major spices: Post harvest technology, composition; Processed products of spices: Ginger, chilli, turmeric, onion and garlic, pepper, cardamom. Equipment for cryogenic grinding; Minor spices: Herbs, leaves and spartan seasonings and their processing and utilization; All spice, Annie seed, sweet basil; Caraway seed, cassia, cinnamon Clove, coriander, cumin, dill seed; Fennel seed, nutmeg, mace, mint marjoram; Rosemary, saffron, sage; Savory, thyme, ajowan; Asafetida, curry leaves; Post-harvest technology for Tea, coffee, cocoa, Vanilla and annatto processing; Post-harvest technology and processing of areca nut, cashew nut, oil palm, coconut. Flavours of minor spices; Flavour of major spices. Spice oil and oleoresins: Extraction techniques; Super critical fluid extraction of spices. Standard specification of spices; Standards like ESA, ASTA, FSSAI and maintenance of quality by fumigation, CAS and ETO sterilization. Functional packaging of spices and spice products; By-products of plantation crops and spices.

Practical

Identification and characterization of flavouring compounds of spices; Valuable oil determination; Extraction of oil from clove, pepper, cardamom, chilli; Extraction of oleoresins: Turmeric, ginger, pepper, clove; Peperine estimation in pepper oleoresin; Steam distillation of spices; Determination of curcumin content in turmeric; Chemical analysis of spices: Moisture, valuable oil,

specific gravity, refractive index, acid value; Study of standard specification of spices; Packaging study of spices; Preparation of curry powder; Visit to spice industry.

Suggested Readings

1. Gupta, S. Handbook of Spices and Packaging with Formulae. Engineers India Research Institute, New Delhi.
2. Hirasa, K. and Takemasa, M. 1998. Spice Science and Technology. Marcel Dekker, NY, USA.
3. Panda, H. Handbook on Spices and Condiments (Cultivation, Processing and Extraction). Asia Pacific Business Press Inc., New Delhi.
4. Pruthi, J.S. 2001. Spices and Condiments – Major Spices of India. National Book Trust, New Delhi.
5. Pruthi, J.S. 2001. Spices and Condiments – Minor Spices of India. National Book Trust, New Delhi.
6. Purseglave, J.W., Brown, E.G., Green, C.L. and Robins. Spices, Vol. I and II. SRJ Academic Press, New Delhi.
7. Shanmugavelu, K.G. Spices and Plantation Crops. Oxford and IBH Publishing Co., New Delhi.

Food Storage Engineering 2 (1+1)

Objectives

1. Understand storage structure for grains and other perishables
2. Learn the design of storage structure

Theory

Introduction: Importance of scientific storage systems, post-harvest physiology of semi-perishables and perishables, climacteric and non-climacteric fruits, respiration, ripening, changes during ripening, ethylene bio-synthesis.

Damages: Direct damages, indirect damages, causes of spoilage in storage (moisture, temperature, humidity, respiration loss, heat of respiration, sprouting), destructive agents (rodents, birds, insects, etc.), sources of infestation and control.

Storage structures: Traditional storage structures, improved storage structures, modern storage structures, godown layout, staking pattern and rodent proof godown design; Farm silos: Horizontal silos, tower silos, pit silos, trench silos, size and capacity of silos.

Storage of grains: Respiration of grains, moisture and temperature changes in stored grains; conditioning of environment inside storage through ventilation.

Aeration and stored grain management: Purposes of aeration, aeration theory, aeration system design, aeration system operation.

Storage pests and control: Damage due to storage insects and pests, its control, seed coating, fumigations, etc.; Damage caused by rodents and its control.

Storage of perishables: Cold storage, controlled and modified atmospheric storage, hypobaric storage, evaporative cooling storage, conditions for storage of perishable products, control of temperature and relative humidity inside storage.

Design of storage structures: Functional and structural design of grain storage structures, pressure theories, pressure distribution in the bin, grain storage loads, pressure and capacities, warehouse and silos, BIS specifications, functional, structural and thermal design of cold stores.

Practical

Visits to traditional storage structures; Layout design, sizing, capacity and drawing of traditional storage structures; Measurement of respiration of fruits/grains in the laboratory; Study on fumigation; Visits to FCI godowns; Design of grain godowns for particular capacity and commodity; Drawing and layout of grain godown for particular commodity and capacity; Visits to cold storage. Design of cold storage for particular capacity and commodity; Drawing and layout of cold storage for particular commodity and capacity; Visits to CA storage; Design of CA storage for particular capacity and commodity; Drawing and layout of CA storage for particular commodity and capacity; Visits to evaporative cooling system for storage; Storage study in the MAP.

Suggested Readings

1. Boumans, G. 1985. Grain Handling and Storage. Elsevier Science Publishers, Amsterdam, The Netherlands.
2. Brooker, D.B., Bakker-Arkema, F.W. and Hall, C.W. 1976. Drying Cereal Grains. The AVI Publishing Company, Inc., Connecticut, MA, USA.
3. Hall, C.W. 1980. Drying and Storage of Agricultural Crops. The AVI Publishing Company, Inc., Westport, Connecticut, USA.
4. Jayas, D.S., White N.D.G. and Muir, W.E. 1994. Stored Grain Ecosystems. Marcel Dekker, New York.
5. Kutz, M. 2007. Handbook of Farm, Dairy, and Food Machinery. William Andrew, Inc., Norwich, NY, USA.
6. Michael, A.M. and Ojha, T.P. 2004. Principal of Food Technology, Vol. I. Jain Brothers, New Delhi.
7. Newbaver, L.W. and Walker, H.B. 2003. Farm Buildings Design. Prentice-Hall Inc., New Jersey, USA.
8. Pandey, H., Sharma, H.K., Chauhan, R.C., Sarkar, B.C. and Bera, M.B. 2010. Experiments in food process engineering. New Delhi: CBS Publisher and Distributors Pvt Ltd.
9. Pandey, P.H. 1997. Post Harvest Technology of Fruits and Vegetables. Saroj Prakashan, Allahabad.

Project Preparation and Management 2 (1+1)

Objectives

1. Understand concepts of project management
2. Develop knowledge to develop a project plan and its analysis

Theory

Project and project Management, Evolution of project management, Forms and environment of project management; Project life cycle; Project Identification, Screening, Project Appraisal, Project

Selection, Project Proposal and Project Scope; Project Planning; Work break down structure and Network Scheduling; Critical Path Method; Program Evaluation and Review Technique; Time-cost relationship in project; Resource Considerations in Projects, Resource Profiles and levelling, limited Resource Allocation; Project Implementation, Monitoring and Control: Project management Process and role of project manager, team building, Leadership in Projects, Organizational and behavioural issues in Project Management; Project Monitoring and Control; Project Completion and Review; Project Management - Recent trends and Future Directions. Computers in Project Management.

Practical

Brainstorming exercise to identify a set of projects and their evaluation; work break down structure for different projects; Network Scheduling and Drawing network charts for different projects; Formulation of CPM scheduling for a specific project; Formulation of PERT scheduling for a specific project; Reduction of Project Duration: Time/cost trade off; Resource Profiles and levelling; PERT/Cost Method, Earned value analysis.

Suggested Readings

1. Chandra, P. 1980. Projects- Preparation, Appraisal, Budgeting and Implementation. Tata McGraw-Hill Publication, New Delhi.
2. Chandra, P. 2014. Projects – Planning, Analysis, Selection, Financing, Implementation, and Review. Tata McGraw-Hill Publishing Company Ltd.
3. Gopalakrishnan, P. and Rama Moorthy, V.E. 2014. Textbook of Project Management. Laxmi Publications Pvt. Limited
4. Kerzner, H. 2006. Project Management – A System Approach to Planning, Scheduling, and Controlling. CBS Publishers and Distributors.
5. Nicholas, J.M. 2005. Project Management for Business and Technology – Principles and Practices. Pearson Prentice Hall.
6. Panneerselvam, R. 2004. Operations Research, 2nd edn. International Book House, Mumbai.

Agricultural Marketing and Trade 3 (2+1)

Objectives

1. To understand the fundamentals of agricultural marketing and trade
2. To analyze the factors influencing supply and demand in agricultural markets
3. To explore different marketing channels and strategies in agriculture
4. To examine the role of government policies and regulations in agricultural markets

Theory

Agricultural Marketing: Concepts and definitions of market, marketing, agricultural marketing, market structure, marketing mix and market segmentation, classification and characteristics of agricultural markets; demand, supply and producer's surplus of agri commodities: nature and determinants of demand and supply of farm products, producer's surplus – meaning and its types, marketable and marketed surplus, factors affecting marketable surplus of agri-commodities; pricing and promotion strategies: pricing considerations and approaches – cost based and competition

based pricing; market promotion – advertising, personal selling, sales promotion and publicity – meaning, merits and demerits; marketing process and functions: Marketing process concentration, dispersion and equalization; exchange functions – buying and selling; physical functions – storage, transport and processing; facilitating functions – packaging, branding, grading, quality control and labelling (Agmark); Market functionaries and marketing channels: Types and importance of agencies involved in agricultural marketing; meaning and definition of marketing channel; number of channel levels; marketing channels for different farm products; Integration, efficiency, costs and price spread: Meaning, definition and types of market integration; marketing efficiency; marketing costs, margins and price spread; factors affecting cost of marketing; reasons for higher marketing costs of farm commodities; ways of reducing marketing costs; Role of Govt. in agricultural marketing: Public sector institutions- CWC, SWC, FCI, CACP and DMI – their objectives and functions; cooperative marketing in India; Risk in marketing: Types of risk in marketing; speculation and hedging; an overview of futures trading; Agricultural prices and policy: Meaning and functions of price; administered prices; need for innovations in agricultural price policy; Trade: Concept of International Trade and its need, theories of absolute and comparative advantage. Present status and prospects of international trade in agri-commodities; WTO; Agreement on Agriculture (AoA) and its implications on Indian agriculture; IPR. Role of government in agricultural marketing. Role of APMC and its relevance in the present day context.

Practical

Plotting and study of demand and supply curves and calculation of elasticities; Study of relationship between market arrivals and prices of some selected commodities; Computation of marketable and marketed surplus of important commodities; Study of price behaviour over time for some selected commodities; Construction of index numbers; Visit to a local market to study various marketing functions performed by different agencies, identification of marketing channels for selected commodity, collection of data regarding marketing costs, margins and price spread and presentation of report in the class; Visit to market institutions –NAFED, SWC, CWC, cooperative marketing society, etc. to study their organization and functioning. Application of principles of comparative advantage of international trade.

Suggested Readings

1. Acharya, S.S. and Agarwal, N.L., 2006, Agricultural Marketing in India, Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi.
2. Chinna, S.S., 2005, Agricultural Economics and Indian Agriculture. Kalyani Pub, N Delhi.
3. Dominic Salvatore, Micro Economic Theory
4. Kohls Richard, L. and Uhl Josheph, N., 2002, Marketing of Agricultural Products, Prentice-Hall of India Private Ltd., New Delhi.
5. Kotler and Armstrong, 2005, Principles of Marketing, Pearson Prentice-Hall.
6. Lekhi, R. K. and Jogindr Singh, 2006, Agricultural Economics. Kalyani Publishers, Delhi.
7. Memoria, C.B., Joshi, R.L. and Mulla, N.I., 2003, Principles and Practice of Marketing in India, Kitab Mahal, New Delhi.
8. Pandey Mukesh and Tewari, Deepali, 2004, Rural and Agricultural Marketing, International Book Distributing Co. Ltd, New Delhi.
9. Sharma, R., 2005, Export Management, Laxmi Narain Agarwal, Agra.

Semester VI

Food Additives and Preservatives 2 (1+1)

Objectives

1. Understand types of food additives and their mechanism
2. Differentiate between natural and synthetic additives

Theory

Introduction to Food additives; Intentional and unintentional food additives, their toxicology and safety evaluation; Naturally occurring food additives; Food colors and dyes: Regulatory aspects of dyes, food color (natural and artificial), pigments and their importance and utilization as food color; Processing of natural and artificial food colorants; flavours, emulsifiers, sweeteners; Food preservatives and their chemical action; Role and mode of action of Class I and Class II preservatives; chelating agents, stabilizers and thickeners; Humectants/polyhydric alcohol, anti-caking agent, firming agent, flour bleaching and maturing agents, antioxidants, nutritional and non-nutritional sweeteners; Production of enzymes, leavening agents, fat substitutes, flavor and taste enhancers in food processing; Acidity regulators; Emulsifiers.

Practical

Evaluation of GRAS aspect of food additives; Estimation of chemical preservatives by TLC (organic and inorganic); Identification of food colour by TLC (organic and inorganic); Quantitative estimation of added dyes; Isolation and identification of naturally occurring food pigments by paper and TLC; Role and mode of action of chelating agent in fruit juice; Role and mode of action of stabilizer and thickener in frozen dairy products (ice-cream); Role and mode of clarifying agent in fruit juices; Role and mode of antioxidant in frozen fish; Role of leaving agent in baked food product; Preservation of coconut shreds using humectants.

Suggested Readings

1. Belitz, H.-D., Grosch, W. and Schieberle, P. 2009. Food Chemistry, 4th edn. Springer-Verlag Berlin Heidelberg
2. Deshpande, S.S. 2002. Handbook of Food Toxicology. Marcel and Dekker AG, Basel, Switzerland.
3. Mahindru, S.N. 2008. Food Additives: Characteristics, Detection and Estimation. Aph Publishing Corporation, New Delhi.

Sensory Evaluation of Food Products 2 (1+1)

Objectives

1. Understand basic concept of sensory evaluation
2. Gain knowledge about consumer study

Theory

Definition and importance of sensory evaluation in relation to consumer acceptability and economic aspects; Factors affecting food acceptance; Terminology related to sensory evaluation;

Principles of good practice: the sensory testing environment, test protocol considerations, Basic principles: Senses and sensory perception, physiology of sensory organs, classification of tastes and odours, threshold value factors affecting senses, visual, auditory, tactile and other responses. Flavour: Definition and its role in food quality; Taste: Classification, taste qualities, relative intensity, reaction time, effect of disease, temperature, and taste medium on taste, basic tastes, interaction of tastes; Odour: Definition, classification, neutral-mechanisms, olfactory abnormalities, odour testing, techniques, thresholds, odour intensities, olfaction; Visual, auditory, tactile and other senses, vision, audition, oral perception other than taste; Factors influencing sensory measurements: Attitudinal factors, motivation psychological errors in judgment, relation between stimulus and perception adaptation; Correlation of sensory and instrumental analysis; Requirements of sensory evaluation, sampling procedures; Factors influencing sensory measurements; Interrelationship between sensory properties of food products and various instrumental and physico-chemical tests.

Quality Evaluations Application of sensory testing: sensory evaluation in food product development, sensory evaluation in quality control. Laboratory quality measurement: Types of tests, panel selection and testing environment, serving procedures, instruction to judges, difference tests, directional difference tests, classification of difference tests, two-sample tests, three-sample tests, multisampling tests, comparison of procedures, ranking, scoring, hedonic scaling; dilution procedures, descriptive sensory analysis, contour method, other procedures; Consumer measurement: Factors influencing acceptance and preference, objectives of consumer preference studies, information obtained from consumer study, factors influencing results from consumer surveys, methods of approach, development of the questionnaire, types of questionnaires, serving procedures; Comparison of laboratory panels with consumer panels; Limitations of consumer survey.

Practical

Determination of threshold value for basic tastes; Odour recognition, difference (PC, Duo- trio, triangle); Determination of threshold value for various odours; Selection of judging panel; Training of judges, for recognition of certain common flavour and texture defects using different types of sensory tests; Descriptive analysis methodology; Sensory evaluation of various food products using different scales, score cards and tests; Texture profile methodology; Estimation of color; Relationship between objective and subjective methods; Designing a sensory laboratory.

Suggested Readings

1. Amerine, M.A., Pangborn, R.M. and Rossles, E.B. 1965. Principles of Sensory Evaluation of Food. Academic Press, London.
2. Early, R. 1995. Guide to Quality Management Systems for Food Industries. Blackie Academic.
3. Jellinek, G. 1985. Sensory Evaluation of Food - Theory and Practice. Ellis Horwood.
4. Lawless, H.T. and Klein, B.P. 1991. Sensory Science Theory and Applications in Foods. Marcel Dekker.
5. Lawless, H.T. and Heymann. H. 2010. Sensory Evaluation of Food: Principles and Practices, 2nd edn. Springer, New York or Dordrecht Heidelberg, London.
6. Macrae, R., Robinson, R.K. and Sadler, M.J. 1994. Encyclopedia of Food Science and Technology and Nutrition. Vol. XI. Academic Press.

7. Moskowitz, H. R. 2000. Applied Sensory Analysis of Foods. Vols. I, II. CRC Press, Boca Raton, FL, USA.
8. Piggot, J.R. 1984. Sensory Evaluation of Foods. Elsevier Science and Technology.
9. Potter, N.N. and Hotchleiss, J.H. 1995. Food Science, 5th edn. CBS Publishers, Delhi.
10. Rai, S.C. and Bhatia, V.K. 1988. Sensory Evaluation of Agricultural Products. Indian Agricultural Statistics Research Institute (ICAR), New Delhi.
11. Stone, H. and Sidel, J.L. 1985. Sensory Evaluation Practices. Academic Press, London.

Processing Technology of Legumes and Oilseeds 3 (2+1)

Objectives

1. Understand the nutritional value and composition of legumes and oil seeds
2. Gain knowledge about milling of pulse and oil seeds

Theory

Present status and future prospects of legumes and oilseeds; Morphology of legumes and oilseeds; Classification and types of legumes and oilseeds; Chemical composition, nutritional value and anti-nutritional compounds in legumes and oilseeds; Methods of removal of anti- nutritional compounds; Pulse milling: Home scale, cottage scale and modern milling methods, machines, milling quality, milling efficiency; Factors affecting milling quality and quantity; Problems in dhal milling industry; Nutritional changes during soaking and sprouting of pulses; Cooking quality of dhal, methods, factors affecting cooking of dhal; Quick cooking dhal, instant dhal; Soybean milk processing and value addition; Fermented products of legumes; Oil seed milling: Ghanis, hydraulic presses, expellers, solvent extraction methods, machines.

Milling quality, milling efficiency, factors affecting milling quality and quantity; Problems in oil milling industry; Desolventization; Refining of oils: Degumming, neutralization, bleaching, filtration, deodorization, winterization and their principles and process controls; Hydrogenation of oils; New technologies in oilseed processing; Utilization of oil seed meals for different food uses: High protein products like protein concentrates and isolates; By-products of pulse and oil milling and their value addition.

Practical

Determination of physical properties of legumes and oil seeds; Determination of proximate composition of selected pulses and oilseeds; Determination of nutritional quality of selected pulses and oilseeds; Study of mini dhal mill; Study of mini oil mill; Preconditioning of pulses before of mini oil mill; Preconditioning of pulses before milling; Preconditioning of oilseeds before milling; Removal of anti-nutritional compounds from selected pulses and oilseeds; Laboratory milling of selected pulses and its quality evaluation; Laboratory milling of selected oilseeds and its quality evaluation; Laboratory refining of selected oils; Laboratory hydrogenation of selected oils; Study of cooking quality of dhal; Processing of composite legume mix and preparation of value added products; Visit to commercial dhal mills and oil mills.

Suggested Readings

1. Chakraverty, A. 2008. Post Harvest Technology of Cereals, Pulses and Oilseeds, 3rd edn. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

2. Chakraverty, A., Mujumdar, A.S., Vijaya Raghavan G.S. and Ramaswamy, H. S. 2003. Handbook of Post Harvest Technology: Cereals, Fruits, Vegetables, Tea, and Spices. Marcel Dekker, Inc., NY, USA
3. Gunstone, F.D. 2008. Oils and Fats in the Food Industry. John Wiley and Sons, Ltd., West Sussex, UK.
4. Sahay, K.M. and Singh, K.K. 2001. Unit Operations of Agricultural Processing. Vikas Publishing House Pvt. Ltd., Noida, UP.
5. Shahidi, F. 2005. Bailey's Industrial Oil and Fat Products, 6th edn., Vols. 1 to 6. John Wiley and Sons, Inc. Hoboken, New Jersey, USA.

Food Refrigeration and Cold Chain 3 (2+1)

Objectives

1. Understand the concept of refrigeration system, refrigerant and their properties
2. Design of cold storage and air conditioning systems for food storage application

Theory

Principles of refrigeration: Definition, background with second law of thermodynamics, unit of refrigerating capacity, coefficient of performance; Production of low temperatures: Expansion of a liquid with flashing, reversible/ irreversible adiabatic expansion of a gas/ real gas, thermoelectric cooling, adiabatic demagnetization. Air refrigerators working on reverse Carnot cycle: Carnot cycle, reversed Carnot cycle, selection of operating temperatures; Air refrigerators working on Bell Coleman cycle: Reversed Brayton or Joule or Bell Coleman cycle, analysis of gas cycle, polytropic and multistage compression; plug and chill type refrigeration based on chemicals. Vapour refrigeration: Vapor as a refrigerant in reversed Carnot cycle with p-V and T-s diagrams, limitations of reversed Carnot cycle; Vapour compression system: Modifications in reverse Carnot cycle with vapour as a refrigerant (dry Vs wet compression, throttling Vs isentropic expansion), representation of vapor compression cycle on pressure- enthalpy diagram, super heating, sub cooling; effect of suction vapour, super heat and liquid sub cooling on actual vapour compression cycle; Vapour-absorption refrigeration system: Process, calculations, maximum coefficient of performance of a heat operated refrigerating machine; water/lithium bromide and ammonia/water absorption cooling. Common refrigerants and their properties: classification, nomenclature, desirable properties of refrigerants-physical, chemical, safety, thermodynamic and economical; azeotrope refrigerants. Components of vapour compression refrigeration system, evaporator, compressor, condenser and expansion valve; Ice manufacture: principles and systems of ice production, basic types of ice, ice makers, Treatment of water for making ice, brines, freezing tanks, ice cans, air agitation, quality of ice; Cold storage: Cold store, design of cold storage for different categories of food resources, size and shape, construction and material, insulation, vapour barriers, floors, frost-heave, interior finish and fitting, evaporators, automated cold stores, security of operations. Refrigerated transport: Handling and distribution, cold chain, refrigerated product handling, order picking, refrigerated vans, refrigerated display. Low temperature Refrigeration: cryogenic fluid and fluid properties; liquefaction; application in food. Air-conditioning: Meaning, factors affecting comfort air-conditioning, classification, sensible heat factor, industrial air-conditioning, problems on sensible heat factor; Winter/summer/year round air-conditioning, unitary air-conditioning systems, central air-conditioning, physiological principles in air-conditioning, air distribution and duct design methods; design of complete air-

conditioning systems; humidifiers and dehumidifiers; Cooling/Refrigeration load calculations: Load sources, product cooling, conduction heat load, convection heat load, internal heat sources, heat of respiration, peak load, miscellaneous loads; etc.

Practical

Study of vapour compression refrigeration system; Determination of COP of vapour compression refrigeration system; Study of various types of compressors, condensers, expansion valves and evaporative coils used in refrigeration systems; Study of refrigerants, their properties and charts; Study of direct and indirect contact freezing equipment for foods; Study of spray freezing process for foods; Study of food cold storage; Estimation of refrigeration load for cold storage; Estimation of refrigeration load for meat and poultry products; Study of refrigeration system of dairy plant; Estimation of refrigeration load for ice-cream; Study of cooling system for bakery and estimation of refrigeration loads; Estimation of refrigeration load during chocolate enrobing process; Study of refrigerated van; Study of deep freezing and thawing of foods; Study of refrigerated display of foods and estimation of cooling load.

Suggested Readings

1. ASHARE Handbook, 2006: Refrigeration.
2. Arora, C.P. 2000. Refrigeration and Air Conditioning, 2nd edn. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
3. Pandey, H., Sharma, H.K., Chauhan, R.C., Sarkar, B.C. and Bera, M.B. 2010. Experiments in food process engineering. New Delhi: CBS Publisher and Distributors Pvt Ltd.
4. Stoecker, W.F. and Jones, J.W.1982. Refrigeration and Air Conditioning, 2nd edn. McGraw-Hill Book Co., New York, USA.
5. Whitman, W.C., Johnson, W.M., Tomczyk, J.A. and Silberstein, E. 2009. Refrigeration and Air Conditioning Technology, 6th edn. Delmar, Cengage Learning, NY, USA.

Processing of Meat, Fish and Poultry Products 3 (2+1)

Objectives

1. Understand types of meat and the unit operations in meat, fish and poultry processing
2. Gain knowledge about various methods of preservation of meat, fish, poultry and their products.

Theory

Status of meat poultry and fish industry in India; Sources and importance of meat, poultry and fish. Structure and composition of muscle, types, classification and composition of fish, Pre-slaughter operations and slaughtering operations for animals and poultry. Dressing and evaluation of animal carcasses; Factors affecting post-mortem changes, properties and shelf life of meat; Mechanical deboning, grading and aging; Eating and cooking quality of meat. Preservation of meat, poultry and fish by chilling, freezing, pickling, curing, cooking and smoking, canning, dehydration, radiation, chemical and biological preservatives. Novel methods: Low dose irradiation; High pressure treatment, hurdle barrier concept for- meat, poultry and fish, Meat tenderization; Meat emulsions; Fish protein concentrates (FPC), fish protein extracts (FPE), fish protein hydrolysates (FPH); Meat

quality parameters – color water holding capacity, palatability, marbling quantum of connective tissue, firmness and storage conditions; Meat cutting and handling; Preparation, preservation and equipment for manufacture of smoked meat and its quality evaluation; Preparation, packaging and equipment for manufacture of dehydrated meat products and their quality evaluation; Preparation, preservation and equipment for manufacture of meat sausages and their quality evaluation; Surimi process, traditional and modern surimi production lines, quality of surimi products, comparison of surimi and fish mince products; Problems on mass balancing of ingredients in formulation of value added meat products; Abattoir design and layout; Preservation of fresh fish, characteristic of fresh fish and fermented and value added products of fish; Spoilage indices of fish and factors affecting the spoilage of fish; Eggs: Structure, composition, quality characteristics, defects and grading of egg processing, preservation of eggs; Processing and preservation of poultry meat and chicken patties, Preparation protocols of indigenous products: Fish sauce and paste; By-products of meat, poultry, fish and eggs and their utilization; Safety standards in meat/ fish industry: HACCP/ISO/MFPO/ FSSAI/ Kosher/Halal, EU hygienic regulations and ISO 9000 standards.

Practical

Pre-slaughter operations of meat animals and poultry birds; Slaughtering and dressing of meat animals; Study of post-mortem changes; Meat cutting and handling; Preservation of meat by freezing; Preservation of meat by curing and pickling; Preservation of meat by dehydration; Evaluation of quality and grading of eggs; Preservation of shell eggs; Preparation of value added poultry meat products; Value added egg products; Visit to abattoir. Study of anatomy and dressing of fish; Study of anatomy and dressing of prawn and other marine products; Identification of different types of fish - Selection and grading; Identification of different types of prawn and other marine products; Quality evaluation of fish; Preparation of sun dried and salt cured fish, fish sauce; Chilling and freezing of fish; Preparations of fish protein concentrate; Preparation of fish meal; Preparation of marine fish oils and various fish products; Preservation of fish: Drying, pickling; Preservation of marine products using fermentation process; Preparation of value added sea products: Cutlets, bullets, wafers; Processing of fish oils; Canning methods for marine fishery products; Estimation of TVB and TMA; Determination of iodine value; Visit to fish and prawn processing industry.

Suggested Readings

1. Berkel, B. M.-V., Boogaard, B.V.-D. and Heijnen, C. 2004. Preservation of Fish and Meat. Agromisa Foundation, Wageningen.
2. Borstorm, G. 1961. Fish as Food - Vol. I, II, III and IV. Academic Press, New York.
3. FAO. 2003. Code of Practices of Canned Fishery products. FAO, UN, Rome.
4. Hall, G.M. 1997. Fish Processing Technology, 2nd edn. Chapman and Hall, London, UK.
5. Kerry, J., Kerry, J. and Ledward, D. 2005. Meat Processing-Improving Quality. Woodhead Publishing Ltd., Cambridge, England.
6. Lawrie, R.A. 1985. Meat Science, 4th edn. Pergamon Press, Oxford, UK.
7. Nanda, Vikas 2014. Meat, Egg and Poultry Science and Technology. I.K. International Publishing House Pvt. Ltd., New Delhi.
8. Rautenstrauss, B.W. and Liehr, T. 2002. Fish Technology. Springer-Verlag, US.
9. Sen, D.P. 2005. Advances in Fish Processing Technology. Allied Publishers Pvt. Ltd., Delhi.

10. Sharma, B.D. and Sharma, K. 2011. Outlines of Meat Science and Technology. Jaypee Brothers Medical Publishers Pvt. Ltd., New Delhi.
11. Sharma, B.D. 2003. Modern Abattoir Practices and Animal Byproducts Technology. Jaypee Brothers Medical Publishers Pvt. Ltd., New Delhi.
12. Stadelman, W.J. and Cotterill, O.J. 1995. Egg Science and Technology, 4th edn. Food Products Press, NY, USA.
13. Swatland, H.J. 2004. Meat Cuts and Muscle Foods, 2nd edn. Nottingham Univ. Press, Nottingham.
14. Toldrá, F., Hui, Y. H., Astiasarán, I., Nip, W.-K., Sebranek, J.G, Silveira, E.-T.F., Stahnke, L.H., Talon, R. 2007. Handbook of Fermented Meat and Poultry. Blackwell Publishing Professional, Ames, Iowa, USA.
15. Varnam, A.H. and Sutherland, J.P. 1995. Meat and Meat Products: Technology, Chemistry and Microbiology. Chapman and Hall, London.

Processing Technology of Beverages 3 (2+1)

Objectives

1. Learn different about types of beverages
2. Various technologies involved in beverage processing
3. Gain knowledge about FSSAI specifications of beverages
4. Understand ingredients, manufacturing and packaging processes for beverages.

Theory

History and importance of beverages and status of beverage industry; Processing of beverages: Packaged drinking water, juice-based beverages, synthetic beverages, still, carbonated; Low-calorie and dry beverages, isotonic and sports drinks. Dairy based beverages, Alcoholic beverages, fruit beverages, specialty beverages, Tea, coffee, cocoa, spices, plant extracts, etc. FSSAI specifications for beverages. Ingredients, manufacturing and packaging processes and equipment for different beverages; Water treatment and quality of process water; Sweeteners, colorants, acidulants, Clouding and clarifying and flavouring agents for beverages, Carbon dioxide and carbonation. Quality tests and control in beverages, Miscellaneous beverages: Coconut water, sweet toddy, Sugar cane juice, coconut milk, flavoured syrups.

Practical

Quality analysis of raw water; Determination of density and viscosity of caramel; Determination of colours in soft drinks by wool technique; Preparation of iced and flavoured tea; Preparation of carbonated and non-carbonated beverages; Determination of caffeine in beverages; Determination of brix value, gas content, pH and acidity of beverages; Quality analysis of tea and coffee; Preparation of miscellaneous beverages; Visit to carbonation unit; Visit to mineral water plant.

Suggested Readings

1. Ashurst, P.R. 2005. Chemistry and Technology of Soft Drinks and Fruit Juices, 2nd edn. Blackwell Publishing Ltd., Oxford, UK.
2. Chakraverty, A., Mujumdar, A.S., Vijaya Raghavan G.S. and Ramaswamy, H. S. 2003. Handbook

of Post Harvest Technology: Cereals, Fruits, Vegetables, Tea, and Spices. Marcel Dekker, Inc., NY, USA.

3. Eblinger, H.M. 2009. Handbook of Brewing: Processes, Technology, Markets. Wiley-VCH Verlag GmbH and Co. KGaA, Weinheim. Germany.
4. Hui, Y.H. 2007. Handbook of Food Products Manufacturing: Principles, Bakery, Beverages, Cereals, Cheese, Confectionary, Fats, Fruits, and Functional Foods. John Wiley and Sons, Inc., Hoboken, New Jersey, USA.
5. Joshi, V.K. and Pandey, A. 1999. Biotechnology: Food Fermentation – Microbiology, Biochemistry and Technology, Vol. II. Educational Publishers and Distributors, New Delhi.
6. Varnam, A.H. and Sutherland, J.P. 1994. Beverages: Technology, Chemistry and Microbiology. Chapman, London, UK.

Bakery, Confectionery and Snack Products 3 (2+1)

Objectives

1. Learn the processing and packaging and storage of bakery and confectionary products
2. Understand extrusion technology and its application in production of breakfast cereals and snacks

Theory

Bakery products- Types (leavened and unleavened), specifications, compositions and ingredients (flour, sugar, fat, shortening, leavening agent etc.); Formulations, processing (mixing, fermentation, rounding, proofing, sheeting, moulding, baking, depanning etc.), equipment, packaging, storage and quality testing of bakery products. Processing technology of bread, biscuits and cakes. Classification of biscuits and manufacturing process of crackers

Confectionery and chocolate products: Types, specifications, compositions, ingredients, formulations; Hard boiled candies, pan coating, toffees and caramels, chewing gum and sugar free confections; Processing of chocolate – types cocoa beans and processing, other ingredients, mixing refining, conching, storage and packaging. Processing, equipment, packaging, storage and quality testing of confectionery and chocolate products. Product quality characteristics; Defects, causes and corrective measures. Extrusion technology and applications in food processing; Snack foods: Types, specifications, compositions, ingredients, Formulations, processing, equipment, packaging, storage and quality testing; Snack food seasonings. Breakfast cereals, macaroni products and malts: Specifications, compositions, ingredients; Formulations, processing, equipment for breakfast cereals, macaroni and malts; Packaging, storage and quality testing for breakfast cereals, macaroni and malts. Cooked corn products – tortilla chips; Modified starches for snack foods; Oils and industrial frying. Preservatives used in Bakery, Confectionery and snack products preservation; Quality testing of Bakery, Confectionery and snack products.

Practical

Identifications and composition of various ingredients for snacks, bakery and confectionery products; Flours, their classifications and characterization; preparation, packaging and quality evaluation of selected snack items; preparation, packaging and quality evaluation of selected bakery items; preparation, packaging and quality evaluation of selected confectionery items; preparation,

packaging and quality evaluation of selected chocolates; Preparation of traditional Indian confection. Visit to bakery, confectionary and snack units (industry).

Suggested Readings

1. Amendola, J. and Rees, N. 2003. Understanding Baking: The Art and Science of Baking. 3rd edn. John Wiley and Sons, Inc., Hoboken, New Jersey, USA.
2. Corke, H., Leyn, I.D., Cross, N.A. Nip, W.K., and Hui, Y.H. 2006. Bakery Products: Science and Technology. Blackwell Publishing Ltd., Oxford, UK.
3. Duncan Manley. 2000. Technology of Biscuits, Crackers and Cookies, 3rd edn. Woodhead Publishing Limited, Cambridge, England.
4. Grewling, P.P. 2013. Chocolates and Confections, 2nd edn. John Wiley and Sons, Inc., Hoboken, New Jersey, USA.
5. Hui, Y.H. 2007. Handbook of Food Products Manufacturing: Principles, Bakery, Beverages, Cereals, Cheese, Confectionary, Fats, Fruits, and Functional Foods. John Wiley and Sons, Inc., Hoboken, New Jersey, USA.
6. Jackson, E.B. 1995. Sugar Confectionery Manufacture, 2nd edn. Springer-Verlag, US.
7. Kent, N.L. and Evers, A.D. 1994. Kent's Technology of Cereals: An Introduction for Students of Food Science and Agriculture, 4th edn. Elsevier Science Ltd., Oxford, UK.
8. Kingslee, J. J. 2006. A Professional Text to Bakery and Confectionery. New Age International, New Delhi.
9. Matz, S.A. 1976. Snack Food Technology, 2nd edn. AVI Publishing Co., Inc., Westport, Connecticut, USA.
10. Minife, B.W. 1989. Chocolate, Cocoa, and Confectionary – Science and Technology, 3rd edn. Chapman and Hall, Inc., New York, USA.
11. Pyler, E.J. and Gorton, L.A. 2009. Baking Science and Technology, Vol. II: Formulation and Production, 4th edn. Sosland Publishing Company, Kansas City, MO, USA.
12. Pyler, E.J. and Gorton, L.A. 2008. Baking Science and Technology, Vol. I: Fundamentals and Ingredients, 4th edn. Sosland Publishing Company, Kansas City, MO, USA.

Processing Technology of Liquid Milk 2 (1+1)

Objectives

1. Understand different steps of milk processing
2. Gain knowledge about different types of milk and their process

Theory

Historical development of dairy in India; Production and utilization of milk; Composition and properties of milk; Liquid milk collection, preservation, processing, packaging and storage - standardized milk, skim milk, sterilized milk, reconstituted/rehydrated milk, recombined milk, flavored milk. Effect of thermal treatment on milk constituents. Fermented milk, acidophilous milk, etc.; Effect of thermal treatment on milk constituents; Fermented milk products: Processing, manufacture, storage and packaging of acidophilus milk, cultured buttermilk and other fermented milk; Bio-chemical changes occurring during manufacture of fermented milks; Factors affecting

these changes and effects of these changes on the quality of finished products. Cream: definition, classification, manufacture of different types of cream, processing of cream; Adulterations in milk and its detection; Quality defects in milk - causes and prevention. Liquid milk collection, processing, packaging and storage systems and equipment - bulk milk coolers, milk chilling units, milk reception equipment, milk tanks/silos, pasteurizers, sterilizers, centrifuges, clarifiers, filtration units, homogenizers, packaging and filling machines, CIP units, etc.; Hygienic design concepts, sanitary pipes and fittings, corrosion process and their control.

Practical

Platform tests of raw milk (clot on boiling (COB) test, alcohol test); Determination of physical properties of milk; Determination of proximate composition and biochemical properties of milk; Determination of microbiological properties of milk; Detection of adulterants in milk; Identification and demonstration of liquid milk processing equipment, pipes and fittings; Preparing standardized milk as per requirement; Separation of fat from milk; Pasteurization and homogenization of milk; Packaging of liquid milk; Preparation of curd and yogurt, Visit to chilling centre and dairy plant.

Suggested Readings

1. De, S. 2005. Outlines of Dairy Technology. Oxford University Press, New Delhi.
2. Hui, Y.H. 1993. Dairy Science and Technology Handbook, Vol. I, II and III. Wiley-VCH, USA.
3. Kanekanian, A. 2014. Milk and Dairy Products as Functional Foods. John Wiley and Sons, Ltd., UK.
4. Kessler, H.G. 1981. Food Engineering and Dairy Technology. Verlag A. Kessler, Fraising (F.R. Germany).
5. Tamime, A. Y. 2009. Milk Processing and Quality Management. Blackwell Publishing Ltd., UK.
6. Walstra, P., Wouters, J.T.M. and Geurts, T.J. 2006. Dairy Science and Technology, 2nd edn. CRC Press, Boca Raton, FL, USA.

Semester VII

Food Process Equipment Design 3 (2+1)

Objectives

1. Learn design consideration for storage vessels, evaporators, crystallizers, separators etc.
2. Knowledge of safety aspects in equipment design

Theory

Materials and properties: Materials for fabrication, mechanical properties, ductility, hardness, corrosion, protective coatings, corrosion prevention linings equipment, choice of materials, material codes. Design considerations: Stresses created due to static and dynamic loads, combined stresses, design stresses and theories of failure, safety factor, temperature effects, radiation effects, effects of fabrication method, economic considerations. Design of pressure and storage vessels: Operating conditions, design conditions and stress; Design of shell and its component, stresses from local load and thermal gradient, mountings and accessories. Design of heat exchangers: Design of shell and tube heat exchanger, plate heat exchanger, scraped surface heat exchanger, sterilizer and retort.

Design of evaporators and crystallizers: Design of single effect and multiple effect evaporators and its components; Design of rising film and falling film evaporators and feeding arrangements for evaporators; Design of crystallizer and entrainment separator. Design of agitators and separators: Design of agitators and baffles; Design of agitation system components and drive for agitation. Design of centrifuge separator; Design of equipment components, design of shafts, pulleys, bearings, belts, springs, drives, speed reduction systems. Design of freezing equipment: Design of ice-ream freezers and refrigerated display system. Design of dryers: Design of tray dryer, tunnel dryer, fluidized dryer, spray dryer, vacuum dryer, freeze dryer and microwave dryer. Design of extruders: Cold and hot extruder design, design of screw and barrel, design of twin screw extruder. Design of fermenters: Design of fermenter vessel, design problems. Hazards and safety considerations: Hazards in process industries, analysis of hazards, safety measures, safety measures in equipment design, pressure relief devices.

Practical

Design of pressure vessel; Design of shell and tube heat exchangers and plate heat exchanger; Design of sterilizers and retort; Design of single and multiple effect evaporators; Design of rising film and falling film evaporator; Design of crystallizer; Design of tray dryer; Design of fluidized bed dryer; Design of spray dryer; Design of vacuum dryer; Design of microwave dryer; Design of belt and chain conveyor; Design of screw conveyor; Design of bucket elevator and pneumatic conveyor; Design of twin screw extruder; Design of fermenter.

Suggested Readings

1. Albert Ibarz and Gustavo V. Barbosa-Cánovas. 2003. Unit Operations in Food Engineering. CRC Press, Boca Raton, FL, USA.
2. Bhattacharyya, B. C. 2008. Introduction to Chemical Equipment Design- Mechanical Aspect. CBS Publishers and Distributors, New Delhi.
3. Couper, J.R., Penney, W.R., Fair, J.R. and Walas, S.M. 2012 Chemical Process Equipment: Selection and Design. Elsevier Inc.
4. Geankoplis, C. J. 2003. Transport Processes and Separation Process Principles (Includes Unit Operations), 4th edn. Prentice-Hall, NY, USA.
5. Pandey, H., Sharma, H.K., Chauhan, R.C., Sarkar, B.C. and Bera, M.B. 2010. Experiments in food process engineering. New Delhi: CBS Publisher and Distributors Pvt Ltd.
6. Richardson, J F. and Peacock, D.G. 1994. Coulson and Richardsons's Chemical Engineering, Vol. 3, Chemical and Biochemical Reactors and Process Control, 3rd edn. Elsevier Butterworth-Heinemann, Amsterdam, The Netherlands.
7. Saravacos, G.D. and Kostaropoulos, A.E. 2002. Handbook of Food Processing Equipment. Springer Science and Business Media, New York, USA.
8. Singh, R.P. and Heldman, D.R. 2014. Introduction to Food Engineering, 5th edn. Elsevier, Amsterdam, The Netherlands.
9. Sinnott, R.K. 1999. Chemical Engineering, Vol. 6, Chemical Engineering Design, 3rd edn. Butterworth-Heinemann, Oxford, UK.
10. Stanbury, P.F. Whitakar, A. and Hall, S.J. 1995. Principles of Fermentation Technology, 2nd edn. Elsevier Science Ltd., Burlington, MA, USA.

11. Valentas, K.J., Rotstein, E. and Singh, R.P. 1997. Handbook of Food Engineering Practice. CRC Press, Boca Raton, FL, USA.

Processing Technology of Dairy Products 3 (2+1)

Objectives

1. Learn the processing of dairy products viz. cream, butter, ghee, ice-cream etc.
2. Gain knowledge of traditional dairy products and their processing

Theory

Cream: Basic aspect, Classification, manufacture of different types of cream, processing of cream; Classification of dairy products; Butter: Definition, composition; processing and production steps, overrun, butter making machines, quality testing of table butter, butter- defects, causes and their prevention, packaging and storage; Butter oil and ghee: Definition, composition, processing, equipment, quality tests; Paneer and Cheese: Definition, composition, types, processing steps, process flow diagram, equipment, quality defects, causes and prevention, packaging and storage. Ice cream and frozen desserts: Definition, composition, types, Processing steps and flow diagram, equipment, quality testing, defects causes and prevention, packaging and storage. Condensed and Dried milk: Definition, composition, role of milk constituents in condensed milk, manufacture of condensed milk, types of standards for dried milk. Manufacture of SMP and WMP using roller and spray drying, instantization, recent developments in drying, quality testing, defects, causes and prevention, packaging and storage. Traditional Indian Dairy Products: Definitions, compositions, processing, packaging, storage, equipment and quality testing; By- products of dairy industry and their utilization.

Practical

Preparation of butter/ table butter, Preparation of ghee, Preparation of paneer; Preparation of selected type of cheese; Preparation of ice-cream and selected frozen desserts; Preparation of condensed milk; Preparation of spray dried milk powder; Preparation of selected Indian dairy products; Shrikhand mawa/khoa based products halwa/ kheer etc., Determination of selected quality parameters of selected dairy products; Visit to dairy plant.

Suggested Readings

1. Aneja, R.P., Mathur, B.N., Chandan, R.C. and Banerjee, A.K. 2002. Technology of Indian Milk Products: Handbook of Process Technology Modernization for Professionals Entrepreneurs and Scientists, Dairy India Yearbook
2. De, S. 2005. Outlines of Dairy Technology. Oxford University Press, New Delhi.
3. Kanekanian, A. 2014. Milk and Dairy Products as Functional Foods. John Wiley and Sons, Ltd., UK.
4. Kessler, H.G. 1981. Food Engineering and Dairy Technology. Verlag A. Kessler, Fraising, F.R. Germany.
5. Hui, Y.H. 1993. Dairy Science and Technology Handbook, Vol. I, II and III. Wiley-VCH, USA.
6. Walstra, P., Wouters, J.T.M. and Geurts, T.J. 2006. Dairy Science and Technology, 2nd edn. CRC Press, Boca Raton, FL, USA.

7. Tamime, A. Y. 2009. Milk Processing and Quality Management. Blackwell Publishing Ltd., UK.

ICT Applications in Food Industry 3 (1+2)

Objectives

1. Understand the requirement of information and its computerization and SCADA systems
2. Learn different software tools like MATLAB, GAMBIT, Fluent, LabVIEW etc.
3. Learn different techniques like Fuzzy logic, Neural network, Image processing etc.

Theory

Importance of computerization in food industry, operating environments and information systems for various types of food industries. Introduction to Supervisory control and data acquisition (SCADA): SCADA systems hardware, firmware, software and protocols, landlines, local area network systems, modems. Spreadsheet applications: Data interpretation and solving problems, preparation of charts, use of macros to solve engineering problems. Use of add-ins, use of solver. Web hosting and webpage design; file transfer protocol (FTP), Online food process control from centralized server system in processing plant. Use of MATLAB in food industry; computing with MATLAB, script files and editor/debugger, MATLAB help system. Problem solving methodologies, numeric, cell, arrays, matrix operations; User defined functions, programming using MATLAB; debugging MATLAB programs, Applications to simulations; Plotting and model building in MATLAB, X-Y plotting functions, subplots and overlay plots, special plot types, interactive plotting in MATLAB; Function discovery, regression, the basic fitting interface, three dimensional plots; Introduction to Toolboxes useful to Food Industry, Curve fitting toolbox, Fuzzy logic toolbox, Neural Network toolbox, Image processing toolbox, statistical toolbox. Introduction to computational fluid dynamics (CFD), governing equations of fluid dynamics; Models of flow, substantial derivative, divergence of velocity, continuity, momentum and energy equations; Physical boundary conditions, discretization; Applications of CFD in food and beverage industry; Introduction to CFD softwares, GAMBIT and Fluent software, LabVIEW – LabVIEW environment: Getting data into computer, data acquisition devices, NI-DAQ, simulated data acquisition, sound card, front panel/block diagram, toolbar/tools palette; Components of a LabVIEW application: Creating a VI, data Flow execution, debugging techniques, additional help, context help, tips for working in LabVIEW; LabVIEW typical programs: Loops, while loop, for loop, functions and sub Vis, types of functions, searching the functions palette, creating custom sub Vis, decision making and file I/O, case structure, select (if statement), file I/O; LabVIEW results: Displaying data on front panel, controls and indicators, graphs and charts, arrays, loop timing, signal processing, textual math, math script.

Practical

Introduction to various features in spreadsheet; Solving problems using functions in spreadsheets; Use of Add-Ins in spread sheet and statistical data analysis using Analysis Tool pack; Solution of problems on regression analysis using Analysis Tool pack in spreadsheet; Solution of problems on optimization using solver package in spreadsheet; Introduction to MATLAB; Writing code using MATLAB programming; Solution of problems using Curve Fitting Toolbox in MATLAB; Solution of problems using Fuzzy Logic Toolbox in MATLAB; Solution of problems using Neural Network Toolbox in MATLAB; Solution of problems using Image Processing Toolbox in MATLAB; Introduction to GAMBIT software; Creation of geometry for laminar flow through pipe using

GAMBIT; Introduction to FLUENT software; Import of geometry and application of boundary conditions; Solution of problems on laminar flow using FLUENT; Introduction to LabVIEW and NI-DAQ.

Suggested Readings

1. Bailey, D. and Wright, E. 2003. Practical SCADA for Industry. Elsevier, Burlington, MA
2. Chapman, N. and Chapman, J. 2006. Web Design: A Complete Introduction. John Wiley and Sons, USA.
3. Palm III, W.J. 2011. Introduction to MATLAB for Engineers, 3rd edn. McGraw-Hill Companies, Inc., NY, USA.
4. Sun, D.W. 2007. Computational Fluid Dynamics in Food Processing. CRC Press, Boca Raton, FL, USA.
5. Singh, R.P. 2014. Computer Applications in Food Technology: Use of Spreadsheets in Graphical, Statistical and Process Analysis. Academic Press, London.

ELECTIVE COURSES

S. No.	Course Title	Credit hours
1.	Design and Formulation of Foods	3 (2+1)
2.	Industrial Microbiology	3 (2+1)
3.	Introduction to Food Biotechnology	3 (2+1)
4.	Business Management and Economics	2 (2+0)
5.	Statistical Methods and Numerical Analysis	2 (1+1)
6.	Instrumentation and Process Control in Food Industry	3 (1+2)
7.	Instrumental Techniques in Food Analysis	2 (1+1)
****8.**	Traditional Indian Dairy Products	2 (1+1)
****9.**	Ice-cream and Frozen Desserts	3 (2+1)
****10**	Energy Conservation and Management	2 (1+1)

** Sr No. 8-10 are cross-listed from Dairy Technology

Design and formulation of foods 3 (2+1)

Objectives

1. Understand about RDA for Indians
2. design and formulate new and innovative target foods
3. Gain knowledge about various therapeutic diets

Theory

Nutrients and their function, food classification and their nutritive value, anti-nutritional factors present in food; Concept of different food groups, recommended dietary allowances (RDA) for Indians; nutrition for infant, pre-school and school children, adult, pregnant and lactating women, old age people. Production and formulation of Indian traditional sweet and snack food products,

steps for quality improvement and value addition. Therapeutic diets – Principles and objectives of diet therapy, diet for patient suffering from Diabetes mellitus, osteoporosis, cardiac problem, gastrointestinal disorder, Diet planning and use of exchange list in nutrient calculation. Functional foods - definition and concepts; design of functional foods; Nutraceuticals food - definition and concepts, design of nutraceutical foods. Recent trends in food formulation; antioxidant rich food products; concepts for formulation of foods for drought and disaster afflicted; defence services, sportsmen, space food.

Practical

To study the principles and planning menu; Develop diet plan using food exchange list and nutrient calculation for school children, adult, pregnant; Preparation and formulation of Indian Traditional Snack, Traditional Sweet; Preparation and development of food for pregnant and lactating women, foods for infants; Preparation and formulation of food and energy drinks for diabetic person (sugar free food products); sports person and osteoporosis; preparation of prebiotic and pro biotic food product; Preparation of functional food using millets; whey beverage probiotic beverage; Production of functional beverage and antioxidant determination; Visit to Food Processing Industries/ Expos.

Suggested Readings

1. Antia, F.P. 1974. Clinical Dietetics and Nutrition, Oxford Medicine Publications.
2. Davidson, S., Passmore, R. and Eastwood, M.A. 1986. Davidson and Passmore Human Nutrition and Dietetics. Churchill Livingstone.
3. Gopalan, C., Ramshastri, B.V., Balasubramaniam, S.C. 1989. Nutritive Value of Indian Foods National Institute of Nutrition, Hyderabad.
4. Pokorny, J., Yanishlieva, N. and Gordon, M. 2001. Antioxidants in Food, Woodhead Publishing Limited, Abington Hall, Abington.
5. Potter, N. N. and Hotchkiss, J.H. 1995. Food Science, 5th edn. Chapman and Hall, NY, USA.
6. Mazza, G.1998. Functional Foods. Biochemical and Processing Aspects, Technomic Publ. Co.
7. Robinson, C. 1975. Basic Nutrition and Diet Therapy, Macmillan.
8. Swaminathan, M.1974. Essentials of Nutrition, Ganesh Co.
9. Steinkrauss, K.H. 1995. Handbook of Indigenous Fermented Foods, Marcel Dekker.

Industrial Microbiology 3 (2+1)

Objectives

1. Learn about industrially important micro-organism and their growth
2. Understand bioreactor design and downstream processing

Theory

Overview of Industrial Microbiology; Introduction to industrial fermentations, Range of fermentation processes, Chronological development, Compartmental part of fermentation processes; Industrially Important Microorganisms. Criteria for Selection of Industrially Important Microorganisms, Overview of strain improvement of Industrially Important Microorganisms,

Preservation of industrially important microorganisms. Fermentation Media; Media selection, Medium Formulation, Medium for industrial fermentation; Microbial Growth; Typical Growth Curve, Synchronous growth, Batch Fermentations, Continuous Fermentation; Fed Batch Fermentation. Bioreactor Design: Basic functions, Parts of stirred tank fermenter: Aeration and agitation; agitator, Impeller, sparger systems, baffles and other accessories, Types of reactor; Problems related to scale up of Process; Upstream and Down Stream Processes: Upstream processes, Overview of Downstream Processing, Methods of cell destruction, Methods of purification of enzyme/product, Concentration and Packaging.

Practical

Isolation and screening of citric acid/ amylase/ protease /antibiotic producing microbes, Production of citric acid/Lactic acid/ Acetic acid, Purification of citric acid/Lactic acid/ Acetic acid and Estimation of citric acid/Lactic acid/ Acetic acid; Standardization of physical factors for higher yields of citric acid; Isolation, identification of cultures producing bio-colours; Production, purification and estimation of beer/ ethanol; Production, purification and assay of fungal amylases/ proteases/Lipase; Production and assay of nisin from lactic acid bacteria; Single cell protein production; Starter activity of Baker's yeast Mushroom production.

Suggested Readings

1. Briggs, D.E., Boulton, C.A., Brookes, P.A. and Stevens, R. 2004. Brewing Science and Practice. Woodhead Publishing Ltd. Cambridge, England.
2. Casida Jr., L.E. 1968. Industrial Microbiology. New Age International Publishers, New Delhi.
3. Okafor, N. 2007. Modern Industrial Microbiology and Biotechnology. Science Publishers, Enfield, New Hampshire, USA.
4. Reed, G. 2004. Prescott and Dunn's Industrial Microbiology, 4th edn. AVI Publishers, Connecticut, USA.
5. Stanbury, P.F., Whitakar, A. and Hall, S.J. 1995. Principles of Fermentation Technology, 2nd edn. Elsevier Science Ltd., Burlington, MA, USA.

Introduction to Food Biotechnology 3 (2+1)

Objectives

1. Understand various biotechnological terminology
2. Understand application of biotechnology in food systems

Theory

Introduction, History and scope of biotechnology, Review of DNA replication, transcription, and translation. Review of DNA replication, transcription, and translation continued, Natural and artificial mechanisms of DNA transfer. Introduction to vectors, Selectable markers, Cloning vectors, Expression vectors, Shuttle vectors, Creation of recombinant DNA molecules, Creation of genomic and cDNA libraries. Library screening, Ligation, Restriction endonuclease digestion and mapping, Gel electrophoresis, Northern blotting, Southern blotting. Polymerase Chain Reaction (PCR), DNA sequencing and sequence analysis, Reverse transcriptase PCR, Real time PCR Week 8 Production of monoclonal antibodies, Immunoblotting. DNA microarrays, Protein microarrays. Introduction to

bioinformatics. Applications of biotechnology: Genetically engineered foods, Bioremediation, DNA fingerprinting, Molecular diagnostics, Molecular forensics Transgenic organisms, Ethical issues in biotechnology, The future of biotechnology.

Practical

Study of auxotroph; Micro-propagation through tissue culture; Strain improvement through U.V. mutation for lactose utilization; Chemical mutagenesis using chemical mutagens (Ethidium bromide); Determination of survival curves using physical and chemical mutagens; Isolation and analysis of chromosomal/genomic DNA from *E. coli* and *Bacillus cereus*; Separation of protoplast using cellulytic enzymes; Production of biomass from fruit and vegetable waste; Introduction of ELISA/Southern blot/DNA finger printing, etc.; Agarose gel electrophoresis of plasmid DNA; Pesticide degradation by *Pseudomonas* spp.

Suggested Readings

1. Brandenberg, Oliver, Dhlamini, Zephaniah, Sensi, Alessandra, Ghosh, Kakoli and Sonnino, Andrea. 2011. Introduction to Molecular Biology and Genetic Engineering. FAO, Rome, Italy.
2. Paul, Meenakshi. 2007. Biotechnology and Food Processing Mechanics. Gene-Tech Books, New Delhi.
3. Primrose, S.B. and R.M. Twyman. 2006. Principles of Gene Manipulation and Genomics, 7th Ed. Blackwell Publishing, Victoria, Australia.
4. Renneberg, R. and Lorch, V. 2017. Biotechnology for Beginners. Academic Press
5. Singh, B.D. 2014. Biotechnology - Expanding Horizons. Kalyani Publishers, New Delhi.
6. Smith, J.E. 2009. Biotechnology, 5th edition, Cambridge University Press, Cambridge, UK
7. Stahl, U., Donalies, U.E.B. and Nevoigt, E. 2009. Food Biotechnology. Springer Berlin, Heidelberg.
8. Watson, James D. 2013. Molecular Biology of the Gene, 7th edn. Benjamin Cummings, San Francisco, USA.

Business Management and Economics 2 (2+0)

Objectives

1. Learn basic principles of management
2. Learn basic financial and human resource management

Theory

Definitions, management principles, scientific principles, administrative principles; Maslow's Hierarchy of needs theory. Functions of management: Planning, organizing, staffing, directing, controlling; Organizational structures, principles of organization; Types of organization: Formal and informal, line, line and staff, matrix, hybrid. Introduction to economics: Definitions, nature, scope, difference between microeconomics and macroeconomics; Theory of demand and supply, elasticity of demand, price and income elasticity; Markets: Types of markets and their characteristics. National income: GDP, GNP, NNP, disposable personal income, per capita income, inflation; Theory of production: Production function, factors of production; Law of variable proportions and law

of returns to scale. Cost: Short run and long run cost, fixed cost, variable cost, total cost, average cost, marginal cost, opportunity cost; Break even analysis; Finance management: Definition, scope, objective; Different systems of accounting: Financial accounting, cost accounting, management accounting. Human resource management: Definitions, objectives of manpower planning, process, sources of recruitment, process of selection; Corporate social responsibility: Importance, business ethics.

Suggested Readings

1. Dewett, K.K. and Navalur, M.H. Modern Economic Theory. S. Chand and Sons, New Delhi.
2. Jain, S.P. Financial Accounting. Kalyani Publications, Ludhiana.
3. Harold, K. Principles of Management. Tata McGraw-Hill Education Private Limited, New Delhi.
4. Prasad, L.M. 2001. Principles and Practices of Management, 9th edn. S. Chand and Sons, New Delhi.
5. Rao, P. Subba. Human Resource Management. Himalaya Publications.
6. Thomas, P.C. Managerial Economics, 9th edn. Kalyani Publishers.

Statistical Methods and Numerical Analysis 2 (1+1)

Objectives

1. Learn different statistical test
2. Understand design of experiments

Theory

Statistical inference and testing of hypothesis – Z test, t test and F test**,** Chi-square test and its uses – testing the goodness of fit and test of independence (contingency table)**,** Correlation and regression analysis**.** Basic principles of experimental design Analysis of variance (ANOVA) – one way and two-way classification. Basic designs- Layout and analysis of completely randomized design (CRD) with equal and unequal number of observations, randomized block design (RBD), Latin square design (LSD). Response surface methodology.

Practical

Problems on Z test – One and two sample test Problems on t test - One and two sample (dependent and independent) test; Problems on F test, chi square test, correlation and regression; Fitting of simple linear regressions; Fitting of multiple regression equations; ANOVA: One way/ two way; 2^2; Problems on CRD, RBD, LSD, Problems on response surface methodology.

Suggested Readings

1. Grewal, B.S. 2004. Higher Engineering Mathematics. Khanna Publishers, Delhi.
2. Gupta, P.P. and Malik, C.C.1993. Calculus of Finite Differences and Numerical Analysis. Krishna Prakash Mandir, Meerut.
3. Kreyszig, E. 2006. Advanced Engineering Mathematics, 9th edn. John Wiley and Sons, New York, USA.

Instrumentation and Process Control in Food Industry 3 (2+1)

Objectives

1. Learn different measurement and control parameters and instruments for their measurement
2. Understand process control in food processing

Theory

Introduction, definitions, characteristics of instruments, static and dynamic characteristics, Temperature and temperature scales; Various types of thermometers; thermocouples, resistance thermometers and pyrometers; Pressure and pressure scales, manometers, pressure elements differential pressure. Liquid level measurement, different methods of liquid level measurement, flow measurement, differential pressure meters, variable area meters; Weight measurement: Mechanical scale, electronic tank scale, conveyor scale, Measurement of displacement, temperature, velocity, force and pressure using potentiometer, resistance thermometer, thermocouples; Transmission: Pneumatic and electrical, Control elements: control actions, pneumatic and electrical control systems; Process control: Definition, simple system analysis, dynamic behavior of simple process, Laplace transform, process control hardware. Frequency response analysis, characteristics, Bode diagram and Nyquist plots and stability analysis; Controllers and indicators: Temperature control, electronic controllers, timers and indicators, discrete controllers, adaptive and intelligent controllers. Computer-based monitoring and control: Importance, hardware features of data acquisition and control computer, signal interfacing, examples in food processing; Introduction of 8051/8085 based system and applications in processing.

Practical

Study on instrumentation symbols; Determination of relative humidity by wet and dry bulb thermometer; Measurement of wind velocity by anemometer; Measurement of intensity of sun shine by sunshine recorders; Study of characteristics of pressure transducers, real-time study of pressure transducers characteristics with PC, characteristics of IC temperature sensor, characteristics of platinum RTD, temperature controlled alarm system; Study of water level to current conversion; Study of characteristics of capacitive transducer; 8051 based programming examples; Programmable Logic Controllers (PLC) Hardware; PLC Ladder programming; control of Multiprocess system.

Suggested Readings

1. Bela G. Liptak. 2003. Instrument Engineer's Handbook, Vol. I and II, 4th edn. CRC Press, Boca Raton, FL, USA.
2. Curtis D. Johnson. 2003. Process Control Instrumentation Technology, 7th edn. Prentice Hall of India Pvt. Ltd., New Delhi.
3. Don W. Green and Robert H. Perry. 2008. Perry's Chemical Engineers' Handbook. McGraw-Hill Co., Inc., NY, USA.
4. Murty, D.V.S. 2004. Transducers and Instrumentation. Prentice Hall of India Pvt. Ltd. New Delhi.

Instrumental Techniques in Food Analysis 2 (1+1)

Objectives

1. Learn various instruments used for food analysis
2. Learn the methods of various analyses
3. Gain knowledge about various equipment and their working for those analyses

Theory

Concepts of food analysis; Rules and regulations of food analysis Principles and methodology involved in analysis of foods: Rheological analysis, textural profile analysis of foods, Methods of analysis: Proximate constituents: Total fat, crude fiber, protein, moisture, minerals analysis; adulterations. Principles and methodology involved in analytical techniques: spectroscopy, ultraviolet visible, infrared spectroscopy, atomic absorption and emission, florescence mass spectroscopy. Food compositional analysis and applications in the food industry.

Chromatography: Principle of chromatography, classifications, (Adsorption, column, partition, gel-filtration, affinity, ion-exchange, size-exclusion method) gas-liquid, high performance liquid chromatography; Ion chromatography and others. Separation techniques: Dialysis, electrophoresis, sedimentation, ultra-filtration, ultra centrifugation, iso-electric focusing, Chemically sensitive semiconductor devices: Solid-state sensors for pH, acidity, amperometric, potentiometric and; Acoustic sensors, Rapid microbiological methods: Overview, Conductance/impedance techniques for microbial assay; chemosensors, biosensors, immunosensors.

Practical

Sampling plan; Sample collection and preparation for analysis; Sensory evaluation of products; Quality evaluation of raw materials: Fruits, vegetables, cereals, dairy products, meat, poultry products; Quality evaluation of food products for color and taste of marketed products; Analysis of heavy metals using atomic absorption spectrophotometer; Estimation of physic acid using spectrophotometer; Separation of amino acids by two-dimensional paper chromatography; Identification of sugars in fruit juice using TLC; Separation of pralines by ion- exchange chromatography; Molecular weight determination using sephadox-gel; Identification of organic acids by paper electrophoresis; Gel-electrophoresis for analytic techniques; Quantitative determination of sugars and fatty acid profile by GLE, GCMS; Quantitative make-up of water and fat soluble vitamins using HPLC; Fatty acid profiling using gas chromatograph; Separation of sugars by paper chromatography; Analysis of wheat flour; Analysis of foods for pesticide and drug residues; Study of colorimetry and spectrophotometry; Spectrophotometric method of total chlorophyll (A and B).

Suggested Readings

1. Nieisen, S.S. 2010. Food Analysis Laboratory Manual, 2nd edn. Springer, NY, USA.
2. Nieisen, S.S. 2003. Food Analysis, 3rd edn. Kluwer Academic, New York, USA.
3. Ötles, S. 2009. Handbook of Food Analysis Instruments. CRC Press, Boca Raton, FL, USA.
4. Sun, D.W. 2008. Modern Techniques for Food Authentication. Elsevier Inc., Burlington, MA, USA.

**Traditional Indian Dairy Products 3 (2+1)

Objectives

1. Understand the processes involved in the manufacture of heat desiccated and acid coagulated dairy products and a wide variety of traditional Indian sweets
2. Learn about the chemical composition and legal standards for traditional Indian sweets
3. Acquire knowledge about packaging options available for traditional dairy products and methods for their shelf life
4. Learn about mechanization of certain processes involved in the large-scale manufacture of traditional Indian dairy products

Theory

Status and significance of traditional Indian milk products in India. Khoa: Classification of types, standards methods of manufacture and preservation, factors affecting yield of khoa. Mechanization in manufacture of khoa. Khoa based sweets: Burfi, Peda, Milkcake, Kalakhand, Gulabjaman and their compositional profile and manufacture practices. Rabri and Basundi: Product identification, process description, factors affecting yield, physico-chemical changes during manufacture. Channa: Product description, standards method of manufacture, packaging and preservation. Chhana-based sweets: Rasogolla, Sandesh, Rasomalai. Mechanization of manufacturing process, advances in preservation and packaging. Paneer: Product description, standards, method of manufacture, packaging and preservation. Mechanization of Paneer manufacturing/packaging process. Chakka/Maska and Shrikhand: Product description, standards, method of manufacture, small scale and industrial process of production, packaging and preservation aspects. Misti Dahi: Product description method of manufacture and packaging process. Kheer and Payasam: Product description methods of manufacture, innovations in manufacturing and packaging processes. Biopreservative principles in enhancing the self-life of indigenous milk products including active packaging.

Practical

Preparation of Khoa from cow, buffalo and concentrated milk; Preparation of Burfi, Peda, Kalakand, Milkcake and Gulabjamun; Preparation of Paneer from cow, buffalo and mixed milk; Preparation of Chhana from cow and buffalo milk and mixed milk; Preparation of Sandesh and Rasogolla; Preparation of kheer; Preparation of Rabri, Misti Dahi, Chhana and Shrikhand; Visit to industry.

Suggested readings

1. Aneja, R.P., Mathur, B.N., Chandan, R.C. and Banerjee, A.K. (2002). Technology of Indian Milk Products. A Dairy India Publ., Delhi, India
2. Agarwala, S.P. (2006). Equipment for paneer making, Lecture compendium on developments in traditional dairy products. Short course organized by CAS from Dec. 10-30, 2006: pp-132-137.
3. Dharam Pal and Narender Raju, P. (Eds). (2006). Developments in Traditional Dairy Products, Lecture Compendium of the 21st Short Course, CAS in Dairy Technology, NDRI, Karnal.
4. Pal, D. (1997). Technology of the manufacture of rabri and basundi. In Advances in Traditional Dairy Products. Short course, CAS in Dairy Technology, NDRl Deemed University, Karnal.

**Ice-Cream and Frozen Desserts 3 (2+1)

Objectives

1. Understand about evolution of ice cream industry, classification of ice cream, ingredients used and their role in determining quality of the final products
2. Learn about design and working of Ice cream freezers including cleaning and sanitization
3. Aquire knowledge about the physic-chemical properties of ice cream mix and effect of process variables on the quality of ice cream
4. Learn about the defects that appear in ice cream, causative factors and measures to control them

Theory

History, development and status of ice cream industry, History, development and status of ice cream industry, Definition, classification and composition and standards of ice cream and other frozen desserts. Stabilizers and emulsifiers-their classification, properties and role in quality of ice cream, Technological aspects of ice cream manufacture, Thermodynamics of freezing and calculation of refrigeration loads, Types of freezers, refrigeration control / instrumentation, Hygiene, cleaning and sanitation of ice cream plant. Effect of process treatments on the physico-chemical properties of ice-cream mixes and ice cream, Processing and freezing of ice-cream mix and control of over run, Packaging, hardening, storage and shipping of ice-cream, Defects in ice cream, their causes and prevention. Recent advances in ice-cream industry (flavourings, colourings, fat replacers, bulking agents) and plant management, Nutritive value of ice-cream.

Practical

Calculation of standardization of ice-cream mixes; Manufacture of plain and fruit flavoured ice-cream; Manufacture of chocolate, fruit and nut ice cream; Preparation of sherbets/ices; Preparation of soft served and filled ice-cream; Manufacture of kulfi. Study of continuous and batch type freezers; Manufacture of ice-cream by continuous process; Determination of overrun in ice cream; Visit to an Ice Cream Plant.

Suggested readings

1. Arbuckle, W.S. 1991. Ice Cream. AVI Publ., Co. Inc., West Port, Connecticut.
2. Hall, C.W. and Hedric, T.T. 1975. Drying of Milk and Milk Products. AVI Publ. Co. Inc., West Port, Connecticut. p-338.
3. Hui, Y.H. 1993. Dairy Science and Technology Handbook 2- Product Manufacturing. Wiley – VCH Inc., USA.
4. Ice Cream Alliance and Ice Cream Federation. 1992. Code of Practice for the Hygienic manufacture of Ice Cream.
5. NDRI. 1998. Advances in Ice Cream and Frozen Desserts. Lecture compendium, Sixth short course, Dec 15, 1998- Jan 4, 1999. NDRI, Karnal.
6. Robinson, R.K. 1986. Modern Dairy Technology. Vol II. Elsevier Sci. Publ. Co., Inc., New York, USA.

7. Robinson, R.K. 2002. Dairy Microbiology Handbook. 3rd edn. John Willey and sons, New York, USA.

8. Sommer, H. H. 1951. The Theory and Practice of Ice Cream Making. 6th edn. Madison, Wisconsin, p 5-10.

**Energy Conservation and Management 2 (1+1)

Objective

- To equip students with the knowledge and skills required to effectively manage and conserve energy resources within the context of dairy and food processing industries

Theory

Introduction: Potential and Importance of industrial energy conservation in dairy and food processing; Energy conservation Act 2001 and its important features, Schemes of Bureau of Energy Efficiency (BEE); Electricity Act 2003, Integrated energy policy; Energy management and audit: Definition, energy audit, need, types of energy audit; Energy audit approach-understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel and energy substitution. Energy balances and computation of efficiencies of equipment; Role of Energy inspectors and Auditors in energy management; Electrical load management: Demand management, energy management information systems, Energy saving controllers and cost saving techniques; Quality of power, Power factor and its improvement; Transformers, losses in transformers; Energy savings in transformers; Electric motor-selection and application, Energy efficient motors; Variable Speed Drives and Variable Frequency Drives (VFD) and their role in saving electric energy; Bureau of Energy Efficiency (BEE): Power saving guide with Star Ratings of electrical appliances: Induction Motors, Air conditioners, Refrigerators and Water Heaters; Industrial Lighting: Quality of light, types of light sources, energy efficiency, Light controls. Energy efficiency and conservation in utilities: High efficiency boilers, improved combustion techniques for energy conservation, Fluidized Bed Combustion and multi fuel capabilities; Energy conservation in steam distribution systems, efficient piping layouts, protective and insulation coverings in utility pipes; Steam conservation opportunities; Upkeep and maintenance of steam auxiliaries and fittings. Energy conservation in Refrigeration and AC systems (HVAC), Cooling towers, Pumps and pumping systems, Fans, Blowers, Air compressors; Maintenance and upkeep of Vacuum lines and Compressed air pipe lines; Conservation and reuse of water, water auditing; Energy conservation opportunities in Wastewater treatment. Processing equipment: Improving efficiency and energy conservation opportunities in few important food processing operations like Thermal processes, Evaporation, Drying and Freezing; Role of steam traps in energy saving; Energy Savings methods in hot air generator, Thermic fluid heater, Steam radiator. Energy conservation in buildings: Concepts of Green Buildings; Waste-heat recovery and thermal energy storage in food processing facilities; Condensate recovery and reuse; Application of recuperator to recover energy from flue gases from boiler, DG exhaust, hot air from spray dryer, FBD etc; Diesel generating sets (stand by AC Gen sets): Energy saving opportunities in DG sets, Fuel and Oil conservation; important regular maintenance aspects; Carbon credits and carbon trade: Concepts of CDM, economic and societal benefits. Cleaner energy sources: Introduction to Solar, and Bio-mass Energy; Solar thermal and photo-voltaic energy options for food processing industries; Role

of automation in conservation of energy in dairy and food processing: Incorporation of enhanced PLC based computer controls and SCADA.

Practical

Study of Energy Conservation Act 2001; Study of schemes of BEE; Study of concepts of Energy Balance in Unit Operations and System boundaries; Solving examples on energy balances; Solving problems on electrical energy use and management: Connected load, Maximum demand, Demand factor and Load curve; Determination of Load factor of an installation; Study of use of power factor meter and determination of true power and wattles power by using PF meters, Watt meter, Ammeter and Volt meter; Study of performances of a general type of induction motor and an energy efficient induction motor; Study of use of VSD; Study of various types of electrical appliances classified under different BEE Star Ratings; Drawing Energy Balance on a boiler: Collection of data, Analysis of results and determination of efficiency; Exercise on energy audit of a Dairy plant.

Suggested readings

1. Tufail Ahmand 2012 Dairy Plant Engineering and Management, Kitab Mahal Publisher.
2. JiřiKlemeš, Robin Smith and Jin-Kuk Kim 2008 Handbook of Water and Energy Management in Food Processing, A volume in Woodhead Publishing Series in Food Science, Technology and Nutrition.
3. Lijun Wang 2008 Energy Efficiency and Management in Food Processing Facilities, CRC Press Inc; 1st edition (4 December 2008); Taylor and Francis.
4. Paul O'Callaghan 1993 Energy Management, McGraw- Hill Book Company Europe, Shppenhangers Road, England.

Applications of Renewable Energy in Food Processing 2 (1+1)

Objective

To equip students with the knowledge about the alternative and renewable sources of energy available for operating of a food processing industry

Theory

Introduction to energy sources; classification of renewable energy sources, utilization of these sources in food processing sector; Solar radiation, measurement of solar radiation, types of solar collectors and their uses; familiarization with solar energy gadgets: solar cooker, solar concentrator, solar dryer, solar steam generator; utilization of solar thermal energy in food processing; Solar photovoltaic cells, modules, arrays, conversion process of solar energy into electricity, applications in food industry; Biomass and its characterization; briquetting of biomass. Biomass combustion, pyrolysis, gasification and uses of gasifiers in food industry and biodiesel preparation; Importance of biogas technology, production mechanism, types of biogas plants, uses of biogas, handling and utilization of digested slurry. Use of food waste for biogas generation and its applications; Brief introduction to wind energy, hydroelectric energy, ocean energy.

Practical

Study of solar radiation measuring instruments; Study of solar cooker; Study of solar water heater; Study of solar dryer; Study of solar PV system; Estimation of calorific value of biomass;

Estimation of moisture content of biomass; Estimation of ash content of biomass; Estimation of fixed carbon and volatile matter of biomass; Study of briquetting machine; Demonstration of up draft gasifier; Demonstration of down draft gasifier; Demonstration of working of a fixed dome type biogas plants; Demonstration of working of a floating drum type biogas plants; Demonstration of biodiesel preparation; Demonstration of wind measuring instruments.

Suggested Readings

1. Khandelwal, K.C. and S. S. Mahdi. 1990. Biogas Technology- A Practical Handbook.
2. Rai, G.D. 2013. Non-Conventional Energy Sources, Khanna Publishers, Delhi.
3. Rai, G.D., Solar Energy Utilization, Khanna Publishers, Delhi.
4. Rathore N. S., Kurchania A. K., Panwar N. L. 2007. Non-Conventional Energy Sources, Himanshu Publications.
5. Rathore N. S., Kurchania A. K., Panwar N. L. 2007. Renewable Energy, Theory and Practice, Himanshu Publications.
6. Tiwari, G.N. and Ghoshal, M.K. 2005. Renewable Energy Resources: Basic Principles and Applications. Narosa Pub. House. Delhi.

Food Plant Design and Layout 3 (2+1)

Objective

To equip students to effectively design food processing plant incorporating the appropriate machinery, equipment, utility services, conforming to the legal standards.

Theory

Introduction Classification of food processing plants, food plant design concepts, situations giving rise to plant design problems and general design considerations (technical, economic, legal, safety and hygiene). Feasibility Study Steps involved in feasibility study, collection of the information, information flow diagrams, market analysis, technical analysis and preparation of feasibility report.

Plant Location Factors affecting plant location, their interaction with plant location, location theory models for evaluation of alternate locations. Plant Size Economic plant size, factors affecting the plant size (technical and economical), raw material availability, market demand, competition in the market, return on investment etc. Procedures for estimation of economic plant size (breakeven analysis and optimization), estimation of volume of production for each product.

Product and Process Design; Design of product, product specifications, least cost mix of raw materials, process design, process selection considering technical, economic and social aspects. Process planning and scheduling, flow sheeting, flow diagrams and process flow charts including their design and computer aided development of flow charts.

Selection of Equipment Process equipment, material handling equipment, service equipment, instruments and controls, considerations involved in equipment selection, economic analysis of equipment alternatives using optimization techniques and cash flows, economic decision on spare equipment, prediction of service life of the equipment.

Plant Layout Types of layouts, considerations involved in planning an efficient layout, preparation and development of layout, evaluation of alternate layouts, use of computers in

development and evaluation of layouts, equipment symbols, flow sheet symbols, electric symbols, graphic symbols for piping systems, standards for space requirement and dimensions, distances between critical plant areas and for different plant facilities.

Planning and Design of Service Facilities and Plant Surroundings Requirements of the steam, refrigeration, water, electricity, waste disposal, lighting, ventilation, drainage, CIP system, dust removal, fire protection etc. Design and installation of piping system, codes for building, electricity, boiler room, plumbing and pipe colouring. Planning of offices, laboratories, lockers and toilet facilities, canteen, parking lots and roads, loading docks, garage, repair and maintenance shop, ware houses etc.

Workers Safety and Health Aspects Falling hazards and safeguards, electric hazards, heat exposure, dust protection, noise control, protection against chemicals, fire safety, fumes, moist conditions, personnel hygiene, sanitary requirements and standards, insect, rodent and bird control.

Building and Building Materials Requirements in respect of building type, wall, ceiling and floor construction, building height and building materials.

Practical

Prepare a feasibility report, prepare a plant location report, study design and layout of milk processing plant, study design and layout of fruit processing plant, To study design and layout of beverage plant, study design and layout of meat and meat products plant, To study design and layout of bakery and confectionery plant, study design and layout of grain processing plant, study design and layout of cold storage and warehouse, Design and layout of milk processing plant, Design and layout of fruit processing plant, Design and layout of beverage plant, Design and layout of meat and meat products plant, Design and layout of bakery and confectionery plant, Design and layout of grain processing plant, Design and layout of cold storages and warehouses.

Suggested Readings

1. Chemical Engineering Handbook by Perry R.H. Published by McGraw-Hill.
2. Chemical Engineering Plant Design by Villbrandt F.C. and Dryden C.E. Published by McGraw Hill.
3. Computer Aided Process Plant Design by Leesley M.E. Published by Gulf Publishing Company, Houston.
4. Engineering Economic Analysis by W.T. Morris. Published by Reston Publishing Company, Inc., New York.
5. Food Plant Economics by Z.B. Maroulis and G.D. Sarvacos. Published by CRC press.
6. Plant Design and Economics for Chemical Engineers by Peters M.S. and K.D. Timmerhaus. Published by McGraw-Hill.
7. Plant Layout and Design by J.M. Moore Published by The McMillan company.
8. Process Plant Design by Backhusrt J.R. and J.H. Barker. Published by Heimann Educational Books, London.
9. Project Feasibility Analysis by Clifton D.S. and D.E. Fyfee. Published by John Willey and Sons, New York.

10. Project Management for Engineers by M.D. Rosenau Published by Van Nostrand Reinhold Co., New York.

Waste and By-Products Utilization 3 (2+1)

Objectives

1. Understand the nature of agricultural wastes and their impact on the environment
2. Conceptualize physical, chemical and biological basis of agricultural waste treatment
3. Analyse and design systems for the collection, handling, treatment and utilization of wastes
4. Understand the waste treatment processes

Theory

Types and formation of by-products and waste; Magnitude of waste generation in different food processing industries; Uses of different agricultural by-products from food industry, rice mill, sugarcane industry, oil mill etc.

Concept, scope and maintenance of waste management and effluent treatment; Waste parameters and their importance in waste management- temperature, pH, Oxygen demands (BOD, COD), fat, oil and grease content, metal content, forms of phosphorous and sulphur in waste waters, microbiology of waste, other ingredients like insecticide, pesticides and fungicides residues. Waste utilization in various industries, furnaces and boilers run on agricultural wastes and by products, briquetting of biomass as fuel, production of charcoal briquette, generation of electricity using surplus biomass, producer gas generation and utilization; biofuels and ethanol, packaging material through recycling. Waste treatment and disposal: Design, construction, operation and management of institutional community and family size biogas plants, vermi-composting. Pre-treatment of waste: sedimentation, coagulation, flocculation and floatation; Secondary treatments: biological and chemical oxygen demand for different food plant waste– trickling filters, oxidation ditches, activated sludge process, rotating biological contractors, lagoons; Tertiary treatments: advanced waste water treatment process- sand, coal and activated carbon filters, phosphorous, sulphur, nitrogen and heavy metals removal. Assessment, treatment and disposal of solid waste; Effluent treatment plants; Environmental performance of food industry to comply with ISO-14001 standards.

Practical

Determination of temperature, pH, turbidity solids content, BOD and COD of waste water. Determination of ash content of agricultural wastes and determination of un-burnt carbon in ash. Study about briquetting of agricultural residues. Estimation of excess air for better combustion of briquettes. Study of extraction of oil from rice bran. Study on bioconversion of agricultural wastes. Recovery of germ and germ oil from by-products of cereals. Visit to various industries using waste and food by-products.

Suggested Readings

1. Bhatia S C. 2001. *Environmental Pollution and Control in Chemical Process Industries*. Khanna Publishers, New Delhi.
2. Garg S K. 1998. *Environmental Engineering* (Vol. II) – *Sewage Disposal and Air Pollution Engineering*. Khanna Publishers, New Delhi

3. Joshi V K and Sharma S K. 2011. *Food Processing Waste Management: Treatment and Utilization Technology*. New India Publishing Agency.
4. Markel I A. 1981. *Managing Livestock Waste.* AVI Publishing Co.
5. Pantastico E C B. 1975. *Post-harvest Physiology, Handling and Utilization of Tropical and Sub-Tropical Fruits and Vegetables.* AVI Pub. Co.
6. Prashar A and Bansal P. 2008. *Industrial Safety and Environment*. S.K. Kataria and Sons, New Delhi.
7. Shewfelt R L and Prussi S E. 1992. *Post-Harvest Handling - A Systems approach*. Academic Press Inc.
8. USDA 1992. *Agricultural Waste Management Field Hand book*. USDA, Washington DC.
9. Weichmann J. 1987. *Post-Harvest Physiology of Vegetables*. Marcel and Dekker Verlag.
10. Vasso O and Winfried R (Eds). 2007. *Utilization of By-products and Treatment of Waste in the Food Industry*. Springer Science and Business Media, LLC 233 New York.

SKILL ENHANCEMENT COURSES

1. Introduction to Drying Technology and Dryers
2. Introduction to Processing of Extruded Foods
3. Introduction to Milling (Rice, Dal, Spices, etc.)
4. Introduction to Electrical and Control Systems in Food Industry
5. Introduction to Mechanical Systems in Food Industry
6. Introduction to AutoCAD
7. Introduction to Food Safety and Sanitation
8. Introduction to Good Laboratory Practices
9. Basic Food Analysis Laboratory Techniques
10. Maintenance of Food Processing Equipment
11. Introduction to Bottling and Canning Line
12. Introduction to Manufacturing of Bakery Products

ONLINE COURSES

(6 credit hours)

Guidelines for taking the online courses

- The students will have to take a minimum of 6 credits of online courses (as per UGC guidelines for online courses) as a partial requirement for the B. Tech. (Food Technology) program.
- The online courses can be from any field such as Engineering, Basic Sciences, Humanities, Psychology, Anthropology, Economics, Business Management, Languages including foreign language, Communication skills/ Music, etc. and can be taken from NPTEL, mooKIT, edX, Coursera, SWAYAM or any other portal.
- The courses can be taken during the third year and 4th year of the UG program as per choice of students.
- The courses will be non-gradial (as separate certificates would be issued by the institutes offering the course).
- The MOOC courses taken by the student will be separately registered/ approved at the University level. The final transcript will indicate the title of courses taken by the student and the total weeks.

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