

Revised BSMA Syllabus of

Ph.D. (Food Processing Technology)

As per Recommendation of Vth Deans
Committee ICAR, New Delhi


for

State Agricultural Universities of Maharashtra
From
Academic Year 2022-23




- **Vasant Rao Naik Marathwada Krishi Vidyapeeth,
Parbhani**
- **Mahatma Phule Krishi Vidyapeeth, Rahuri**
- **Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola**
- **Dr. Balasaheb Sawant Kokan Krishi Vidyapeeth,
Dapoli**

BSMA Degree and Discipline Coordinators

Broad Subject Coordinator and Chairman

	Name	Designation
	Dr. R. B. Kshirsagar	Professor & Head Dept. of Food Engineering, College of Food Technology, Vasantrao Naik Marathwada Krishi Vidyappeth, Parbhani

Discipline Coordinators

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

Foreword

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

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

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

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

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

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

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

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

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



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

**Ph.D.(Food Processing Technology)
Degree Programme**

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Preamble

The efficient use of resources is the growing concern for all involved in food production, processing, distribution and retailing. The unique features of the raw materials of the food processing industries such as seasonality, perishability and variability in conjunction with sophistication required for processing to maintain high quality standards, necessitates special attention towards focused availability of qualified technical manpower, effective technologies and efficient machinery. The food industries in the country need modernization to face the challenges of the globalization. Government of India is also paying special attention to this important sector and associated stakeholders. Efficient utilization of resources will definitely help in manufacturing of nutritious and healthy food but also help in fostering economic development and therefore, improving livelihoods by promoting access to domestic, regional and international markets.

This has motivated the ICAR-BSMA Broad Subject committee framed by DICC and MCAER, Pune for Food Science and Technology to strive hard to enrich the content and syllabus of the MTech and PhD programmes in the area of Food Processing Technology. This will hopefully produce competent food technologists to handle resources from farm-to-fork and cater the various sectors of food processing industries.

By learning the innovative novel technologies and advancement in food processing technology and new packaging techniques are introduced. Moreover, a new course is introduced named as Industrial Manufacturing of food and beverage which gives exposure to understand raw material quality, processing and production of food and beverage on industrial scale. Many new courses are introduced, viz. Frozen and Concentrated Foods, Aseptic Processing and Packaging, Traditional Foods, Technologies of Convenience Foods, Food Powders and Premixes, Food Business Management. A new subject Global Food Laws and Regulations is introduced which helps the food industry to export the food product to the world as per their specifications and regulations. New courses like Novel Technologies for Food Processing and Shelf-Life Extension, Food Manufacturing Technology, Formulation of Standards of Food Products, Packaging and Labeling are introduced in PhD programme through which the students will develop and formulate new product, new technology and helps in developing the regulations of different food products.

The proposed revised and restructured curricula of the MTech and PhD programmes in the area of Food Processing Technology. and quality measures should render Food Technology as an intellectually more stimulating skill-oriented discipline and an economically rewarding profession to attract talent and investment.

(Implementation of New Curriculum)

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

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

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

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

Expected Outcome

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

Organization of Course Contents & Credit Requirements

Minimum Residential Requirement:

Ph. D : 6 Semesters

Name of the Departments / Divisions

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

Nomenclature of Degree Programme

Ph. D. Programmes

Ph. D. (Food Processing Technology)

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600-series to Doctoral level.
- Credit Seminar for Master's level is designated by code no. 591, and the Two Seminars for Doctoral level are coded as 691 and 692, respectively
- Deficiency courses will be of 400 series.
- Master's research: 599 and Doctoral research: 699

Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not obviously exclude such a reference material that may be recommended according to the advancement and local requirement.
- A list of international and national reputed journals pertaining to the discipline is provided at the end which may be useful as study material for 600/700 series courses as well as research topics.
- Lecture schedule and practical schedule has also be given at the end of each course to facilitate the teacher to complete the course in an effective manner.

Minimum Credit Requirements

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

Academic Regulation

Sr.No.		M.Tech. (Food Tech.)	Ph.D. (Food Tech.)
1	Examination system and Weight age	(1) Course work Theory- Midterm – 30 % Semester end Theory 70 % Practical- Class room Record – 5 % Assignments – 10 % SE practical – 35% 2) written Comprehensive qualifying examination(after completion of 80 % of core and optional courses separately)	(1) Course work Theory- Midterm – 30 % Semester end Theory 70 % Practical- Class room Record – 5 % Assignments – 10 % SE practical – 35% 2) written Comprehensive qualifying examination(after completion of 80 % of core and optional / minor courses separately)
2	Grading of courses	10 point scale Deficiency Courses : Satisfactory / Unsatisfactory Non Credit Compulsory : S / US Research / Thesis : S / US	10 point scale Deficiency Courses : Satisfactory / Unsatisfactory Non Credit Compulsory : S / US Research / Thesis : S / US
3	Question paper setting of Semester End Theory Exam	External system	External system
4	Evaluation of SE Exam	Internal	Internal
5	Minimum passing grade in a course	55 %	65 %
6	Minimum CGPA to obtain for degree	5.5 / 10.0 points scale	6.5 / 10.0 point scale
7	Publications	The M.Tech. Thesis shall be accompanied with atleast One	The Ph.D.Thesis shall be accompanied with atleast Two

		manuscript of research articles on topic of research problem before the thesis submission of thesis	manuscript of research articles on topic of research problem before the thesis submission of thesis . Acceptance of One compulsory
8	Plagiarism Check	Plagiarism Check report to be appended in the thesis (50 % of less level of acceptance)	Plagiarism Check report to be appended in the thesis (75 % of less level of acceptance)
9	Research and Thesis*	i) External Evaluation ii) Viva-voce - Internal	i) External Evaluation by Two experts ii) Viva-voce - External
10	Degree Class / Division	5.5 to 6.49 – Pass Class 6.5 to 7.49 – Second Class 7.5 to 8.49 – First Class 8.5 and Above – First with distinction	6.5 to 7.49 – Second Class 7.5 to 8.49 – First Class 8.5 and Above – First with distinction

Eligibility for Admission

- **Master’s Degree Programme**
 - i. B. Tech (Food Technology) / B.Tech. (Food Science) /B.Tech. (Food Science and Technology) or equivalent degree with four years duration of agriculture related Universities (SAUs) and having the Common Entrance Test in Food Technology faculty conducted by MAUEB, Pune.
 - ii. The candidate must have scored Overall Grade Point Average (OGPA) of at least 5.50/10.00 in ten-point scale.
- **Doctoral Degree Programme**
 - i. The candidate must have passed 4 years B. Tech (Food Technology)/ B. Tech Food Science or Equivalent degree with four years duration of agricultural related universities (SAUs).
 - ii. Master’s degree in the concerned Discipline of Food Technology and having appearing the Common Entrance Test of Food Technology subject conducted by MAUEB, Pune.
 - iii. The candidate must have scored Overall Grade Point Average (OGPA) of at least 6.5/10.00 in ten-point scale.

Name of Department	Specialization in Ph. D FoodTechnology	Eligibility criteria
Food Technology	1. Ph. D (Food Processing Technology)	M. Tech. (Food Technology) / M. Tech. (Food Science and Technology) / M. Tech. (Food Technology) in Food Processing Technology from agriculture related Universities (SAUs) and having the Common Entrance Test in Food Technology faculty conducted by MAUEB, Pune.
	Ph. D.(Food Process Engineering)	M. Tech. (Food Technology) in Food Process Engineering
	Ph. D (Food Safety and Quality)	M. Tech. (Food Technology) in Food Safety and Quality

Ph. D. (Food Processing Technology) Course Structure

Ph. D. (Food Processing Technology)

Course Code	Semester	Course Title	Credit Hrs.
Major courses		Proposed	
FPT 601	I	Novel Technologies for Food Processing and Shelf-Life Extension	3 (3+0)
FPT 602	I	Food Packaging	3 (3+0)
FPT 604	II	Plant Food Products	3 (3+0)
FPT 606	III	Animal Food Products	3 (3+0)
Total			12 (12+0)
Note: Optional Major Subjects: The said courses are subjected to availability of infrastructure and facilities and to be decided by SAC committee			
FPT 603		Food Manufacturing Technology	3 (3+0)
FPT 605		Food Process Modeling and Scale up	3 (3+0)
FPT 607		Special Problem	2 (0+2)
Minor courses		Proposed	
FPE 602	I	Concentration and Drying Engineering	3 (3+0)
FSQ 603	II	Quality Assurance in Food Supply Chain	3 (3+0)
Total			(6+0)
Note: Optional Minor Subjects: The said courses are subjected to availability of infrastructure and facilities and to be decided by SAC committee			
Minor courses from discipline of Food Process Engineering or Food Safety and Quality			
FPE 606		Food Handling and Storage Engineering	3 (3+0)
FSQ 604		Formulation of Standards of Food Products, Packaging and Labeling	2 (2+0)
Supporting courses		Proposed	
FPE 605	II	Food Analytical Techniques	3 (1+2)
FSQ 607	I	Sensory Evaluation of Foods	2 (2+0)
Total			5 (3+2)
Seminar			
FPT 691	III	Seminar I	1 (0+1)
FPT 692	IV	Seminar II	1 (0+1)
FPT 699		Doctoral Research	75 (75+0)

***Compulsory Courses**

**SEMESTER WISE
COURSE LAYOUT**

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

ABSRTACT

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

PhD Food Processing Technology Course Content

Theory, Practical Syllabus and Teaching Schedule

A. Major Courses

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

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

Teaching Schedule

Theory

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

Text/Reference Books/Suggested Readings

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

FPT 602	Food Packaging	3(3+0)
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Theory

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

Teaching Schedule

Theory

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

Text/Reference Books/Suggested Readings

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

FPT 604	Plant Food Products	3(3+0)
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Theory

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

Teaching Schedule

Theory

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

Text/Reference Books/Suggested Readings

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

FPT 606	Animal Food Products	3(3+0)
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Theory

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

Teaching Schedule

Theory

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

Text/Reference Books/Suggested Readings

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

B. Minor Courses

FPE 602	Concentration and Drying Engineering	3(3+0)
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Theory

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

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

Teaching Schedule

Theory

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

Text/Reference Books/Suggested Readings

- Anandharamakrishnan C and Padma IS. 2015. *Spray Drying Techniques for Food Ingredient Encapsulation*. Wiley-Blackwell
- Oetjen GW, Haseley P. 2018. *Freeze-Drying*, 3e. Wiley-VCH
- Krokida M. 2018. *Thermal and Nonthermal Encapsulation Methods*. CRC Press
- Anandharamakrishnan C. 2017. *Handbook of Drying for Dairy Products*. Wiley-Blackwell
- Zhang M, Bhandari B, Fang Z. 2017. *Handbook of Drying of Vegetables and Vegetable Products*. CRC Press
- Prakash O, Kumar A. 2017. *Solar Drying Technology: Concept, Design, Testing, Modeling, Economics and Environment*. Springer Singapore
- Karim A, Law CL. 2017. *Intermittent and Nonstationary Drying Technologies: Principles and Applications*. CRC Press

- Vasile M. 2016. *Advances in Heat Pump-Assisted Drying Technology*. CRC Press
- MengWai W. 2016. *Computational Fluid Dynamics Simulation of Spray Dryers: An Engineer's Guide*. CRC Press
- Reis FR. 2014. *Vacuum Drying for Extending Food Shelf-Life*. Springer International Publishing
- Rodrigues S. 2008. *Advances in Fruit Processing Technologies*. CRC Press
- Angela M and Meireles A. 2008. *Extracting Bioactive Compounds for Food Products Theory and Applications*. CRC Press
- Rivas EO. 2009. *Processing Effects on Safety and Quality of Foods*. CRC Press
- Lebovka NI, Vorobiev E, Cheimat F. 2012. *Enhancing Extraction Processes in the Food Industry*. CRC Press

FSQ 603	Quality Assurance in Food Supply Chain	3 (3+0)
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Theory

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

Teaching Schedule

Theory

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

Text/Reference Books/Suggested Readings

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

C. Syllabus of Supportive Courses

FPE 605	Food Analytical Techniques	3(1+2)
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Theory

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

Practical

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

Teaching Schedule

Theory

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

Practical

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

Text/Reference Books/Suggested Readings

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

FSQ 607	Sensory Evaluation of Foods	2(2+0)
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Theory

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

Teaching Schedule

Theory

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

Text/Reference Books/Suggested Readings

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

I	Course Title	:	DOCTORAL SEMINAR
II	Course Code	:	FPT 691
III	Credit Hours	:	1(0+1)
	Objective		<ul style="list-style-type: none"> • The students should be encouraged to make presentations on the latest developments and literature in the area of research topic. This will provide training to the students on preparation for seminar, organizing the work, critical analysis of data and presentation skills

I	Course Title	:	DOCTORAL SEMINAR
II	Course Code	:	FPT 692
III	Credit Hours	:	1(0+1)
	Objective		<ul style="list-style-type: none"> • The students should be encouraged to make presentations on the latest developments and literature in the area of research topic. This will provide training to the students on preparation for seminar, organizing the work, critical analysis of data and presentation skills

I	Course Title	:	RESEARCH WORK
II	Course Code	:	FPT 699
III	Credit Hours	:	75(0+75)

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*** Currently Ph. D. (Food Technology) degree programme at Mahatma Phule Krishi Vidyapeeth, Rahuri is temporary suspended due to lack of manpower. It will be started as Ph. D. (Food Technology) Food Processing Technology in future.**

Note :	Optional Major Subjects: The said courses are subjected to availability of infrastructure and facilities and to be decided by SAC committee
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FPT 603	Food Manufacturing Technology	3 (3+0)
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Theory

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

Suggested Reading

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

FPT 605	Food Process Modeling and Scale-up	3 (3+0)
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Theory

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

Suggested Reading

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

Note :	Optional Minor Subjects: The said courses are subjected to availability of infrastructure and facilities and to be decided by SAC committee
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FPE 606	Food Handling and Storage Engineering	3(3+0)
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Theory

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

Suggested Reading

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

List of Journals

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

- 34) [Food Control](#)
- 35) [Molecular Nutrition and Food Research](#)
- 36) [LWT - Food Science and Technology](#)
- 37) [Frontiers in Nutrition](#)
- 38) [Journal of Food and Drug Analysis](#)
- 39) [Food Chemistry: X](#)
- 40) [Food and Function](#)
- 41) [International Journal of Food Microbiology](#)