



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: Undergraduate

Branch: Food Engineering & Technology

Course / Subject Code: BE05051071

Course / Subject Name: Thermal and Non-Thermal Processing of Food

w. e. f. Academic Year:	2026-27
Semester:	05
Category of the Course:	Professional Elective Course - 2

Prerequisite:	Basic understanding of Food Engineering operations
Rationale:	Food engineering operations are essential for the safe processing, preservation, and quality maintenance of food products. Thermal processing methods such as blanching, pasteurisation, sterilisation, and drying are widely used to inactivate microorganisms and enzymes. Non-thermal technologies such as high-pressure processing, pulsed electric fields, ultrasound, and cold plasma have emerged as innovative techniques to extend shelf life while maintaining nutritional and sensory quality. This course introduces students to the engineering principles, equipment, and applications of thermal and non-thermal food processing technologies.

Course Outcome:

After Completion of the Course, the Student will be able to:

No	Course Outcomes
01	Analyse heat and mass transfer mechanisms (conduction, convection, and radiation) involved in food processing operations and their impact on product quality.
02	Explain the principles of thermal processing in food preservation, including pasteurisation, sterilisation, blanching, and evaporation.
03	Discuss the principles and application of emerging non-thermal technology, such as high-pressure processing, pulsed electric fields, cold plasma, ultrasound, and irradiation
04	Understand the effect of thermal and non-thermal processing on food safety, shelf life, nutritional quality, and sensory attributes.
05	To use the principles of processing technique for the design of processing operations.

Teaching and Examination Scheme:

Teaching-Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
L	T	P	PBL*	TH		Theory		Tutorial/Practical			
						ESE (E)	PA (M)	PA/ (I)	PB L (I)	ES E (V)	
45	0	30	15	90	03	70	30	20	30	50	200



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Where L=Lecture, T=Tutorial, P=Practical, TW/SL=Term-Work/Self-Learning, TH=Total Hours, ESE=End- Semester Examination, PA = Progressive Assessment

***Problem-Based Learning (PBL) aims to accommodate learning beyond the syllabus as per clause 9.4 of the NBA manual.**

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Fundamentals of food processing Principles and objectives of food processing, importance of thermal and non-thermal methods, heat transfer mechanisms: conduction, convection, radiation, kinetics of microbial destruction (D-value, Z-value, F-value).	7	15
2.	Thermal processing techniques: Blanching principles, Pasteurisation techniques (LTLT, HTST, UHT). Sterilisation and commercial sterility. Canning and retort processing, processing and aseptic processing systems. UHT processing, drying and dehydration, extrusion cooking and its types. Fat frying and kinetics.	10	25
3.	Advanced thermal techniques Ohmic heating, infrared, dielectric heating, induction, microwave irradiation, radiofrequency heating and their food applications.	10	20
4.	Non- thermal processing techniques High-pressure processing, pulse electric field, ultrasound technology, irradiation principles, sources, ozonation, and types of cold plasma.	10	20
5.	Thermal parameters and heat penetration Concept of heat penetration characteristics in food systems during thermal processing. Evaluation of thermal process parameters such as heating rate index, lag factor, cold point determination, and thermal processing time.	8	20
Total		45	100

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
35	35	10	10	10	00

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

The syllabus of Thermal and Non-Thermal Processing of Food directly contributes to:

SDG 2	Zero Hunger
SDG 3	Good Health and Well-Being



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SDG 4	Quality Education
SDG 7	Affordable and Clean Energy
SDG 9	Industry, Innovation and Infrastructure
SDG 12	Responsible Consumption and Production

References/Suggested Learning Resources:

(a) Books:

- Introduction to Food Engineering – R. Paul Singh & Dennis R. Heldman.
- Food Processing Technology: Principles and Practice – P. J. Fellows.
- Principles of Food Processing – Dennis R. Heldman & Richard W. Hartel.
- Handbook of Food Engineering – Dennis R. Heldman et al.
- Transport Phenomena in Food Processing – Jorge Welte-Chanes et al.

(a) Open-source software and website:

- NPTEL / SWAYAM – Free online courses on food engineering and processing.
- National Institute of Food Technology Entrepreneurship and Management – Research resources and training materials.
- Indian Institute of Food Processing Technology – Technical reports, publications, and learning resources.
- Central Food Technological Research Institute – Open research articles and food technology resources.
- Food Safety and Standards Authority of India – Guidelines, standards, and food safety documentation.

Suggested Course Practical List

- Determination of thermal conductivity of selected food materials.
- Determination of specific heat capacity of food samples using calorimetric methods.
- Study of heat transfer through conduction using a composite wall apparatus.
- Determination of convective heat transfer coefficient in heating and cooling systems.
- Determination of drying characteristics and drying rate curve of food materials using a tray dryer.
- Determination of moisture content and equilibrium moisture content of foods.
- Study of the pasteurisation process and assessment of microbial reduction.
- Determination of freezing time of food products and analysis of freezing curves.
- Study of evaporation and concentration of liquid foods using a laboratory evaporator.
- Demonstration of non-thermal processing techniques, such as ultrasound or high-pressure processing, for food preservation



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List of Laboratory/Learning Resources Required: Equipment

- Thermal conductivity measurement apparatus
- Calorimeter for specific heat determination
- Composite wall heat transfer apparatus
- Convective heat transfer apparatus
- Tray dryer or cabinet dryer
- Moisture analyser or hot air oven
- Laboratory pasteurisation unit or water bath pasteurizer
- Deep freezer or freezing unit with temperature probe
- Laboratory evaporator or rotary evaporator
- Ultrasonic processor or high-pressure processing demonstration unit
- Digital thermometer and thermocouples
- Analytical balance

List of suggested activities for Problem-Based Learning:

Sr. No.	Activity Name	Suggested Topics / Focus Area	Hours	Evaluation Criteria
1.	Industry / Research Laboratory Visit	Visit food processing industries (dairy, beverage, canning units) to observe thermal (pasteurisation, sterilisation, UHT) and non-thermal processes (HPP, PEF, irradiation, cold plasma)	10 h (Visit + Report)	Report with process flow diagrams, equipment study, identification of critical control points (CCPs) and quality changes
2.	Assignment (Numericals)	Solve problems related to thermal processing (D-value, Z-value, F-value), heat penetration, pasteurisation calculations, and basic non-thermal process kinetics	10 h	Accuracy, methodology, and conceptual understanding
3.	Complex Problem Solving	Thermal death kinetics, sterilisation time calculation, heat exchanger design basics, comparison of thermal vs non-thermal methods	10 h	Analytical approach, correctness, depth of solution
4.	Problem Solving / Coding	Simulation or case studies using NPTEL/SWAYAM on food preservation technologies, thermal processing, and emerging non-thermal techniques	10 h	Functionality, correctness, usability, and validation



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5.	Online Course (MOOC)	NPTEL/SWAYAM courses on Food Preservation, Thermal Processing, Emerging Non-Thermal Technologies	10 h	Course completion certificate and assessment performance
6.	Industrial Safety Videos	Study safety aspects in thermal processing (boilers, retorts, steam systems) and non-thermal technologies (radiation safety, high voltage systems)	10 h	Evaluation through report, quiz, or safety protocol analysis
7.	Discussion on Research Papers	Review 4–5 research papers on novel thermal techniques (microwave, ohmic heating) and non-thermal methods (HPP, PEF, ultrasound, cold plasma)	20 h (5 papers × 4 h)	Understanding, critical analysis, and presentation
8.	Poster / Chart / PPT Presentation	Topics such as pasteurization methods, sterilization, UHT processing, high-pressure processing, pulsed electric field, irradiation	6 h	Clarity, technical accuracy, presentation effectiveness
9.	Model Development (Working / Non-working)	Develop models of heat exchanger, pasteurizer, retort system, or demonstration models of non-thermal technologies (HPP/PEF concept models)	8–12 h	Innovation, demonstration quality, explanation of concept
10.	Industrial Exposure (2–3 Days)	Exposure to food industries using thermal and non-thermal processing to identify process efficiency, quality retention, and energy use	20 h	Detailed report with observations, problem identification, and practical solutions
11.	Industry / Research Laboratory Visit	Visit food processing industries (dairy, beverage, canning units) to observe thermal (pasteurisation, sterilisation, UHT) and non-thermal processes (HPP, PEF, irradiation, cold plasma)	10 h (Visit + Report)	Report with process flow diagrams, equipment study, identification of critical control points (CCPs) and quality changes
12.	Assignment (Numericals)	Solve problems related to thermal processing (D-value, Z-value, F-value), heat penetration, pasteurisation calculations, and basic non-thermal process kinetics	10 h	Accuracy, methodology, and conceptual understanding
