



S.No.	Topic	No. of Lectures
11.	Pulsed electric field preservation; Principles and application, microbial inactivation mechanism, determinant factors in PFE technology, influence on food ingredients, pulsed electric field treatment unit, modeling PFE microbial inactivation, alternative applications of PEF technology, decontamination of microorganisms by surface treatment.	2
12.	Extrusion cooking; Rheology of extrudates, Newtonian and non-Newtonian models of single-screw extruder performance, extruder leakage flows, extruder die and its interaction with extruder behaviour, screw power demand, non-isothermal screw operation, single-screw designs, multiple-screw extruders, partially filled screws, analysis of complex screws, heat transfer in extruders, extruder residence-time distributions, recent developments, design criteria of extruders.	4
Total		30

IX. List of Practicals

S.No.	Topic	No. of Practicals
1.	Study of thermal processing of foods and equipment, viz. pasteurization and sterilization and tutorials.	2
2.	Study of different irradiation processes and equipments.	1
3.	Study of different membrane separation processes and equipments.	1
4.	Study of different ultrasound processes and equipments	1
5.	Study of different ohmic heating method and equipments.	1
6.	Study of different pulsed electric field preservation processes and equipments.	1
7.	Study of different extrusion cooking method and equipments.	2
8.	Product quality determination	2
9.	Visit of various food industries.	3
10.	Development of experimental setup by students	1
Total		15

X. Suggested Reading

- Brennan JG, Butters JR, Cowell ND and Lilly AEI. 1990. *Food Engineering Operations*. Elsevier Publications.
- Fellows P. 1988. *Food Processing Technology: Principle and Practice*. VCH Publications.
- Geankoplis J Christie. 1999. *Transport Process and Unit Operations*. Allyn & Bacon.
- Henderson S and Perry SM. 1976. *Agricultural Process Engineering*. 5th Ed. AVI Publishing Company.
- McCabe WL and Smith JC. 1999. *Unit Operations of Chemical Engineering*. McGraw Hill.
- Sahay KM and Singh KK. 1994. *Unit Operation of Agricultural Processing*. Vikas Publishing House Pvt Ltd.
- Singh RP and Heldman DR. 1993. *Introduction to Food Engineering*. Academic Press.
- Singh RP. 1991. *Fundamentals of Food Process Engineering*. AVI Publishing Company.

I. Course Title : Drying and Dehydration of Food Materials

II. Course Code : PFE 602

III. Credit Hours : 2+1

IV. Aim of the course

To acquaint and equip the students with the latest technologies of dehydration of food products and the design features of different dryers.

V. Theory

Unit I

Importance of drying, principles of drying, moisture determination, equilibrium moisture content, determination of EMC, methods and isotherm models. Psychrometry; Psychrometric terms, construction and use of psychrometric charts.

Unit II

Air flow and resistance, principles and equipment for air movement and heating, drying methods and theory of drying, dryers, classification and other allied equipment, thin layer drying of cereal grains, deep bed and continuous flow drying, drying models.

Unit III

Heat requirements and thermal efficiency of drying system, aeration, tempering and dehydration, operation of dryers and their controls, selection of dryers, performance testing of grain dryers, drying characteristics of cereals, pulses and oilseeds, microwave drying, radio frequency drying and tunnel drying, principles and equipment.

Unit IV

Drying of liquid foods, spray drying, drum drying, freeze drying, foam mat drying, heat pump drying, refractance window drying, infrared drying osmotic dehydration. Principles, methods, construction and adjustments, selection of dryers, heat utilization factor and thermal efficiency.

VI. Practical

Experiments on batch type thin layer dryer, fluidized bed dryer, continuous flow mixing type dryer, continuous flow non mixing type dryer, sand medium dryer (conduction type drying), agricultural waste fired furnace dryer, spray dryer, drum dryer, foam mat drying and osmotic dehydration to evaluate the thermal efficiency and heat utilization factor.

VII. Learning outcome

Student's capability to develop dehydrated food products with higher retention of nutrients using different drying techniques and equipments.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Importance of drying, principles of drying, moisture content determination, equilibrium moisture content, determination of EMC.	2
2.	Basic concepts associated with drying – Intermolecular forces, Water activity, Molecular mobility, Glass transition temperature, Isotherm models – Langmuir, BET Isotherm	3
3.	Psychrometry; Psychrometric terms, construction and use of psychrometric charts.	3
4.	Air flow and resistance, principles and equipment for air movement and heating	3
5.	Theory of drying, Dryers, Classification and other allied equipment,	2
6.	Thin layer drying of cereal grains, deep bed and continuous flow drying, drying models.	3
7.	Heat requirements and thermal efficiency of drying system, aeration, tempering and dehydration.	3



S.No.	Topic	No. of Lectures
8.	Operation of dryers and their controls, selection of dryers, performance testing of grain dryers Drying characteristics of cereals, pulses and oilseeds,	3
9.	Microwave drying, radio frequency drying and tunnel drying, principles and equipment.	2
10.	Drying of liquid foods, spray drying, drum drying. Principles, methods, construction and adjustments.	2
11.	Freeze drying, foam mat drying, heat pump drying, refractance window drying, infrared drying, and osmotic dehydration. Principles, methods, construction and adjustments.	3
12.	Selection of dryers, heat utilization factor and thermal efficiency.	1
	Total	30

IX. List of Practicals

S.No.	Topic	No. of Practicals
1.	Determination of moisture content with Oven method.	1
2.	Determination of moisture content (w.b.) with Universal/Digital moisture meter.	1
3.	Determination of moisture content (w b) with Infrared moisture meter.	1
4.	Determination of Equilibrium moisture content of grains.	1
5.	Drying of grains in a batch type thin layer dryer to evaluate the thermal efficiency and heat utilization factor.	1
6.	To evaluate the performance of fluidized bed dryer in terms of thermal efficiency and heat utilization factor.	1
7.	To draw a drying rate curve for wet grains in Satake test dryer i.e. Compartment type dryer.	1
8.	Drying of food materials in a solar assisted mechanical tray drying system.	1
9.	To dry grains in continuous flow mixing type dryer.	1
10.	To evaluate the performance of conduction type dryer.	1
11.	To determine the drying efficiency of agricultural waste fired furnace dryer.	1
12.	Drying of liquid food material in a spray dryer and evaluate its thermal efficiency and heat utilization factor.	1
13.	To evaluate the performance of a drum dryer.	1
14.	Experimentation on foam mat drying process.	1
15.	Experiment on osmotic dehydration of grapes.	1
	Total	15

X. Suggested Reading

- Bala BK. 1998. *Drying and Storage of Cereal Grains*. Oxford and IBH.
- Brooker DB, Bakker Arkema FW and Hall CW. 1974. *Drying Cereal Grains*. The AVI Publishing Company.
- Chakraverty A and De DS. 1999. *Post-Harvest Technology of Cereals, Pulses and Oilseeds*. Oxford & IBH.
- Hall CW. 1970. *Drying Farm Crops*. Lyall Book Depot.
- Kudra and Mujumdar. 2009. *Advanced Drying Technologies*. CRC press.