

# 21 Post Harvest Technology

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## TRIMESTERWISE DISTRIBUTION OF COURSES

### I TRIMESTER

	L	P
<b>PHT 501</b> FUNDAMENTALS OF POST HARVEST TECHNOLOGY OF HORTICULTURAL AND ARABLE CROPS	3	1
<b>PHT 502</b> APPLIED FOOD ENGINEERING	3	1
<b>PHT 503</b> LABORATORY TECHNIQUES FOR FOOD CROPS	2	2
<b>PHT 504</b> TECHNOLOGY OF PLANTATION CROPS AND SPICES	2	0
<b>PHT 602</b> PROCESS PLANT DESIGN	2	1
<b>PHT 603</b> ADVANCES IN FOOD PROCESSING AND QUALITY MANAGEMENT	3	1
<b>PHT 601/ EXPORT ORIENTED HORTICULTURE HORT 601</b>	3	1
<b>PHT 630/ HEAT AND MASS TRANSFER AE 630</b>	3	0
<b>PHT 691</b> SEMINAR	1	0

### II TRIMESTER

<b>PHT 511</b> TECHNOLOGY OF MILK AND MILK PRODUCTS	2	0
<b>PHT 611</b> POST HARVEST PROCESSING OF CEREALS, PULSES AND OILSEEDS	2	1
<b>PHT 612</b> POST HARVEST MANAGEMENT OF HORTICULTURAL CROPS	3	1
<b>PHT 613</b> FOOD CHEMISTRY	2	1
<b>PHT 614</b> PRINCIPLES AND PRACTICES OF FOOD HANDLING AND PACKAGING	2	1
<b>AGR 009</b> PRINCIPLES OF POST HARVEST TECHNOLOGY	1	1
<b>PHT631/ DRYING AND DEHYDRATION AE 631</b>	2	1
<b>PHT 691</b> SEMINAR	1	0

### III TRIMESTER

<b>PHT 521</b> TECHNOLOGY OF MEAT, POULTRY AND FISH PROCESSING	2	0
<b>PHT 621</b> PROCESSING OF HORTICULTURAL CROPS	3	1
<b>PHT 624</b> ADVANCED STORAGE ENGINEERING	2	1

<b>PHT 623</b> DESIGN OF FOOD PROCESSING EQUIPMENTS	2	1
<b>PHT 617/</b> PHYSIOLOGY OF RIPENING AND SENESCENCE <b>PP 617</b>	2	1
<b>PHT 530/</b> ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS <b>AE 530</b>	2	1
<b>PHT 622/</b> VALUE ADDITION IN ORNAMENTAL CROPS <b>FLA 622</b>	1	1
<b>PHT 691</b> SEMINAR	1	0

**Core Courses**

**M.Sc.:** PHT 501, PHT 502, PHT 503

**Ph.D.:** PHT 603, PHT 614

# POST HARVEST TECHNOLOGY

**Major Fields :** Post Harvest Technology of Horticultural Crops  
Post Harvest Engineering and Technology

**Minor Field :** Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.  
M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

## DESCRIPTION OF COURSES

### AGR-009 PRINCIPLES OF POST HARVEST TECHNOLOGY

(1L+1P) II

#### Objective

To acquaint with the basics of post harvest management of perishables and durable crops.

#### Theory

##### UNIT I

History and role of post harvest technology; principles and methods of food preservation.

##### UNIT II

Post harvest technology of durables (rice processing, wheat milling, oil extraction, pulse milling etc.); Post harvest handling (harvesting, sorting, grading and packaging) of perishables i.e. fruits, vegetables and flowers.

##### UNIT III

Food storage systems; ripening and senescence of horticultural crops; Post harvest treatments for quality retention of horticultural crops; spoilage of fruits & vegetables, methods to reduce decay.

##### UNIT IV

Processing of fruits and vegetables (canning, dehydration, freezing and value added products).

#### Practicals

Acquaintance with basic PHT equipment, Determination of TSS and acidity, Packaging, Visual identification of spoilage, Specific gravity, and Texture analysis, On- Farm storage of fruits and vegetables, Respiration, Processing of F&V to value added products, Demonstration on PHT of cereals, pulses.

#### Suggested Readings

Preservation of Fruits & Vegetables by Srivastava & Kumar. 1996. Intl. Book Publishing Co. Lucknow.  
Preservation of Fruits & Vegetables by Siddappa et al. 1999. ICAR, New Delhi  
An introduction to Post Harvest Technology by RBH Wills. 2003.  
Post Harvest Technology of Fruits & Vegetables by Verma & Joshi. 2000. Indus Publication, New Delhi  
Hand Book of Post Harvest Technology by Chakravarty et al. 2003. Mercer-Dekker Ltd.

**PHT 501 FUNDAMENTALS OF POST HARVEST TECHNOLOGY OF HORTICULTURAL & ARABLE CROPS** (3L+1P) I

**Objective**

To acquaint with different methods of food preservation, different groups of micro-organisms associated with food, sensory quality parameters, and methods of sensory evaluation of foods.

**Theory**

UNIT I

Composition of food and nutritive value of horticultural and arable crops. Methods of preservation, Contamination and spoilage of foods, spoilage of fresh fruits, vegetables, cereals and other crops, spoilage of various processed products, canned foods, dehydrated and frozen foods, pickles, chutneys and cereal products, intrinsic and extrinsic parameters that affect microbial growth and their control measures.

UNIT II

Classification of microorganisms and their sources in food, various types of fermentation and their utilization, microbial examination of foods. Food borne diseases and poisoning.

UNIT III

Food safety and quality, importance of hygiene and sanitation.

UNIT IV

Importance of micro organisms in industrial fermentation process and production of various by-products, production of vinegar, Fermented beverages, bread and traditional food products.

**Practicals**

Morphology of food spoilage microorganisms. Preparation of bacteriological media and their sterilization for culturing of microorganisms Staining and counting of microorganisms. Checking of spoiled products. Lactic fermentation of mixed vegetables. Lactic fermentation of cabbage. Estimation of TSS, acidity, pH & Enzyme test for adequacy of blanching. Estimation of ascorbic acid. Estimation of carotenoid pigments. Estimation of sugars. Calculation of ingredients for preparation of fruit nectar and squash. Estimation of color and texture.

**Suggested Readings**

Frazier, J. and Westhoff, D.C. 1988. *Food Microbiology*. 4th Ed. McGraw Hill.

Jay, J.M., Loessner, M.J. and Golden, D.A. 2005. *Modern Food Microbiology*. 7<sup>th</sup> Ed. Springer.

Steinkraus, K.S. 1996. *Handbook of Indigenous Fermented Foods*. Marcel Dekker.

James, M.J., Loessner, M.J. and David, A. 2005. *Modern Food Microbiology*. 7<sup>th</sup> Ed. Golden Food Science Text Studies

Yousef, A.E. 2002. *Food Microbiology: A Laboratory Manual*. AVI.

Piggot, J.R. 1984. *Sensory Evaluation of Foods*. Elbview Applied Science Publ.

**PHT 502 APPLIED FOOD ENGINEERING**

(3L+1P) I

**Objective**

To acquaint with basic principles of Food Engineering and transport processes, and unit operations associated with engineering applications.

## Theory

### UNIT I

Cleaning of raw food materials and related equipment, sorting and grading methods and equipment,

### UNIT II

Size reduction and screening of solid food materials, filtration and separation, centrifugation, extraction and leaching, mixing and emulsification.

### UNIT III

Heat processing (blanching, pasteurization and sterilization), Kinetics of biological reactions - kinetics of reactions occurring in processed foods, reaction velocity constant, order of reaction; application of Arrhenius equation to biological reactions, process of heat transfer, modes of heat transfer and overall heat transfer; Fourier's law, heat exchange equipment; determination of the process time based on region of greatest temperature lag; the process equivalence in terms of minutes at 121.1°C, evaporation and freezing- common methods and equipment.

### UNIT IV

Drying of food grains, mass transfer, molecular diffusion and diffusivity, handling and storage.

## Practicals

Cleaning of food materials, Blanching, pasteurization, and sterilization. Sorting & grading, size reduction, screening, mixing, filtration, centrifugation, extraction and leaching, mechanical extraction of oil, evaporation, freezing, drying, storage.

## Suggested Readings

Charm, S.E., McCabe, W.L., Smith, J.C. and Harriott, P.1993. *Unit Operations of Chemical Engineering*. McGraw Hills.

Earle, R.L. 1985. *Unit Operations in Food Processing*. Pergamon Press.

Heldman, D.R. and Singh, R.P.1995. *Food Process Engineering*. AVI Publ.

Sahay, K.M. and Singh, K.K. 1994. *Unit Operation of Agricultural Processing*. Vikas Publ. House.

Singh, R.P. and Heldman, D.R. 1993. *Introduction to Food Engineering*. Academic Press.

Cheryan, M. 1998. *Ultra-filtration and Micro-filtration Handbook*. Technomic Publ.

Heldman, D.R. and Singh, R.P.1984. *Food Process Engineering*. AVI Publ.

## PHT 503 LABORATORY TECHNIQUES FOR FOOD CROPS

(2L+2P) I

### Objective

To familiarize with the conventional analysis of raw and processed food products of all commodity technologies used for routine quality control in food industry, and their role on nutritional labelling.

### Theory

#### UNIT I

Safety aspects of lab, sampling procedure for quantitative analysis, determination of moisture, determination of relative water content (RWC), physiological loss in weight (PLW), calibration and standardization of instruments, textural properties of harvested produce and processed foods, TSS, Sp. gravity, pH and acidity,

## UNIT II

Spectrophotometry, nondestructive determination of colour, ascorbic acid, sugars, and starch in food crops.

## UNIT III

Basic chromatographic techniques, GC, HPLC, GCMS, Electrophoresis techniques, ultrafiltration, Application of nuclear techniques in harvested produce.

## UNIT IV

Microscopy, Ion leakage as an index of membrane permeability, determination of biochemical components in cereals, pulses and oilseeds. Importance of ethylene, quantitative estimation of rate of ethylene evolution by fruits and vegetables, using gas chromatograph (GC). Micropropagation techniques in horticultural crops, sensory analysis techniques, control of test rooms, products and panel.

### Practicals

Determination of moisture, determination of relative water content (RWC), physiological loss in weight (PLW), calibration and standardization of instruments, textural properties of harvested produce and processed foods, TSS, Sp. gravity, pH and acidity; nondestructive determination of colour, ascorbic acid, sugars, and starch in food crops; estimation of rate of ethylene evolution by fruits and vegetables, using gas chromatograph (GC), determination of biochemical components in cereals, pulses and oilseeds.

### Suggested Readings

AOAC International. 2003. *Official methods of analysis of AOAC International*. 17th Ed. Gaithersburg, MD, USA, Association of Analytical Communities.

Leo, M.L. 2004. *Handbook of Food Analysis*. 2nd Ed. Vols. I-III.

Pomrenz, Y. and Meloan, C.E. 1996. *Food Analysis - Theory and Practice*. 3<sup>rd</sup> Ed. CBS.

Ranganna, S. 2001. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*. 2nd Ed. Tata-McGraw-Hill.

Robinson, J.W. 1970. *Undergraduate Instrumental Analysis*. Marcel Dekker.

Clifton, M. and Pomeranz, Y. 1988. *Food Analysis - Laboratory Experiments*. AVI Publ.

Thompson, A.K. 1995 *Post harvest Technology of fruits and vegetables*. Blackwell Sciences

## PHT 504 TECHNOLOGY OF PLANTATION CROPS AND SPICES

(2L+0P) I

### Objective

To provide an understanding of the science and technology for processing of coffee, tea, cocoa products and spices.

### Theory

#### UNIT I

Coffee: Occurrence, chemical constituents; harvesting, fermentation of coffee beans; changes taking place during fermentation; drying; roasting process, flow sheet for the manufacture of coffee powder; instant coffee technology; chicory chemistry; quality grading of coffee.

## UNIT II

Tea: Occurrence, chemistry of constituents; harvesting; types of tea – green, oolong and CTC; chemistry and technology of CTC tea; manufacturing process for green tea and black tea manufacture; instant tea manufacture; quality evaluation and grading of tea.

## UNIT III

Cocoa: Occurrence, chemistry of the cocoa bean; changes taking place during fermentation of cocoa bean; processing of cocoa bean; cocoa powder; cocoa liquor manufacture; chocolates–types, chemistry and technology of chocolate manufacture; quality control of chocolates.

## UNIT IV

Major spices: Pepper, cardamom, ginger, chili and turmeric–oleoresins and essential oils; method of manufacture; chemistry of the volatiles; enzymatic synthesis of flavour identicals; quality control; fumigation and irradiation of spices.

## UNIT V

Other spices: Cumin, coriander, cinnamon, fenugreek, garlic, mace, clove, mint and vanilla; present trends in synthesis of volatiles; microbial and chemical contaminants, plant suspension cultures.

### Suggested Readings

Banerjee, B. 2002. *Tea Production and Processing*. Oxford Univ. Press.

Minifie, B.W. 1999. *Chocolate, Cocoa and Confectionery Technology*. 3<sup>rd</sup> Ed. Aspen Publ.

NIIR. 2004. *Handbook on Spices*. National Institute of Industrial Research Board, Asia Pacific Business Press Inc.

Sivetz, M. and Foote, H.E. 1963. *Coffee Processing Technology*. AVI Publ.

## PHT 511 TECHNOLOGY OF MILK AND MILK PRODUCTS

(2L+0P) II

### Objective

To acquaint with techniques and technologies of testing and processing of milk into various products and by products.

### Theory

#### UNIT I

Present status of milk & milk products in India and Abroad; market of milk, composition of milk of various species, quality evaluation and testing of milk, procurement, transportation and processing of market milk, cleaning & sanitization of dairy equipments. Special milks such as flavoured, sterilized, recombined & reconstituted toned & double toned.

#### UNIT II

Condensed milk- definition, methods of manufacture, evaluation of condensed & evaporated milk; dried milk- methods of manufacture of skim & whole milk powder, instantiation, physiochemical properties, evaluation, defects in dried milk powder.

#### UNIT III

Cream: Definition, classification, composition, cream separation, sampling, neutralization, sterilization, pasteurization & cooling of cream, evaluation, defects in cream; butter- definition, composition, classification, methods of manufacture, theories of churning, evaluation, defects in butter.

#### UNIT IV

Ice cream: Definition, composition and standards, nutritive value, classification, methods of manufacture, evaluation, defects in ice cream, and technology aspects of softy manufacture.

#### UNIT V

Cheese: Definition, composition, classification, methods of manufacture, cheddar, Gouda, cottage and processed cheese, evaluation, defects in cheese. Indigenous milk products, present status, method of manufacture of *yoghurt, dahi, khoa, burfi, kalakand, gulabjamun, rosogolla, srikhand, chhana, paneer, ghee, lassi* etc; probiotic milk products.

### Suggested Readings

- Aneja, R.P., Mathur, B.N., Chandan, R.C. and Banerjee, A.K. 2002. *Technology of Indian Milk Products*. Dairy India Publ.
- De, S.1980. *Outlines of Dairy Technology*. Oxford Univ. Press.
- Henderson, J.L. 1971. *Fluid Milk Industry*. AVI Publ.
- Spreer, E. 1993. *Milk and Dairy Products*. Marcel Dekker.
- Walstra, P. 1999. *Dairy Technology*. Marcel Dekker.
- Walstra, P. (Ed.). 2006. *Dairy Science and Technology*. 2nd Ed. Taylor & Francis.

### PHT 521 TECHNOLOGY OF MEAT, POULTRY AND FISH PROCESSING

(2L) III

#### Objective

To provide an understanding of the technology for handling, processing, preservation and by-product utilization of meat, poultry and fish products processing.

#### Theory

##### UNIT I

Meat composition from different sources; muscle structure and compositions; post-mortem muscle chemistry; meat colour and flavours; meat microbiology and safety.

##### UNIT II

Modern abattoirs, typical layout and features, ante-mortem handling and design of handling facilities; hoisting rail and traveling pulley system; stunning methods; steps in slaughtering and dressing; offal handling and inspection; inedible by-products; operational factors affecting meat quality; effects of processing on meat tenderization; abattoir equipment and utilities

##### UNIT III

Chilling and freezing of carcass and meat; canning, cooking, drying, pickling, curing and smoking; prepared meat products like salami, kebabs, sausages, sliced, minced, corned; intermediate moisture and dried meat products; meat plant hygiene – GMP and HACCP. Packaging of meat products.

##### UNIT IV

Poultry industry in India, measuring the yields and quality characteristics of poultry products, microbiology of poultry meat, spoilage factors; lay-out and design of poultry processing plants, plant sanitation; poultry meat processing operations, equipment used – defeathering, bleeding, scalding etc.; packaging of poultry products, refrigerated storage of poultry meat, by products – eggs, egg products, whole egg powder, egg yolk products, their manufacture, packaging and storage.



## UNIT V

Commercially important marine products from India; product export and its sustenance; basic biochemistry and microbiology; preservation of postharvest fish freshness; transportation in refrigerated vehicles; deodorization of transport systems; design of refrigerated and insulated trucks; grading and preservation of shell fish; pickling and preparation of fish protein concentrate, fish oil and other by products.

### Suggested Readings

- Forrest, J.C. 1975. *Principles of Meat Science*. Freeman.
- Govindan, T.K. 1985. *Fish Processing Technology*. Oxford & IBH.
- Hui, Y.H. 2001. *Meat Science and Applications*. Marcel Dekker.
- Kerry, J. et al. 2002. *Meat Processing*. Woodhead Publ. CRC Press.
- Levie, A. 1984. *Meat Hand Book*. 4th Ed. AVI Publ.
- Mead, M. 2004. *Poultry Meat Processing and Quality*. Woodhead Publ.

## PHT 530/AE 530 ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS (2L+1P) III

### Objective

To acquaint and equip the students with different techniques of measurement of engineering properties and their importance in the design of processing equipments.

### Theory

#### UNIT I

Biological materials, uniqueness in relation to other materials; physical characteristics viz. dimensions, density, volume, porosity and surface area.

#### UNIT II

Concept of rheology; rheological equations for stress and strain; visco-elastic characteristics of food materials;

#### UNIT III

Aerodynamic and hydrodynamic properties; thermal, electrical and optical properties.

#### UNIT IV

Applications of engineering properties in design and operation of agricultural equipment and systems.

### Practicals

Experiments for the determination of physical properties like, length, breadth, thickness, surface area, bulk density, porosity, true density, coefficient of friction, angle of repose and colour for various food grains, fruits, vegetables, spices and processed foods, aerodynamic properties like terminal velocity, lift and drag force for food grains, firmness and hardness of grain, fruits and stalk.

### Suggested Readings

- Mohesenin, N.N. 1980. *Physical Properties of Plant and Animal Materials*. Gordon & Breach Science Publ.

- Mohesenin, N.N. 1980. *Thermal Properties of Foods and Agricultural Materials*. Gordon & Breach Science Publ.
- Peleg, M. and Bagelay, E.B. 1983. *Physical Properties of Foods*. AVI Publ.
- Rao, M.A. and Rizvi, S.S.H. (Eds.). 1986. *Engineering Properties of Foods*. Marcel Dekker.
- Ronal, Jowitt, Felix Escher, Bengt Hallsram, Hans, F., Th. Meffert, Walter EC Spices, Gilbert Vox. 1983. *Physical Properties of Foods*. Applied Science Publ.
- Singhal, O.P. and Samuel, D.V.K. 2003. *Engineering Properties of Biological Materials*. Saroj Prakasan.

## **PHT 601/HORT 601 EXPORT ORIENTED HORTICULTURE**

**(3L+1P) I**

### **Objective**

To acquaint the students with the export oriented requirements of horticultural crops.

### **Theory**

#### UNIT I

India's position and potentiality in world trade; export promotion zones in India.

#### UNIT II

Scope, produce specifications, quality and safety standards for export of fruits *viz.*, mango, grape, litchi, pomegranate, walnut, cashewnut *etc.*, vegetables *viz.*, onion, chilli, okra, bitter gourd, gherkin *etc.*, flowers *viz.*, rose, carnation, chrysanthemum, gerbera, specialty flowers *etc.*, cut green and foliage plants,

#### UNIT III

Processed and value-added products, post harvest management for export including packaging and cool chain; HACCP, Codex alimentarius, ISO certification; WTO and its implications, sanitary and phyto-sanitary measures.

#### UNIT IV

Seed and planting material; hi-tech nurseries, implications of PVP.

### **Practicals**

Export promotion zones for vegetables and export of fresh vegetables and their products; quality standards of vegetables for export purpose; practical on quality standards of major flower for exports; quality standards of planting material and seeds; Hi-tech nursery in floriculture; quality standards of major fruits for exports; practical on ISO specifications and HACCP for export of fruits; Sanitary and phytosanitary measures during export of horticultural produce; post harvest management chain of horticultural produce for exports.

### **Suggested Readings:**

- Islam, C.N. 1990. Horticultural Export of Developing Countries: Past preferences, future prospects and policies. International Institute of Food Policy Research, USA.
- Bartz, J.A. and Brecht, J.K. 2002. Post Harvest Physiology and Pathology of Vegetables (II<sup>nd</sup> Edition) Marcel Dekkar, Inc, New York.
- Sheela, V.L. 2007. Flowers in Trade. New India Publ. Agency.
- Bhattacharjee, SK. 2006. Advances in Ornamental Horticulture. Vols. I-VI. Pointer Publ.
- Bose, T.K. and Yadav, L.P. 1989. *Commercial Flowers*. Naya Prokash, Kolkata.

- Bose, T.K, Maiti, R.G., Dhua, R.S. and Das, P. 1999. Floriculture and Landscaping. Naya Prokash.
- Chadha, K.L. 1995. Advances in Horticulture. Vol. XII. Malhotra Publ. House.
- Reddy, S., Janakiram, T., Balaji, T., Kulkarni, S. and Misra, R.L. 2007. Hightech Floriculture. Indian Society of Ornamental Horticulture, New Delhi.

## **PHT 602 PROCESS PLANT DESIGN**

**(2L+1P) I**

### **Objective**

Introduce students to the methodology of project formulations and the implementation procedures and strategic planning of new projects.

### **Theory**

#### UNIT I

Plant design concepts and general design considerations; plant location - location factors and their interaction with plant location, location theory models.

#### UNIT II

Computer aided selection of the location; feasibility analysis and preparation of feasibility report; plant size-factors affecting plant size and their interactions, estimation of breakeven and economic plant size; product and process design.

#### UNIT III

Process selection; process flow charts, computer aided development of flow charts; equipment selection including economic analysis of equipment, alternatives; plant layout including computer aided development and evaluation, layout symbols; planning and design of service facilities, human resource.

#### UNIT IV

Packaging and marketing system; hygienic design aspects and workers' safety; functional design of plant building and selection of building materials; estimation of capital investment, analysis of plant costs and profitabilities; management techniques in plant design including applications of network analysis; preparation of project report and its appraisal.

### **Practicals**

Preparation of a model detailed project report for a small scale food processing unit, case studies of various food products, projections planning, analysis for financial and technical feasibilities of the projects.

### **Suggested Readings**

Pavlyak, M.M.2000. *Systems Survival Guide*. Ruby Moon Press.

Thomsett, T.C.1990. *The Little Book of Project Management*. American Management Association.

## **PHT 603 ADVANCES IN FOOD PROCESSING AND QUALITY MANAGEMENT (3L+1P) I**

### **Objective**

To develop an insight among the students about the existing modern techniques to aware them about their methodology and applications in food processing as well as to acquaint with food quality parameters and control systems, food standards, regulations, specifications.

## Theory

### UNIT I

Introduction to quality, importance of quality, management principles, estimation of quality parameters, quality and business environment.

### UNIT II

Quality management standards, ISO/BIS, PFA, AGMARK and QMS standards, quality system components and their requirements., Food safety and standards, hazard analysis and critical control points (HACCP), Codex alimentarius, total quality management (TQM), statistical processed control, quality auditing.

### UNIT III

Recent advances in processing technologies, aseptic processing, individual quick freezing and cryogenic freezing, high pressure technology, heat and ultrasound, high voltage pulse technology, irradiation, membrane technology, microwave heating, enzymes, natural antimicrobial agents, food additives, fermentation, minimal processing. Principles of food biotechnology, genetic modification of microorganisms in the food industry (lactic acid bacteria, yeasts and moulds), production of high valued food products by microorganisms viz. enzymes, organic acids, SCP, antibodies, nutritional additives, flavors, pigments.

## Practicals

Testing and evaluation of quality attributes of raw and processed foods; detection and estimation of food additives and adulterants; quality assurance procedure, GMP, GAP documentation. Preparation of quality policy & documentation, application of HACCP to products, preparation of HACCP chart; preparation of documentation & records, visit to units with ISO systems; visit to Units with HACCP certification; visit to units implementing GMP, GAP; mini-project on preparation of a model laboratory manual.

## Suggested Readings

Amerine, M.A., Pangborn, R.M. and Rosslos, E.B. 1965. *Principles of Sensory Evaluation of Food*. Academic Press.

Early, R.1995.*Guide to Quality Management Systems for Food Industries*. Blackie Academic.

Krammer, A. and Twigg, B.A.1973. *Quality Control in Food Industry*. Vol. I, II. AVI Publ.

Ranganna, S. 2001. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*. 2nd Ed. Tata-McGraw-Hill.

Barbosa-Canovas 2002. *Novel Food Processing Technologies*. CRC.

Shi, J. (Ed.). 2006. *Functional Food Ingredients and Nutraceuticals:Processing Technologies*. CRC.

## PHT 611 POST HARVEST PROCESSING OF CEREALS, PULSES AND OIL SEEDS (2L+1P) II

### Objective

To acquaint with production and consumption trends, structure, composition, quality evaluation, and processing technologies for product development and value addition of various cereals, pulses and oilseeds.

## Theory

### UNIT I

Objectives and requirements of processing; raw grain characteristics and quality.

### UNIT II

Wheat milling - products and by-products; roller flour milling; separation of milled products; manufacture of bakery products, pasta products and various processed cereal-based foods; manufacture of whole wheat *atta*, blended flour and fortified flour.

### UNIT III

Rice milling technology; by-products of rice milling and their utilization; parboiling of rice-technology and effect on quality characteristics; processed products based on rice;

### UNIT IV

Corn: Types and nutritive value; dry and wet milling, manufacture of value-added products; processing of barley, oats, sorghum and millets.

### UNIT V

Legumes and oilseeds: composition, anti-nutritional factors, processing and storage; processing of oilseeds, construction and working mechanism of different extraction equipments like single stage extraction, multiple stage static bed system, bollmann extractor, hildebrandt extractor; assessment of processed product quality; packaging of processed products .

## Practicals

Cleaning & grading of raw grains, grain drying , parboiling of paddy , paddy milling and separation, cleaning & grading of grains, pulse milling and separation, cleaning & grading of milled pulse, pre-treatments for oil extraction, oil extraction, separation of milled products product quality assessment, plant layout & design, packaging for processed products. Physicochemical and rheological properties; conditioning of wheat; milling of wheat and rice by laboratory mill; parboiling of rice; puffing and popping of grains; experimental parboiling and assessment of degree of polishing; extraction of oil using expeller and solvent extraction methods; visit to related processing industries.

## Suggested Reading

Dendy, D.A.V. and Dobraszczyk, B.J. 2001. *Cereal and Cereal Products*. Aspen.

Lorenz, K.L. 1991. *Handbook of Cereal Science and Technology*. Marcel Dekker.

Marshall, W.E. and Wadsworth, J.I. 1994. *Rice Science and Technology*. Marcel Dekker.

Araullo, E.V., dePadna, D.B. and Graham, Michael. 1976. *Rice Post Harvest Technology*. International Development Res. Centre, Ottawa, Canada

A. Chakravarty et al 2003. *Handbook of Post Harvest Technology* Marcel Dekker.

Mathews, R.H. 1989. *Legumes Chemistry, Technology and Human Nutrition*. Marcel Dekker.

## PHT 612 POST HARVEST MANAGEMENT OF HORTICULTURAL CROPS

(3L+1P) II

### Objective

To acquaint with the proper handling technologies of fruits and vegetables to reduce post harvest losses.

## Theory

### UNIT I

Maturity indices of horticultural crops, composition and structure of fruits and vegetables and their significance with post harvest management.

### UNIT II

Harvesting and its relationship with quality, sorting and grading, pre-harvest crop management practices and their influence on quality during storage and marketing.

### UNIT III

Respiration, ethylene in post-harvest biology, artificial ripening and de-greening of fruits. Physiology of ripening and senescence. Storage system: on-farm storage-evaporatively cooled stores, ventilated storage, pit storage etc. Refrigerated storage refrigeration cycle, controlled/modified atmosphere, hypobaric storage.

### UNIT IV

Application of growth regulators for quality assurance, post-harvest treatments: pre cooling, heat treatments (hot water, hot air and vapor heat), fungicides & biologically safe chemicals, irradiation, curing, pulsing etc. Packing line operations, packaging of horticultural produce. Transportation-rail, road, sea, air. Codex norms for export of perishables.

### UNIT V

Post harvest diseases of Hort. Products infection process, factors affecting it; modern methods of controlling decay (use of microbial antagonists their mode of action etc.

## Practicals

Morphological features of some selected fruits and vegetables; maturity indices, harvesting techniques of fruits, field visit & identification of spoilage of fruits and vegetables, on-farm storage/chilling injury, pre-cooling, CA- treatment post harvest treatments to Hort. produce, pre cooling and storage of fruits and vegetables; studies on pre-treatments of selected fruits; use of chemicals for ripening and enhancing shelf life of fruits and vegetables, various storage systems and structures; pre packaging of fruits; GC for ethylene estimation. Pre packaging of vegetables; physiological disorders-chillign injury of banana and custard apple, Electrolyte leakage/membrane permeability/RWC HPLC analysis.

## Suggested Readings

- Kadar, A.A. 1992. *Post-harvest Technology of Horticultural Crops*. 2<sup>nd</sup> Ed. University of California.
- Salunkhe, D.K., Bolia, H.R. and Reddy, N.R. 1991. *Storage, Processing and Nutritional Quality of Fruits and Vegetables*. Vol. I. Fruits and Vegetables. CRC.
- Verma, L.R. and Joshi, V.K. 2000. *Post Harvest Technology of Fruits and Vegetables*. Indus Publ.
- Thompson, A.K. 1995. *Post harvest technology of fruits and vegetables*. Blackwell Sciences.
- Peter, K.V. 2003. *Plantation Crops*. NBT, New Delhi.

## PHT 613 FOOD CHEMISTRY

(2L+1P) II

### Objective

To acquaint with properties and role of various constituents in foods, interaction and changes during processing and with importance of various foods and nutrients in human nutrition.

## Theory

### UNIT I

Basic knowledge on major food components and their chemical reactivity with focus on water and ice. Carbohydrates, lipids, amino acids, proteins.

### UNIT II

Enzymes, minerals, phenolics, flavonoids, colourants, flavours, chemical additives, food contamination and toxic substances. Interaction of constituents in food systems; changes during storage and processing; browning reactions in foods.

### UNIT III

Chemistry of fruits, vegetables, cereals, legumes, oilseeds; essential nutrients- sources, functions, deficiency diseases; requirements and recommended dietary allowances.

## Practicals

Determination of peroxidase and catalase activity. Comparison of different methods for moisture determination in food samples. Test for presence of carbohydrates, and proteins. Identification of gums. Estimation of minerals by atomic absorption, spectrophotometer, estimation of minerals by flame photometer. Determination of fat and protein content, determination of NEB, determination of total carotenoids; determination of reducing and total sugars, determination of extent of rancidity in fats.

## Suggested Readings

Bamji, M.S., Rao, N.A. and Reddy, V. 2003. *Textbook of Human Nutrition*. Oxford & IBH.

Belitz, H.D.1999. *Food Chemistry*. Springer Verlag.

Fennema, O.R.1996. *Food Chemistry*. Marcel Dekker. 601 *Advances in Food and Nutrition Research*. Elsevier Book Series.

Aurand, L.W., Woods, A. and Wells, M.R. 1987. *Food Composition and Analysis*. AVI Publ.

Baynes, J.W., Monnier, V.M., Ames, J.M. and Suzanne, R. 2005. *The Maillard Reaction: Chemistry at the Interface of Nutrition, Aging, and Disease Thorpe*. Annals of the New York Academy of Science.

## PHT 614 PRINCIPLES AND PRACTICES OF FOOD HANDLING AND PACKAGING

(2L+1P) II

## Objective

To acquaint the students with packaging methods, packaging materials, packaging machineries, modern packaging techniques etc.

## Theory

### UNIT I

Handling requirements and equipment for agricultural products involved at various stages of total food chain; packaging and transport of semi processed, processed and frozen food produce.

## UNIT II

Packaging materials, their structural qualities and performance including moisture and gas transmission; selection of packaging materials for various food products; methods and equipment for filling and packaging of liquid, semisolid and solid foods.

## UNIT III

Design and testing of packages; newer concepts in packaging - edible film, modified/controlled atmosphere, aseptic, barrier film and retortable plastic packaging; package labeling tools and techniques. Active and intelligent packaging, and their techniques. Packaging-flavour interactions. Factors affecting flavour absorption, role of the food matrix, role of differing packaging materials.

### Practicals

Packaging of fresh produce, packaging of semi-processed produces, packaging of processed product. CA & MA storage, design considerations, handling equipments, package testing & evaluation, field visit.

### Suggested Readings

- Crosby, N.T. 1981. *Food Packaging: Aspects of Analysis and Migration Contaminants*. App. Sci. Publ.  
Mahadeviah, M. and Gowramma, R.V. 1996. *Food Packaging Materials*. Tata McGraw Hill.  
Palling, S.J. (Ed). 1980. *Developments in Food Packaging*. App. Sci. Publ.  
Painy, F.A. 1992. *A Handbook of Food Packaging*. Blackie Academic.  
Sacharow, S. and Griffin, R.C. 1980. *Principles of Food Packaging*. AVI Publ.  
Stanley, S. and Roger, C.G. 1970. *Food Packaging*. AVI Publ.  
Ahvenainen, R. 2001. *Novel Food Packaging Techniques*. CRC.  
Rooney, M.L. 1988. *Active Food Packaging*. Chapman & Hall.

## PHT 617/PP 617 PHYSIOLOGY OF RIPENING AND SENESCENCE

(2L+1P) III

### Objective

To impart knowledge about physiological and molecular changes during senescence and ripening.

### Theory

#### UNIT I

Environmental factors influencing senescence, ripening and post harvest life of fruits, flowers and vegetables.

#### UNIT II

Molecular mechanism of senescence and ageing. Physiological, biochemical and molecular aspects of senescence and fruit ripening. Senescence associated genes and gene products.

#### UNIT III

Functional and ultra structural changes in chloroplast membranes, mitochondria and cell wall during senescence and ripening.

#### UNIT IV

Ethylene biosynthesis, perception and molecular mechanism of action; regulatory role of ethylene in senescence and ripening, biotechnological approaches to manipulate ethylene biosynthesis and action.



## UNIT V

Alternate post harvest methodology and quality attributes. Scope for genetic modification of post harvest life on flowers and fruits. Uses of GM crops and ecological risk assessment.

### Practicals

Physiological and biochemical changes during senescence and ripening, estimation of ethylene during senescence and ripening, determination of Reactive Oxygen Species and scavenging enzymes, measurement of dark and alternate respiration rates during senescence and ripening. Estimation of ripening related enzyme activity, cellulases, pectin methyl esterases, polygalacturonase, etc.

### Suggested Readings

- Knee, M. 2002. Fruit Quality and its Biological Basis. Sheffield Academic Press, CRC Press.
- Khan, N.A. 2006. Ethylene action in plants. Springer Verlag.
- Davis, P.J. 2004. Plant Hormone: Biosynthesis, Signal transduction and action. Kluwer Academic Publishers.
- Bartz, J.A. and Brecht, J.K. 2003. Post harvest physiology and pathology of vegetables. Marcel Dekker Inc.
- Seymour, G., Taylor, J. and Tucker, G. 1993. Biochemistry of fruit ripening. Edited Chapman and Hall, London.
- Valpuesta, V. 2002. Fruit and vegetable biotechnology. Woodhead Publishing Limited, Cambridge, England.
- Dris, R. and Jain, S.M. 2004. Production practices and quality assessment of food crops, Vol. 4: Post harvest treatment and Technology. Kluwer Academic Publisher.
- Paliyath, G. Murr, D.P., Handa, A.K. and Lurie, S. 2008. Post harvest biology and technology of fruits, Vegetables and Flowers. Blackwel Publishing, Iowa, USA.
- Nooden, L.D. 2004. Plant Cell Death Processes. Elsevier Science, USA.

## PHT 621 PROCESSING OF HORTICULTURAL CROPS

(3L+1P) III

### Objective

To acquaint with methods of preservation of fruits and vegetables and development of various process products.

### Theory

#### UNIT I

Quality requirements of raw materials for processing, preparation of raw material, primary processing: grading, sorting, cleaning, washing, peeling, slicing and blanching; minimal processing.

#### UNIT II

Preparation of various processed products from fruits and vegetables, flowers; role of sugar and pectin in processed products. Freezing of fruits and vegetables. Containers, equipment and technologies in canning.

### UNIT III

Juice extractions, clarification and preservation, recent advances in juice processing technology, application of membrane technology in processing of juices, preparation of fruit beverages and juice concentrate. Sensory evaluation.

### UNIT IV

Dehydration of fruits and vegetables using various drying technologies and equipment, solar drying and dehydration, packaging technique for processed products.

### UNIT V

Quality assurance and storage system for processed products. Nutritive value of raw and processed products, plant sanitation and waste disposal. Types of fruits and vegetables wastes and their uses, utilization of by- products from fruits and vegetables processing industries.

## Practicals

Preparation and preservation of ketchup and sauces, preparation and preservation of pickles, preparation of squash, nectar, syrup etc.), Preparation and preservation of jam, jelly, marmalade, preserve, candy etc. Calculation of drying rate of the sample during drying. Estimation of total and free SO<sub>2</sub> and benzoic acid. Preparation and preservation of fruits and vegetables juices. Enzyme test and dehydration of fruits and vegetables. Preparation and preservation of fruits and vegetables pulp. Standardization of optimum time for soaking, volume and temperature of water for better rehydration ratio of dried products. Freezing preservation.

## Suggesting Readings

Lal, G., Siddappa, G.S. and Tandon, G.L. 1998. *Preservation of Fruits and Vegetables*. ICAR.

Salunkhe, D.K. and Kadam, S.S. 1995. *Handbook of Fruit Science & Technology: Production, Composition and Processing*. Marcel Dekker.

Srivastava, R.P. and Kumar, S. 2003. *Fruit and Vegetable Preservation - Principles and Practices*. International Book Distributors.

Verma, L.R. and Joshi, V.K. 2000. *Post Harvest Technology of Fruits and Vegetables*. Indus Publ.

Desrosier, N.W. and James, N. 2004. *The Technology of Food Preservation*. 4<sup>th</sup> Ed. CBS.

## PHT 622/FLA 622 VALUE ADDITION IN ORNAMENTAL CROPS

(1L+1P) III

### Objective

To acquaint the students about the scope and ways of value addition in ornamental crops.

### Theory

#### UNIT I

Importance, opportunities and prospects of value addition in floriculture; national and global scenario; production and exports, supply chain management

#### UNIT II

Dry flower making including pot pourries, their uses and trade; extraction technology, uses, sources and trade in essential oils; aromatherapy; pigment and natural dyes extraction technology, sources, uses and trade

### UNIT III

Pharmaceutical and neutraceutical compounds from flower crops; petal embedded hand made paper making and uses preparation of products like *gulkand*, rose water, *gulroghan*, *attar*, *pankhuri*;

### UNIT IV

Floral craft including bouquets, garlands, flower arrangements *etc.* tinting (artificial colouring) of flower crops; Women empowerment through value added products making.

### Practicals

Dry flower making including pot pourries; extraction technology, uses, sources and trade in essential oils. Pigment and natural dyes extraction technology; pharmaceutical and neutraceutical compounds from flower crops; preparation of products like *gulkand*, rose water, *gulroghan*, *attar*, *pankhuri*: petal embedded handmade paper making, floral craft including bouquets, garlands, flower arrangements *etc.*; tinting (artificial colouring) of flower crops.

### Suggested Readings

- Bhattacharjee, S.K. and De, L.C. 2004. Advances in Ornamental Horticulture Vol. V, Pointer publishers, Jaipur.
- Randhawa, G.S. and Amitabha Mukhopadhyay, 2000. Floriculture in India, Allied publishers, India.
- Gary L. McDaniel. 1989. Floral design and arrangement. A Reston Book. Prentice hall. New Jersey.
- Lesniewicz, Paul. 1994. Bonsai in your home. Sterling publishing Co, New York.
- Salunkhe, K., Bhatt, N.R. and Desai, B.B. 2004. Postharvest biotechnology of flowers and ornamental plants. Naya Prokash, Kolkata.
- Lauria, A. and Victor, H.R. 2001. Floriculture – Fundamentals and Practices. Agrobios.
- Prasad, S. and Kumar, U. 2003. Commercial Floriculture. Agrobios.
- Reddy, S., Janakiram, T., Balaji, T., Kulkarni, S. and Misra, R.L. 2007. *Hightech* Floriculture. Indian Society of Ornamental Horticulture, New Delhi.

## PHT 623 DESIGN OF FOOD PROCESSING EQUIPMENTS

(2L+1P) III

### Objective

To introduce basic equipment design and various process control mechanisms and related engineering aspects.

### Theory

#### UNIT I

Applications of engineering design to food processing equipment; design parameters and codes, materials selection;

#### UNIT II

Design of storage and pressure vessels, material handling equipment - belt, bucket, screw, apron, chain and pneumatic conveyors, heat exchangers- shell and tube and plate heat exchangers, seed processing equipment - air screen and rotary cleaners, grading equipment and seed treaters.

### UNIT III

Process characteristics, controller characteristics, closed loop system, pneumatic and electric controllers, final controlling elements, control valves, valve sizing, electronic actuators, motor drives and controls, introduction to programmable logic controllers (PLC): internal structure, inter facing with sensors and actuators, binary logic diagrams and ladder diagrams, choosing a PLC system.

#### Practicals

Design of pressure vessels, design of material handling equipment, design of heat exchangers, design of spherical vessels, design of shell and tube, design of seed processing equipment, design of dryers, visit of a food processing plant.

#### Suggested Readings

Considine, D.M. 1964. *Handbook of Applied Instrumentation*. Mc-Graw-Hill.

Hesse, N.D., C.R. & Ruston, J.H. 1964. *Process Equipments Design*. Affiliated East-West Press.

Liptak, B.G. 1995. *Process Measurement and Analysis*. Butterworth-Heinmann. McCabe WL, Smith JC & Harriott P. 1993. McGraw Hill.

Clarke & Wright W. 1999. *Managing New Product and Process Development*. Free Press.

Earle and Earle 2001. *Creating New Foods*. Chadwick House Group.

Earle, R., Earle, R. and Anderson, A. 2001. *Food Product Development*. Woodhead Publ.

Fuller 2004. *New Food Product Development - from Concept to Market Place*. CRC.

### PHT 624 ADVANCE STORAGE ENGINEERING

(2L+1P) III

#### Objective

Expose the students to the large scale handling and storage mechanism of grains, engineering operations and the control of physical, chemical and biological spoilage during storage of grains.

#### Theory

##### UNIT I

Physico-chemical and thermal properties of grains - grain dimensions, bulk density, true density, porosity, coefficient of friction, angle of repose, thermal conductivity and aerodynamic properties. humidity, % relative humidity, humid heat, deterioration index, wet bulb temperature, use of psychrometric charts,

##### UNIT II

Grain drying, equilibrium moisture content. Storage environment and its interaction with stored products, factors/ parameters influencing the shelf life of the stored products; storage practices (including fumigation) and structures (traditional and modern) for food grains;

##### UNIT III

Climatograph and deterioration index. modeling of metabolic activities and prediction of storage life, quality deterioration mechanisms and their control;

##### UNIT IV

Design of bulk storage and aeration system, analysis of heat, moisture and gas transfer in bulk storage structures; quality analysis of stored produce; bag storage structures, their design and management.

## Practicals

Determination of bulk density, true density and porosity of grains, determination of angle of repose and coefficient of friction, measurement of water activity of grains, determination of grain moisture content, identification of storage insects-pests, determination of EMC, determination of grain hardness, study of designs of storage bins and godowns as per capacity requirement, visit to storage lab. Plotting of sorption isotherm and calculation of EMC, computation of doses of insecticides in ware house, visit of commercial godowns, identification of common storage insect.

## Suggested Readings

- Chakravarty, A. 1995. Post Harvest Technology of Cereals, Pulses & Oilseeds Oxford-IBM Pub. Co. Delhi.
- Ramamurtham, S. and Narayan, R. 1998. Design of Reinforced concrete structures. Dhanpat Rai Publishing Co. (P) Ltd., New Delhi
- Birewar, B.R., Krishnamurthy, K., Girish, G.K., Varma, B.K. and Kanjilal, S.C. 1983. Modern Storage Structures. Indian Grain Storage Institute, Hapur.
- Mohsenin, N.N. 1986. Physical Properties of Plant and Animal Materials. Gordon & Breach Science Publishers.

## PHT 630/AE 630 HEAT AND MASS TRANSFER

(3L+0P) I

### Objective

To acquaint and equip the students with the principles of heat and mass transfer and its applications in food processing.

### Theory

#### UNIT I

Modes of heat and: uni- and multi-directional heat conduction; principles of conservation; boundary layer and turbulence: momentum and energy equations;

#### UNIT II

Convective heat transfer in food processing systems involving laminar and turbulent flow heat transfer in boiling liquids, heat transfer between fluids and solid foods.

#### UNIT III

Radiative heat transfer and its governing laws, its applications in food processing.

#### UNIT IV

Mass transfer; heat and mass transfer analogy; molecular diffusion of fluids; mass transfer operations; absorption; adsorption; extraction-exchange and leaching.

## Suggested Readings

- Benjamin, G. 1971. *Heat Transfer*. 2nd Ed. Tata McGraw Hill.
- Coulson, J.M. and Richardson, J.F. 1999. *Chemical Engineering*. Vol. II, IV. The Pergamon Press.
- Earle, R.L. 1985. *Unit Operations in Food Processing*. Pergamon Press.
- Eckert, E.R.G. and Draker McRobert 1975. *Heat and Mass Transfer*. McGraw Hill.
- Geankoplis J Christie 1999. *Transport Process and Unit Operations*. Allyn & Bacon.

- Holman, J.P. 1992. *Heat Transfer*. McGraw Hill.
- Kreith Frank 1976. *Principles of Heat Transfer*. 3rd Ed. Harper & Row.
- McCabe, W.L. and Smith, J.C. 1999. *Unit Operations of Chemical Engineering*. McGraw Hill.
- Treybal, R.E. 1981. *Mass Transfer Operations*. McGraw Hill.
- Warren Gretd, H. 1987. *Principles of Engineering Heat Transfer*. Affiliated East-West Press.

**PHT 631/AE 631 DRYING AND DEHYDRATION**

**(2L+1P) II**

**Objective**

To acquaint and equip the students with drying and dehydration of grains and seeds and the design features of the equipments used.

**Theory**

UNIT I

Kinetics of moisture sorption and desorption, mechanism of moisture transport.

UNIT II

Theory of drying, drying rate calculation, methods of drying grains, seeds and forage crops, dehydration techniques for different food products,

UNIT III

Effect of drying and dehydration on physico-chemical compositions.

**Practical**

Determination of moisture content by direct and indirect methods, determination of drying characteristics under sun, mechanical (tray type, fluidized bed type) of grains, seeds, study of different types of dryers (LSU, batch, RPEC etc)

**Suggested Readings**

- Gregg *et al.* 1970. *Seed Processing*. NSC.
- Henderson, S. and Perry, S.M. 1976. *Agricultural Process Engineering*. 5th Ed. AVI Publ.
- Sahay, K.M. and Singh, K.K. 1994. *Unit Operation of Agricultural Processing*. Vikas Publ. House.