(IV) M.Sc. (Hort.) Post Harvest Management

Major Courses

Course Code	Course Title	Credit hrs
	Semester I	
PHM-511*	Postharvest Physiology and Biochemistry of Perishables	2+1
PHM-512*	Principles and Methods of Fruit And Vegetable Preservation	2+1
PHM-513	Functional Foods from Horticultural Produce	2+0
	Semester II	
PHM-521*	Postharvest Management of Horticultural Produce	2+1
PHM-522	Packaging and Storage of Fresh Horticultural Produce	1+1
PHM-523*	Processing of Horticultural Produce	2+2
PHM-524	Marketing and Entrepreneurship in Postharvest Horticulture	1+1
	Semester III	
PHM-531	Packaging and Storage of Processed Horticultural produce	1+1
PHM-532	Laboratory Techniques in Postharvest Management	1+2
PHM-533	Quality Assurance, Safety and Sensory Evaluation of Fresh and Processed Horticultural Produce	2+1
	Semester IV	
PHM 591	Seminar	0+1
PHM 599	Research	0+30

Syllabus of Major courses of Postharvest Management

PHM 511 Postharvest Physiology and Biochemistry of Perishables (2+1)
Theory

Block 1: Biochemistry of perishables

Unit I: Introduction, biochemical structure and composition of fruits, vegetables and ornamentals.
Unit II: Biochemical changes during development and ripening. Structural Deterioration of the Produce-cell wall degradation, change in membrane lipid. Biosynthesis of ethylene and its regulation. Ethylene action and ripening processes, its perception-action and regulation.
Block 2: Postharvest physiology of perishables
Unit I: Determining maturity and maturity indices. Ripening processes: eventsof ripening and factors affecting them.
Unit II: Physiology of pre-harvest and postharvest; factors affecting shelf-life and quality of fruits, vegetables and ornamentals.
Unit III: Respiration: respiratory climacteric, its significance. Transpiration and water stress during postharvest. Postharvest oXidative stress: active oXygen species, AOS generation, physiological effects on horticultural commodity, control of oxidative injury.

Practical

- Determination of physical parameters like specific gravity, fruit firmness, etc.;
- Determination of physiological loss in weight;
- Determination of chemical constituents like sugar, starch, pigments, Vitamin C,acidity during maturation and ripening in fruits/ vegetables;
- Estimation of ethylene evolved from ripening fruits;
- Delay/ Hastening of ripening by ethylene treatments;
- Determination of firmness, TSS, moisture, Titratable acid, sugar, protein, starch,fats, chlorophyll, carotene, anthocyanin, phenols and tannins;
- Measurement of respiration and ethylene evaluation.

Suggested readings:

1. Chadha KL and Pal RK. 2015. *Managing postharvest quality and losses in horticultural crops*.
2. Vol-1: General Issues, 1-231p Astral International (P) Ltd., New Delhi
3. Chadha KL and Pal RK. 2015. *Managing postharvest quality and losses in horticultural crops*.

4. Vol-2: Fruit Crops, 253-561p Astral International (P) Ltd., New Delhi
5. Chadha KL and Pal RK. (2015) *Managing postharvest quality and losses in horticultural crops*. Vol-3: Vegetables, Flowers and Plantation Crops, 581-727p Astral International (P) Ltd., New Delhi
6. Hodges DM. 2003. *Postharvest Oxidative Stress in Horticultural Crops*, 1st Edition, ISBN 9781560229636
7. Paliyath G, Murr DP, Handa AK and Lurie S. 2008. *Postharvest Biology and Technology of Fruits, Vegetables and Flowers*, Wiley-Blackwell, ISBN: 9780813804088.
8. Sunil Pareek (Ed.) 2016. *Postharvest Ripening Physiology of Crops*, CRC Press, ISBN 9781498703802.
9. Thompson AK. 1995. *Post harvest Technology of fruits and vegetables*. Blackwell Sciences Verma LR and Joshi VK. 2000. *Postharvest Technology of Fruits and Vegetables: Handling,*
10. *Processing, Fermentation and Waste Management*. Indus Publishing Company, New Delhi, India. ISBN 8173871086.
11. Wills RBH and Golding J. 2017. *Advances in Postharvest Fruit and Vegetable Technology*, CRC Press, ISBN 9781138894051.
12. Wills RBH and Golding J. 2016. *Postharvest: an introduction to the physiology and handling of fruit and vegetables*, CABI Publishing, ISBN 9781786391483.

Websites

1. Food and Agriculture Organization http://www.fao.org/home/en/ Respiration in plants http://ncert.nic.in/ncerts/l/kebo114.pdf
2. Ethylene biosynthesis and its response http://www.biologydiscussion.com/plants/hormones- plants/ethylene-biosynthesis-and-its-responses-plant-hormones/25986

PHM 512 Principles and Methods of Fruit and Vegetable Preservation 2+1

Theory

Block 1: Principles and Methods of Fruit and Vegetable Processing

Unit I: Introduction, Historical development in food processing, type of food and causes for food spoilage. Basic principles of fruits andvegetables processing;

Unit II: Thermal processing, pH classification of foods, heat resistance of microorganism; Heat resistance of enzymes in foods, Spoilage ofthermal processed food; Containers – canning, rigid tin plates and cans, aluminium cans, glass containers – types; flexible packaging materials, Composite can, specification, corrosion of cans, heat penetration into containers and methods for determination of process time.

Unit III: Effects of low temperature on fresh commodities and prepared product. Freezing preservation, freezing points of foods, slow andquick freezing, Cryogenic freezing and frozen food storage. Dryingand dehydration, sun drying solar dehydration, mechanical dryingtypes of driers, osmotic dehydration.

Unit IV: Food fermentation – alcoholic, acetic and lactic fermentation. Pickling and curing; Effect of salt on food preservation, types of salt cured products. Traditional and new products; chemical preservation, SO_2, benzoic acid, sorbic acid, antioXidants and antibiotics, newer preservatives. Preservation by controlling water activity – high sugar products, intermediate moisture food, food concentration.

Unit V: Food irradiation, principles, types and sources of radiation, mode of action of ionizing radiation; radiation effect on food constituents and regulation.

Practical:

- Preparation and preservation of fruit based beverages and blended products fromfruits and vegetables;
- Evaluation of pectin grade; preparation and quality evaluation of fruit jam;
- Preparation of papain;
- Blanching and its effects on enzyme;
- Preparation of dehydrated vegetables;
- Study of different types of spoilages in fresh as well as processed horticulturalproduce;
- Study of biochemical changes and enzymes associated with spoilage;
- Sensory evaluation of fresh and processed fruits and vegetables;
- Visit to processing units.

Suggested readings

1. Barret DM, Somogyi LP and Ramaswamy H. Eds. 2005. *Processing Fruits: Science and Technology* (2nd Edition), CRC Press, ISBN 9780849314780.
2. FAO. 2007. *Handling and Preservation of Fruits and Vegetables by Combined Methods for Rural Areas-Technical Manual*. FAO Agricultural Services Bulletin 149.
3. Fellows PJ. 2009. Food Processing Technology: Principles and Practice (3rd Edition), Woodhead Publishing, ISBN 9781845692162.
4. Lal G, Siddappa GS and Tandon GL. 1998. Preservation of Fruits and Vegetables. ICAR, ISBN 9788171640904.
5. Ramaswamy H and Marcotte M. 2006. *Food Processing: Principles andApplications*. Taylor & Francis.
6. Salunkhe DK and Kadam SS. 1995. Handbook of Fruit Science and Technology:Production, Composition and

Processing. Marcel Dekker.
7. Srivastava RP and Kumar S. 2014. *Fruit and Vegetable Preservation: Principles and Practices* (3rd Edition), CBS Publishing, ISBN 9788123924373.
8. Verma LR and Joshi VK. 2000. *Postharvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management*. Indus Publishing Company, New Delhi, India. ISBN 8173871086.

Websites

1. http://agriinfo.in/default.aspX?page=topic&superid=2&topicid=2065
2. http://www.fao.org/docrep/X0209e/X0209e02.htm
3. http://www.cstaricalcutta.gov.in/images/CTS%20Fruits_and_Vegetables%20NSQF.pdf

PHM 513 Functional Foods from Horticultural Produce (2+0)

Theory

Block 1: Functional food and importance

Unit I: Functional foods- Introduction, definition, history; Importance, relevanceand need of functional foods. Sources and classification of functional foods. Importance of horticultural produce as functional foods. Functional foods derived from fruits, vegetables, medicinal and aromatics.

Unit II: Functional ingredients and their properties. Therapeutic potential and effects of horticultural produce; Herbs, herbal teas, oils, etc. in the prevention and treatment of various diseases. Effect of preservation and processing on functional properties of horticulture produce.

Block 2: Bioactive Compounds

Unit I: Introduction, Classes of bioactive compounds present in fruits andvegetables. Polyphenols: Phenolic acid, Stilbenes, Flavonoids, Lignin, Coumarin, Tannin, etc. –their chemistry, source, bioavailability, interaction in food systems; changes during storage and processing. Alkaloids; Nitrogen Containing Compounds; Sulphur compounds; phytosterols; carotenoids; dietary fibers, etc.–their chemistry, source, bioavailability, interaction in food systems; changes during storage andprocessing.

Unit II: Mechanism of neuroprotection by bioactive compounds. Techniques of EXtraction, purification and concentration of bioactive compounds from fruits and vegetables. Bioactive compound and health benefits Incorporation of bioactive compounds in foods.

Block 3: Neutraceuticals

Unit I: Nutraceuticals- Introduction, classification of nutraceuticals, dietary supplements, fortified foods, functional foods and phytonutraceuticals. Role of medicinal and aromatic plants in nutraceutical industry. Health benefits of phytoneutraceuticals.

Suggested readings

1. Rosa LA, Alvarez-Parrilla E and Gonzalez-Aguilar GA. 2009. *Fruit and Vegetable Phytochemicals: Chemistry, Nutritional Value and Stability*, Wiley-Blackwell, ISBN 9780813803203.
2. Senrawat R, Khan KA, Goyal MR and Paul PK. 2018. *Technological Interventions in the Processing of Fruits and Vegetables*, Apple Academic Press, ISBN 9781771885867.
3. Vattem DA. 2016. *Functional Foods, Nutraceuticals and Natural Products: Concepts and Applications*. DEStech Publications, Inc, ISBN 978 1 60595 101 0.
4. Watson RR and Preedy V. 2009. *Bioactive Foods in Promoting Health: Fruits and Vegetables* (1st Edition), Academic Press, ISBN 9780123746283

PHM 521 Postharvest Management of Horticultural Produce (2+1)

Theory

Unit I: History, Importance and scope of Postharvest technology of horticultural produce. Nature and structure of horticultural produce. Pre and Postharvest losses and their causes.

Unit II: Climacteric and non-climacteric fruits. Regulation of ripening by use of chemicals and growth regulators. Control of sprouting, rooting anddiscoloration in vegetables.

Unit III: Maturity indices for harvest. Harvesting and harvesting tools. Curing in roots and tubers. Prepackage Operation: Precooling, washing,sorting, grading of horticultural perishables for local markets and eXport. Postharvest handling of spices, plantation crops, medicinal and aromatic plants. Equipments for washing, sizing, grading.

Unit IV: Pre and Postharvest treatments for eXtending storage life/ vase life.VHT, irradiation treatment, skin

coating, degreening, etc. Prepackaging, Packaging techniques for local market andStandards and specifications for fresh produce.

Unit V: Postharvest handling system for horticulture crops of regional importance. Principles of transport, modes of transportation, types of vehicles and transit requirements for different horticultural produce. Marketing: Factors influencing marketing of perishable crops, marketing systems and organizations.

Practical

- Study of maturity indices for harvest of fruits, vegetables, spices and plantation crops;
- Protective skin coating with waX emulsion and pre and Postharvest treatment with fungicides, chemicals and growth regulators to eXtend the shelf life of fruits and vegetables;
- Prepackaging of perishables;
- EXtension of vaselife of cut flowers by use of chemicals and growth regulators;
- Control of sprouting of potato and onion by using growth regulators;
- Study of modern harvesting, sorting and grading equipments;
- Study of effect of pre-cooling on shelf-life and quality of fresh fruits, vegetablesand flowers;
- Visit to packaging centers;
- Visit to local markets, cooperative organizations, and super markets dealing with marketing of Perishables.

Suggested Reading

1. Bhattacharjee SK and Dee LC. 2005. *Postharvest technology of flowers and ornamental plants*. Pointer publishers, Jaipur.
2. Chattopadhyay SK. 2007. *Handling, transportation and storage of fruit and vegetables*. Gene- Tech books, New Delhi.
3. FAO. 2007. *Handing and Preservation of Fruits and Vegetables by Combined methods for Rural Areas*-Technical Manual. FAO Agr.Ser.Bull., 149.
4. Kader AA. 1992. *Postharvest technology of horticultural crops*. 2nd ed university of California. Paliyath G, Murr DP, Handa AK and Lurie S. 2008. *Postharvest Biology and Technology of Fruits, Vegetables and Flowers*, Wiley-Blackwell, ISBN: 9780813804088.
5. Pruthi JS. 2001 (Reprint). *Major spices of India crop management and Postharvest technology*. ICAR, NewDelhi
6. Stawley J Kays. 1998. *Postharvest physiology of perishable plant products*. CBS publishers. Sudheer KP, Indira V. 2007. *Postharvest Technology of Horticultural Crops*, Peter K.V. (Ed.), New India Publishing Agency, ISBN 9788189422431.
7. Sunil Pareek (Ed.) 2016. *Postharvest Ripening Physiology of Crops*, CRC Press, ISBN 9781498703802.
8. Thompson AK. (Ed.) 2014. *Fruit and Vegetables: Harvesting, Handling and Storage* (Vol. 1 & 2) Blackwell Publishing Ltd, OXford, UK. ISBN: 9781118654040
9. Verma LR and Joshi VK. 2000. *Postharvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management*. Indus Publishing
10. Company, New Delhi, India. ISBN 8173871086.Wills RBH and Golding J. 2016. *Postharvest: an introduction to the physiology and handling of fruit and vegetables*, CABI Publishing, ISBN 9781786391483.
11. Wills RBH and Golding J. 2017. *Advances in Postharvest Fruit and Vegetable Technology*, CRC Press, ISBN 9781138894051.

Websites:

1. Horticulture-Post harvest management CSIR-NISTADS http://www.nistads.res.in/indiasnt2008/t6rural/t6rur13.htm
2. Post harvest technology- MANAGE http://www.manage.gov.in/ftf-itt/prgReports/iihr.pdf Role of post-harvest management http://www.fao.org/3/y5431e/y5431e02.htm

PHM 522 Packaging and Storage of fresh Horticultural Produce (1+1)

Theory

Block 1: Storage Systems

Unit I: Importance of storage of horticultural produce, present status and future scope. Principles and methods of storage – field storage structures and designs for bulk storage of horticultural produce- onion and potato, etc. Evaporative cool chambers. Physiological changes during storage.

Unit II: Refrigerated storage – principles of refrigeration, types of refrigerants, refrigeration equipments. Cold storage rooms – Calculation of refrigeration load. Storage requirements of different fruits, vegetables, flowers. Storage disorder symptoms and control.

Unit III: Controlled or modified atmosphere (CA/MA) storage – principles, uses,structures and equipments, methods and requirements. Effect of CA storage on the physiology of stored produce. Hypobaric storage- principle, uses, and

requirements. Storage disorders.

Block 2: Packaging

Unit I: Importance of packaging of fresh and processed horticultural produce, present status and future scope. Gaps in packaging concepts. Packagingrequirements of fresh horticultural produce. Packaging patterns and methods. Food packaging systems: Different forms of packaging such as rigid, semi-rigid, flexible forms. Traditional, improved and specialized packages. Paper based packages: corrugated fibre board boxes – raw material and types of boxes. Flexible packaging materials – types and their properties. Consumer and intermediate flexible bulk containers. Testing of flexible packaging material. Barrier properties of packaging materials.

Unit 2: New technology in packaging – stretch wrapping system, vacuum packaging, gas packaging, controlled atmosphere (active and intelligent) packaging, vibra packaging, skin packaging, shrink packaging, form- fill-seal packaging, Packaging machines. Quality control and safety aspects of packaging materials.

Practical

- Study of special storage structures for bulk storage of onion/ potato, etc.;
- Study of storage behavior of different fruits and vegetables in zero energy coolchamber;
- Determination of refrigeration requirements (capacity) for given quantity of fruitsand vegetables;
- Study of storage behaviour of different fruits and vegetables in cold room;
- Study of chilling injury and storage disorders;
- Study of shelf-life of fruits and vegetables in modified atmosphere packaging. Visit to special storage structures, cold storage units. Study of types of packaging materials, types of plastic films and their properties;
- Determination of water vapour transmission rate (WVTR) and gas transmissionrate (GTR) of packaging material;
- Applications of packaging material for fresh fruits and vegetables, beverages, spice products;
- Determination of shelf-life of fresh products in different types of packages;
- Study of packaging machines – vacuum packaging machine, shrink wrappingmachine, double seamer, etc. Visit to packaging unit.

Suggested readings

1. Ahvenainen R. 2003. Novel Food Packaging Techniques, CRC Press, ISBN 0849317894. Ahvenainen R. 2001. *Novel Food Packaging Techniques*. CRC.
2. Burg SP (Ed.). 2004. *Postharvest physiology and hypobaric storage of fresh produce*, CABIPublishing, ISBN 0851998011.
3. Chattopadhya SK. 2007. *Handling, transportation and storage of fruits and vegetables*. Gene- Tech books, New Delhi.
4. Chandra GopalaRao. 2015. *Engineering for Storage of Fruits and Vegetables*; Academic Press, 1st Edition.
5. Coles R, McDowell D and Kirwan MJ. (Eds.). 2003. *Food Packaging Technology*, BlackwellPublishing, ISBN 1841272213.
6. Mahadevaiah M and Gowramma RV. 1996. *Food packaging materials*. Tata McGraw Hill.Painy FA. 1992. *A handbook of food packaging*. Blackie Academic.
7. Pantastico B. 1975. Postharvest Physiology, Handling and Utilization of Tropical and Subtropical Fruits and Vegetables. AVI Publ.
8. Robertson GL. (Ed.). 2010. Food packaging and shelf life: a practical guide CRC Press, ISBN 9781420078442.
9. Thompson AK. 2010. *Controlled atmosphere storage of fruits and vegetables* (2nd Edition), CABI International, ISBN 9781845936464.
10. Wilson CL. (Ed.). 2007. *Intelligent and active packaging for fruits and vegetables*, CRC Press, ISBN 9780849391668.

Websites

1. Storage practices and structures UCANR http://ucanr.edu/datastoreFiles/234-1303.pdf
2. Low cost storage technologies for preservation-IARI http://www.iari.res.in/download/pdf/ story4_eng.pdf

https://energypedia.info/wiki/Cold_Storage_of_Agricultural_Products

PHM 523 Processing of Horticultural Produce (2+2)

Theory

Block 1: Importance and Thermal processes

Unit I: Processing unit- layout and establishment, processing tools. 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.

Block 2: Processing equipment and enzyme kinetics

Unit I: Dehydration of fruits and vegetables using various drying technologies and equipment, solar drying and dehydration, packaging techniquefor processed products.

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

Practical:

- Handling of harvesting equipments;
- Determination of physical and thermal properties of horticultural commodities;
- Thermal process calculations;
- Particle size analysis, Storage structure design;
- Numerical problems in freezing, drying, conveying and calculations pertaining totexture and Rheology;
- Handling of heating equipment, pulper, juice extractor, deaerator, juice filters;
- Processing industries waste treatment;
- Working of a canning unit;
- Visit to commercial processing units and storage units.

Suggested readings

1. Karel M and Lund DB. 2003. *Physical Principles of Food Preservation* (2nd Edition), CRC Press, ISBN 9780824740634.
2. Paul Singh R and Heldman DR. 2009. *Introduction to Food Engineering* (4th Edition), Academic Press, ISBN 9780123709004.
3. Rao DG. 2010. *Fundamentals of Food Engineering*, PHI Learning Pvt. Ltd., ISBN 9788120338715.
4. Ratti C. 2008. *Advances in Food Dehydration*, CRC Press, ISBN 9781420052527.
5. Toledo RT. 2007. *Fundamentals of Food Process Engineering* (3rd Edition), Springer, ISBN 9780387290195.
6. Smith PG. 2011. *Introduction to Food Process Engineering*, Springer, ISBN 9781441976611.

PHM 524 Marketing and Entrepreneurship in Post-Harvest Horticulture (1+1)

Theory

Unit I: Entrepreneurship – Concept, need for entrepreneurship – Types of entrepreneurs -entrepreneurial opportunities in horticultural processing sector-Government schemes and incentives for promotion of entrepreneurship in processing sector.

Unit II: Writing Business Plan- Business Plan Format for Small and micro Enterprises-Generation, incubation and commercialization of businessideas – Environment scanning and opportunity identification.

Unit III: Steps in establishment of MSME Enterprise – Planning of an enterprise – Formulation and project report-Meaning – Importance Components and preparation.-Government Formalities and Procedures.

Unit IV: Marketing potential of processed products at domestic and internationallevel-Marketing management-Marketing functions, market information and market research-Problems in marketing of processed products- Demand and supply analysis of important processed products- Marketing channels – Marketing strategy (product strategy and pricing strategy)-Supply chain management – Meaning, importance, advantages, supply chain management of important processed products.

Unit V: Institutional support to Entrepreneurship Role of Directorate of Industries, District Industries, Centres (DICs), Industrial Development Corporation (IDC), State Financial corporation (SFCs), Commercial banks Small Scale Industries Development Corporations (SSIDCs), Khadi and village Industries Commission (KVIC), National Small Industries Corporation (NSIC), Small Industries Development Bank of India (SIDBI).

Practical

- Consumer Behaviour towards Processed Foods;
- An Empirical Test-Carrying out the SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis of successful Enterprises;
- Constraints in setting up of horti based industries;
- Field visits to study any one of the Local Financial Institutions to study the MSMEPolicies;
- Preparation of business plan and proposal writing-Project evaluation techniques;
- Discounted and undiscounted techniques;
- Case studies of successful entrepreneurs.

Suggested readings

1. Adhikary MM. 2014. *Enterprise and Entrepreneurship for Agri-Business Management andPlanning*. Daya Publishing House. New Delhi
2. Bhaskaran S. 2014. *Entrepreneurship Development and Management*. Aman Publishing House, Meerut.
3. Choudhury M and Barua N. 2014. *Marketing of Processed Fruit and Vegetable*. Daya Publishing House. New Delhi.
4. Gaur SC. 2012. *Handbook of Agro Food Processing and Marketing*. Agrobios. Jodhpur Kadam MM and Bishe RN. 2018. *Textbook on Agricultural Entrepreneurship*. Narendra publishing house. New Delhi.
5. Sudheer KP and Indira V. 2018. *Entrepreneurship and Skill Development in Horticultural Processing*. New India Publishing Agency. New Delhi.

PHM 531 Packaging and storage of Processed Horticultural Produce (1+1)

Theory

Block- 1 Packaging principles and functions

Unit I: Functions of packaging; Type of packaging materials; Selection of packaging material for different foods; Selective properties of packaging film; Methods of packaging and packaging equipment.

Unit II: Mechanical strength of different packaging materials; Printing of packages; Barcodes and other marking; Interactions between packaging material and foods; Environmental and cost consideration in selecting packaging materials.

Unit III: Manufacture of packaging materials; Potential of bio composite materials for food packaging; Packaging regulations; Packaging and food preservation; Disposal of packaging materials.

Unit IV: Metal cans: types, fabrication, lacquering and tin quality. Double seaming technology – defects and causes. Glass containers – types; testing quality – thermal shock resistance, thermal shock breakage, impact breakage.

Unit V: Testing of packaging; Rigid and semi rigid containers;flexible containers; Sealing Equipment. Labeling; Aseptic and shrink packaging; Secondary and transport packaging. Different packaging systems for dehydrated foods,frozen foods, dairy foods, fresh fruits and vegetables.

Practical:

- Testing of packaging material: compression strength/drop test/thermal shock test/seam evaluation/ seam defects;
- Determination of shelf-life of processed products in different types of packages;
- Study of packaging machines – vacuum packaging machine, shrink wrapping machine, double seamer, etc.;
- Visit to packaging units.

Suggested readings

1. Ahvenainen R. 2001. *Novel Food Packaging Techniques*.CRC
2. Ahvenainen R. 2003. *Novel Food Packaging Techniques*, CRC Press, ISBN 0849317894. Coles R, McDowell D and Kirwan MJ. (Eds.) 2003. *Food Packaging Technology*, Blackwell
3. Publishing, ISBN 1841272213.
4. Joseph H Hotchkiss. 1987. *Food and Packaging Interactions*, (ACS symposium series -365, April 5-10, 1987. American Chemical Society, Washington DC. 1988)
5. Mahadevaiah M and Gowramma RV. 1996. *Food packaging materials*. Tata McGraw Hill.Painy FA. 1992. A handbook of food packaging. Blackie Academic.
6. Robertson G. L. Ed. 2010. *Food packaging and shelf life: a practical guide CRC Press*, ISBN 9781420078442.
7. Thompson AK. 2010. *Controlled Atmosphere Storage of Fruits and Vegetables*, CABI Publishing; 2nd revised edition.
8. Wilson CL. (Ed.). 2007. *Intelligent and active packaging for fruits and vegetables*, CRC Press, ISBN 9780849391668.

PHM 532 Laboratory Techniques in Postharvest Management (1+2)

Theory

Block 1: Laboratory Techniques in Postharvest Management

Unit I: Rheological techniques and instrumentation used in food industry. Analysis of food additives like food colour, antioXidants, emulsifier,etc.

Unit II: Analysis of pesticide residues, metallic contaminants,Analysis of food flavours. Aflatoxin.

Unit III: Quality analysis of processed fruits and vegetables, coffee, tea and spices. Identification and enumeration of microbial contaminants.

Unit IV: Principles of chromatography (GC, GCMS, HPLC, LCMS), spectrophotometry (Atomic absorption spectrophotometer, ICAP spectrophotometer), ICP-MS, ICPOES, NMR, ESR, amino acid analyser, flame photometry, electrophoresis.

Unit V: Colour measurement in foods, IRGA, Radio-isotopic techniques. Nondestructive quality evaluation (NDQE) - E-

nose, E-tongue, machine vision. Electrophoresis.

Practical:

- Sample preparation for quality analysis. Energy calculation, sample calculations;
- TeXture analysis, Rheology of different foods;
- Instrumental colour analysis;
- Sensory evaluation and microbiological eXaminations of fresh and processedproducts;
- Estimation of tannin/ phytic acid by spectrometric method;
- Moisture and fat analysis by NIR spectroscopy;
- Separation and identification of sugars in fruit juices;
- Separation and identification of carotenoids by column chromatography;
- Estimation of respiration in fruits and vegetables;
- Flavour profile in essential oils using GC;
- Identification and determination of organic acids by HPLC;
- Capsaicin content and Scoville Heat Units in chillies;
- Heavy metal analysis using atomic absorption spectrometry;
- Residue analysis.

Suggested readings

1. Lundanes E., Reubsaet L and Greibrokk T. 2013. *Chromatography: Basic Principles, Sample Preparations and Related Methods*, ISBN-13: 978-3527336203, Wiley VCH
2. Mark F Vitha. 2016. *Chromatography: Principles and Instrumentation*. John Wiley & Sons, ISBN 9781119270881
3. Suzanne NS. 2010. *Introduction to Food Analysis*, ISBN 978-1-4419-1478-1, Springer.
4. Ranganna S. 2001. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*, Tata McGraw-Hill ISBN 9780074518519.
5. Semih Otles (Ed). 2016. *Methods of Analysis of Food Components and Additives* (*Chemical and Functional Properties of Food Components*) CRC Press, ISBN-13: 978-1138199149

PHM 533 Quality Assurance, Safety and Sensory Evaluation of Fresh and Processed Horticultural Produce (2+1)

Theory

Block 1: Quality Assurance

Unit I: Concept of quality: Quality attributes- physical, chemical, nutritional, microbial, and sensory; their measurement and evaluation. Concepts of quality management: Objectives, importance and functions of quality control; Quality management systems in India; Sampling procedures and plans.

Unit II: Food laws and regulations in India, Quality management standards, ISO, BIS, PFA, AGMARK and QMS standards, quality system components and their requirements.

Block 2: Safety

Unit I: Food safety and standards act (FSSA,2006); Strategies for compliance with international agri-food standards; EXport specification and with international agri-food standards; EXport specification and guidelines by APEDA. Hazard analysis and critical control points (HACCP), design and implementation of an HACCP system, steps in the risk management process. Traceability in food supply chains.

Unit II: Organic Certification, GAP, GMP, TQM. Indian and International quality systems and standard like, CodeX Alimentarius, ISO, etc. Consumer perception of safety; Ethics in food safety.

Block 3: Sensory Evaluation

Unit I: Introduction to sensory analysis; general testing conditions, Requirements of sensory laboratory; organizing sensory evaluation programme. Selection of sensory panellists; Factors influencing sensory measurements; Sensory quality parameters -Size and shape, teXture, aroma, taste, colour and gloss; Detection, threshold and dilution tests. Different tests for sensory evaluation– discrimination, descriptive, affective; Flavour profile and tests; Ranking tests.

Unit II: Methods of sensory evaluation of different food products. Designing of experiments. Handling and interpretation of Data. Role of sensory evaluation in product optimization. Relationship between objective and subjective methods. Sensory analysis for consumer evaluation. Computer-aided sensory evaluation of food and beverage.

Practical:

- Analysis for TSS, pH, acidity, sugars, pectic substances, minerals, vitamin C, carotene, alcohol, benzoic acid and SO_2 contents, yeast and microbial examinationin processed products;
- Demonstration of measurement of vacuum/ pressure, head space, filled weight, drained weight, cut-out analysis and chemical additives;

- Moisture content, rehydration ratio and enzymatic/ non-enzymatic browning in dehydrated products;
- Analysis of spices for quality parameters. Evaluation of processed products according to FSSAI specification;
- Selection and training of sensory panel;
- Identification of basic taste, odour, texture and colour;
- Detection and threshold tests; Ranking tests for taste, aroma, colour and texture; Sensory evaluation of various horticultural processed products using different scales, score cards and tests, Hedonic testing;
- Estimation of color and texture; optimising a product by sensory analysis;
- Studying relationship between objective and subjective methods.

Suggested readings

1. Amerine MA, Pangborn RM and Rosslos EB. 1965. Principles of Sensory Evaluation of Food. Academic Press.
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