DEPARTMENT OF HIGHER EDUCATION

RAJA MAHENDRA PRATAP SINGH UNIVERSITY, ALIGARH

AS PER THE ICAR-Sixth Deans' Committee

Course Curriculum of M. Sc. (Ag.) Animal Husbandry and Dairying (Dairy Science)

Course Curriculum of M.Sc. (Ag.) Dairy Science
(Based on Restructured and Revised Syllabi of PG Programme by ICAR)

1st Year (1st Semester)			Evaluation Marks			
Code No.	**Course Title**	**Credit Hours**	**Mid Term (Internal)**	**Practical (External)/ Assignment (Internal 2)**	**End term/Final (External)**	**Total**
DSC 501	Advances in Dairy Processing	3(2+1)	20	30	50	100
DSC 502	Physicochemical Aspects of Milk Constitutes	3(2+1)	20	30	50	100
DSC 503	Chemical Quality Assurance and Management Tools	3(2+1)	20	30	50	100
	Elective	3(2+1)	20	30	50	100
AST 501	Experimental Design	3(2+1)	20	30	50	100
PGS 501	Basic Concepts in Laboratory Technique	1(0+1)	40	10	-	50
PGS 502	Intellectual Property and Its Management in Agriculture	1(1+0)	-	-	50	50
	Total Credit	**17**				**600**
1st Year (2nd Semester)			**Evaluation Marks**			
DSC 504	Production and Applications of Dairy Ingredients	3(2+1)	20	30	50	100
DSC 505	Chemistry of Processed Dairy Foods	3(2+1)	20	30	50	100
DSC 506	Microbiology of Fluid Milk and Dairy Products	2(1+1)	20	30	50	100
	Elective	3(2+1)	20	30	50	100
AST 502	Date Analysis Using Statistical Packages	3(2+1)	20	30	50	100
PGS 503	Agriculture Research, Research Ethic and Rural Development Programmes	1(1+0)	-	-	50	50
PGS 504	Library and Information Services	1(0+1)	40	10	-	50
	Total Credit	**16**				**600**
2nd Year (3rd Semester)			**Evaluation Marks**			
DSC 507	Design of Dairy and food Process Equipment	3(2+1)	20	30	50	100
DSC 508	Market Milk Processing and Dairy Plant Practices	3(2+1)	20	30	50	100

DSC 509	Advances in Traditional Indian Dairy Products	2(1+1)	20	30	50	100
	Elective	2(1+1)	20	30	50	100
PGS 505	Technical Writing and Communications Skills	1(0+1)	20	30	50	100
	Total Credit	**11**				**500**
2nd Year (4th Semester)			**Evaluation Marks**			
DSC 510	Master' Seminar	1(0+1)	-	-	100	100
DSC - 511 A	Master Research (Thesis)	30	Satisfactory/Unsatisfactory			
OR						
DSC- 511 B	IDEA (Internship for Development of Entrepreneurship In Agriculture)	30	Satisfactory/ Unsatisfactory	-	-	100
	TOTAL	**1+30**				
	Grand total credit hours	**45+30=75**				**1800**

M.Sc. (Ag.) Animal Husbandry and Dairying (Dairy Science)

The following nomenclature and Credit Hrs. are following while structuring Syllabus:

A. Course Work	Course Code	Allotted Credit Hours
1. Major Course	DSC- 501 To DSC- 509	25
2. Minor Course	Elective	08
3. Supporting Course	AST-501 & AST-502	06
4. Common Course	PGS-501 To PGS-505	05
5. Seminar	DSC- 510	01
B. 1.Thesis Research/ IDEA	Master Research or IDEA	30
Total		**75**

List of Minor Papers for Other Departments

Sr. No.	**Course Code**	**Course Name**	**Allotted Credit Hours**	Sem.
1	DSC 501	Advances in Dairy Processing	3(2+1)	1st
2	DSC 504	Production and Applications of Dairy Ingredients	3(2+1)	2nd
3	DSC 507	Design of Dairy and food Process Equipment	2(1+1)	3rd

Note: - 1. The student has to opt. Minor Courses of Minimum 8 credit hours offer by other department

2. The first course of every semester from the respective department is treated as a Minor for other department.

1st Semester

DSC 501 Advances in Dairy Processing 3(2+1)

Theory

Unit I

Use of bio-protective factors for preservation of raw milk: effects on physico-chemical, micro-bial and nutritional properties of milk and milk products; Present status of preservation of raw milk.

Unit II

Methods of determining lethality of thermal processing; UHT processed milk products, their properties and prospects, types of UHT plants, aseptic fillers, heat stability and deposit formation aspects, effect on milk quality; techno-economic considerations; Nutritional aspects of UHT treated milk vis-à-vis retort sterilized/ HTST treated milk.

Unit III

Principles and equipment for bactofugation and bactotherm processes; Partial homogenization and its application in dairy industry, Low pressure homogenization; Microfluidization of milk: Principle, equipment, effects and applications.

Unit IV

Concentration processes and their impact on quality of finished products; Dehydration: advances in drying of milk and milk products; Freeze dehydration: physico-chemical changes and in-dustrial developments; Glass Transition Temperature and its relevance to dried milks.

Unit V

Water activity; Sorption behaviour of foods, energy of binding water, control of water activity of different milk products in relation to their chemical, microbiologi-cal and textural properties; Hurdle technology and its application in development of shelf-stable and intermediate-moisture foods; Use of carbonation in extending the shelf life of dairy products. Current trends in cleaning and sanitization of dairy equipment; Automation, Ultrasonic techniques in cleaning; Bio-films; Bio-detergents, innovations in sanitizers - chemical, radiation; Mechanism of fouling and soil removal; Assessing the effectiveness of cleaning and sanitization of dairy equipment, Water conservation methods.

Practical

Measurement of thiocyanate in milk system
LP system for extending the keeping quality of raw milk
Determination of HCT-pH profile of milk
Determination of water activity and sorption isotherms of milk products
Determination of WPNI of milk powders
Functional properties of milk powders
Determination of HMF content in dried milks
Freeze drying of milk and milk products
Homogenization efficiency
Cleaning and sanitization efficiency of dairy equipment
Visit to a UHT Processing plant.

Suggested Reading

Barbosa-CA, GV, Fontana Jr, AJ, Schmidt SJ, and Labuza TP. (Eds.). 2008. *Water Activity in Foods: Fundamentals and Applications* (Vol. 13). John Wiley and Sons.

Britz T and Robinson RK. (Eds.). 2008. *Advanced Dairy Science and Technology*. John Wiley and Sons.

Chandan RC and Kilara A. 2015. Dairy-based Ingredients. In: *Dairy Processing and Quality Assurance*. (2nd Edn.). Wiley-Blackwell.

DSC 502 Physico-Chemical Aspects of Milk Constituents 3(2+1)

Theory

Unit I: Chemical and Enzymatic reactions

Basics of chemical reaction kinetics, Order and molecularity of a reaction. Kinetics of denaturation of whey proteins and Maillard browning. Kinetics of enzymatic reactions; the role of enzymes as biological catalysts; factors affecting the rate of enzyme reaction: concentration of substrate, concentration of enzyme, concentration of reaction products, pH, temperature, time, activators and inhibitors. Thermal inactivation of enzymes present in milk. Concept of activation energy

Unit II: Electrochemistry

Electrolytic dissociation: activity, ionic strength and dissociation constants of acids and bases; effect of ionic strength on dissociation constants. Buffer, buffer capacity and buffer index of milk and milk products. Redox reactions and photo-oxidation of milk.

Unit III: Surface Chemistry

Adsorption at solid – vapour interphase; Monolayer and multilayer adsorption; capillary condensation;

adsorption isotherms; Hysteresis. Sorption of water on milk

Unit IV: Foams and Emulsions

Colloidal and surface phenomena in milk; adsorption at solid-liquid and liquid- liquid interphases; Gibb's equations. Interfacial tension, surface tension, surface active agents, general aspects of foaming, churning and whipping of cream; emulsion and emulsion stability; coalescence and dispersion; an introduction to the concept of Nano emulsion and Nano micelles.

Unit V: Micelles and Gelation

Micelles: definition, critical micelle concentration, formation and stability; Colloidal stability of casein micelles in milk, zeta potential, size distribution of casein micelles and fat globules. Gels and their formation, structure and stability; acid and rennet gels.

Practical

- Determination of the order of hydrolysis of an ester and measurement of activation energy.
- Measurement of the order of hydrolysis of a carbohydrate and measurement of activation energy.
- Assessment of the progress curve obtained during the hydrolysis of p-nitrophenyl phosphate by milk alkaline phosphatase.
- Analysis of effect of substrate concentration on hydrolysis of p-nitrophenyl phosphate by milk alkaline phosphatase.
- Study of effect of enzyme concentration on hydrolysis of p-nitrophenyl phosphate by milk alkaline phosphatase.
- Michaelis constant determination for the digestion of casein by trypsin.
- Measurement of pH and buffering capacity of different types of milk.
- Preparation of a buffer of a given molarity/ionic strength and pH and determination of pH of the buffer.
- Stability analysis of an oil-in-water emulsion stabilised by milk proteins
- Foaming capacity and foam stability of caseins/whey proteins.
- Study of the gel formation and gel stability of milk proteins.
- Drawing of an adsorption isotherm of water on casein.
- Measurement of thermal inactivation of enzymes (Alkaline phosphatase, Lactoperoxidase).

- Ancheyta J. 2017. *Chemical Reaction Kinetics: Concepts, Methods and Case Studies*. John Wiley and Sons.
- Dickinson E. 1995. *Food Macromolecules and Colloids*, RSC Special Publication.
- Dickinson E. 2005. *Food Colloids: Interactions, Microstructure and Processing,* RSC advancing chemical series.
- Fox PF, Uniacke-Lowe T, McSweeney PLH and O'Mahony JA. 2015. *Dairy Chemistry and Biochemistry*. Springer International Publishing-Switzerland.
- McClements DJ. 2016. *Food Emulsions: Principles, Practices and Techniques*, 3rd Edn, CRC press Taylor and Fracis group.
- Puri BR, Sharma LR, Pathania MS. 2016. *Principles of Physical Chemistry,* 47th Edition Vishal Publishing Co.
- Rockland LB and Beuchat LR. 1987. *Water Activity: Theory and Applications to Food*, Marcel Dekker Inc, NY.Walstra P and Jenness R. 1984. *Dairy Chemistry and Physics*. John Wiley and Sons.

DSC 503 Chemical Quality Assurance and Management Tools 3(2+1)

Theory

Unit I: Quality Tools and Management System

Concept of quality assurance and quality control in relation to dairy industry; Quality management systems - good manufacturing practices (GMP); HACCP certification; ISO 9001, ISO 22000, FSSC, total quality management (TQM); Lean and Six sigma, Five –S, Kaizen, Kanban and other quality tools; Good laboratory practices (GLP), laboratory accreditation

Unit II: International and National Organizations

Role of international organizations such as ISO, IDF, CAC, AOAC, WTO and national organizations like BIS, FSSAI, Ag Mark and APEDA in dairy industry, Quality Council of India (QCI), Export Inspection Council (EIC); Guidelines for setting up quality control laboratory and chemical safety aspects; sampling of milk and milk product; Food labeling guidelines.

Unit III: Assessment of Quality of milk and milk products

Detergents, sanitizers and disinfectants; Calibration of milk testing glassware; Preparation of standard reagents; Detection of adulterants in milk and milk products; Quality of packaging material for dairy products; Instrumentation in analysis of milk and milk products.

Unit IV: Contaminants and Food Traceability

Agro-chemicals/veterinary drug residues; occurrence of pesticide residues, antibiotic residues, heavy metals etc. in dairy products and their testing methods, Laboratory auditing, Food traceability systems, Food recall and withdrawal

Practical

- Preparation of standard solutions
- Testing of available chlorine content in hypochlorites/ bleaching powder
- Determination of purity of common salt to be used for butter and cheese making
- Detection of common adulterants in milk and foreign fat/ oil in ghee
- Checking the accuracy of calibration of hydrometers/ lactometers, butyrometers, milk pipette and thermometer
- Qualitative colour tests to distinguish between azo dyes and natural dyes in butter dairy Science and Technology: Dairy Chemistry
- Maintenance of records as per NABL and ISO criteria.
- Visit to a food analytical laboratory.

Suggested Reading

- Hoorfar J. 2012. *Case Studies in Food Safety and Authenticity*. 1st Ed. Woodhead Publishing
- IDF. 1993. *Quality Assurance* (*QA*) *and Good Lab. Practices* (*GLP*) *in Dairy Laboratories*. Special Issue No. 9302.
- IDF. 1997. *Monograph on Residues and Contaminants in Milk and Milk Products*. Special Issue No. 9701.
- Konieczka P and Namiesnik J. 2018. *Quality Assurance and Quality Control in The Analytical Chemical Laboratory: A Practical Approach*. CRC Press.
- Ralph Early. 1995. *Guide to Quality Management System for Food Industry*. Blackie.
- Schrenk D and Cartus A. 2017. *Chemical Contaminants and Residues in Food*. 2nd Ed. Woodhead Publishing.
- Young W. Park and George FW. Haenlein 2013. *Milk and Dairy Products in Human Nutrition*. John Wiley and Sons, UK.
- Restructured and Revised Syllabi of Post-graduate Programmes

(AST 501) Experimental Designs 3(2+1)

Theory

Unit I

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

Unit II

Uniformity trials, size and shape of plots and blocks, Analysis of variance, completely randomized design, randomized block design and Latin square design.

Unit III

Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom. Concept of confounding.

Unit IV

Split plot and strip plot designs, analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, Balanced Incomplete Block Design, resolvable designs and their applications,

Unit V

Lattice design, alpha design - concepts, randomization procedure, analysis and interpretation of results. Response surfaces. Combined analysis.

Practical

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD, Analysis of factorial experiments, Analysis with missing data, Split plot and strip plot designs.

Suggested Reading

Cochran WG and Cox GM. 1957. *Experimental Designs*. 2nd Ed. John Wiley.

Dean AM and Voss D. 1999. *Design and Analysis of Experiments*. Springer.

Montgomery DC. 2012. *Design and Analysis of Experiments*, 8th Ed. John Wiley.

Federer WT. 1985. *Experimental Designs*. MacMillan.

Fisher RA. 1953. *Design and Analysis of Experiments*. Oliver & Boyd.

Nigam AK and Gupta VK. 1979. *Handbook on Analysis of Agricultural Experiments*. IASRI Publ.

Pearce SC. 1983. *The Agricultural Field Experiment: A Statistical Examination of Theory and Practice*. John Wiley.

(PGS 501) BASIC CONCEPTS IN LABORATORY TECHNIQUES 1(0+1)

Practical

- Safety measures while in Lab;
- Handling of chemical substances;
- Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets;
- Washing, drying and sterilization of glassware;
- Drying of solvents/ chemicals;
- Weighing and preparation of solutions of different strengths and their dilution;
- Handling techniques of solutions;
- Preparation of different agro-chemical doses in field and pot applications;
- Preparation of solutions of acids;
- Neutralization of acid and bases;
- Preparation of buffers of different strengths and pH values;
- Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sand bath, water bath, oilbath
- Electric wiring and earthing;
- Preparation of media and methods of sterilization;
- Seed viability testing, testing of pollen viability;
- Tissue culture of crop plants;
- Description of flowering plants in botanical terms in relation to taxonomy.

Suggested Readings

- Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press
- Gabb MH and Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

PGS 502) Intellectual Property and Its Management In Agriculture 1(1+0)

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

- Erbisch FH and Maredia K.1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.
- Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.
- *Intellectual Property Rights: Key to New Wealth Generation*. 2001. NRDC and Aesthetic Technologies.
- Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V.Technology Generation and IPR Issues. Academic Foundation.
- Rothschild M and Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.

2nd Semester

(DSC-504) Production and Applications of Dairy Ingredients 3(2+1)

Theory

Unit I

An overview of dairy ingredients for food processing; Composition, nutritive value and health attributes of dairy ingredients; Important quality indices; National and international regulatory standards.

Unit II

Principles of conventional and novel approaches for separation, concentration and fractionation of milk components (Ig, lf, b-Lg): centrifugal separation, concentration, drying, membrane processing, enzyme-assisted separation, supercritical fluid extraction, electric field assisted membrane technique, etc.

Unit III

Chemical, physical and functional characteristics of concentrated and dried dairy ingredients (SMP, WMP, lactose, whey powder, WPC, WPI, MPC, casein and caseinates, cream powder, butter powder, cheese powder, yogurt powder, buttermilk powder, etc.).Miscellaneous dairy ingredients, viz. dairy permeates, hydrolysates, coprecipitates andlactoferrin.

Unit IV

Interactions of dairy ingredients with other food components and its effect on product quality.

Unit V

Applications of dairy ingredients in food industry: bakery and confectionery; Infant, adult and sports nutrition; Processed meat products; spreads; functional Foods; edible films and coatings.

Practical

- Manufacture of whey powder, caseinates, whey protein/milk protein concentrates, lactose, sweet cream butter milk powder, cream powder, yogurt powder and cheese powder.
- Determination of functional and nutraceutical properties of dried dairy ingredients.
- Manufacture of enzyme-modified dairy ingredients
- Production of eggless cakes using WPC
- Production of processed meat products incorporating caseinates
- Visit to a dairy ingredients manufacturing industry.

Suggested Reading

- Chandan RC and Kilara A. 2011. *Dairy Ingredients for Food Processing*. Iowa, USA: Blackwell Publishing Ltd.
- Corredig M. 2009. *Dairy Derived Ingredients: Food and Nutraceutical Uses*. Cambridge, UK: Woodhead Publishing Ltd.
- Fox PF. 1985. *Developments in Dairy Chemistry*. Vol.3.Lactose and minor constituents, New York: Elsevier Applied Science.
- Fox PF. 1989. *Developments in Dairy Chemistry*. Vol.4. Functional milk proteins, New York:

DSC-505 Chemistry of Processed Dairy Foods 3(2+1)

Theory

Unit I: Process induced changes in concentrated and dried milks

Process induced changes in milk constituents during preparation and storage of concentrated and dried milks.

Unit II: Human milk and infant food

Role of biologically active components in human milk; Standards, composition and properties of infant milk and infant food formulations

Unit III: Heat induced changes in milk

Heat induced changes in milk leading to coagulation; Heat stability of concentrated milk as affected by different process variables, Milk constituents and additives; Age gelation: Mechanism and control.

Unit IV: Cheese and other fermented dairy products

Biochemical changes during ripening of different varieties of cheese; Lactic acid fermentation in cheese and other fermented dairy products; chemical defects in cheese.

Unit V: Cream, butter and ghee

Storage stability of cream, butter and ghee. Physico-chemical properties of ghee; Ghee flavour, texture

(grains) and colour in ghee.
Role of different ingredients during processing and storage of ice cream/ frozen desserts; Concept of antifreeze protein/ice structuring protein in ice cream

Practical

- Determination of lactose and sucrose in condensed milk and ice-cream.
- Determination of weight per litre of ice-cream.
- Determination of heat stability of milk and concentrated milks.
- Determination of WPNI of skim milk powder.
- Determination of fat in cream and butter by Mojonnier method.
- Determination of salt in butter.
- Determination of diacetyl and acetyl methyl carbinol in butter/ cultured products.
- Determination of RM, Polenske value, iodine value, saponification value of ghee.
- Determination of soluble proteins, salt and free fatty acids in cheese.
- Determination of rennet clotting time of milk.

Suggested Reading

- Fox PF, Uniacke-Lowe T, McSweeney PLH and O'Mahony JA. 2015. *Dairy Chemistry and Biochemistry*. Springer International Publishing-Switzerland.
- Koca N. (Ed.). 2018. *Technological Approaches for Novel Applications in Dairy Processing*. BoD– Books on Demand.
- Mathur MP, Roy DD and Dinakar P. 1999. *Textbook of Dairy Chemistry*. ICAR.
- Official methods of AOAC. 11th and 15th Eds.
- Walstra P and Jenness R. 1984. *Dairy Chemistry and Physics*. John Wiley and Sons.

Wong NP, Jeness R, Keeney M and Elmer HM. 1988. *Fundamentals of Dairy Chemistry*. Van Nostrand Reinhold Co

(DSC-506) Microbiology of Fluid Milk and Dairy Products 2(1+1)

Theory

Unit I

Common microbes in milk and their significance, Microflora of mastitis milk and its importance in dairy industry, Sources of microbial contamination of raw milk and their relative importance in influencing quality of milk during production, collection, transportation and storage; Clean milk production and natural antimicrobial systems in raw milk, Microbial changes in raw milk during long storage, Microbiological grading of raw milk.

Unit II

Microbiological aspects of processing techniques like bactofugation, thermization, pasteurization, sterilization, boiling, UHT, non-thermal processes (pulsedelectric field) and membrane filtration of milk; Role of psychrotrophic, mesophillic, thermophilic and thermoduric bacteria in spoilage of processed milks, their sources and prevention; Heat induced damage in bacteria and role of resuscitation in recovery of injured microbial cells. Microbiological standards (BIS/ FSSAI) of heat- treated fluid milks

Unit III

Microbiological quality of dairy products; fat rich (cream and butter), frozen (ice cream), concentrated (evaporated and condensed milk), dried milks (roller and spray dried), infant dairy foods and legal standards; Sources of contamination and factors affecting microbial quality of these products during processing, storage and distribution; Microbiological defects associated with these products and their control.

Unit IV

Microbiological quality of traditional dairy products in India; heat desiccated (khoa, burfi, peda, kheer, etc.), acid coagulated (paneer, chhana, rasogolla, etc.), fermented (dahi, lassi, srikhand, etc.) and frozen (kulfi); Sources of microbial contaminants and

their role in spoilage; Importance of personnel and environmental hygiene on quality of traditional milk products; Microbiological standards for indigenous dairy foods.

Unit V

Food poisoning- Food intoxications, Food infections and Toxi-infections, pathogens associated with fluid milks, dairy products and their public health significance; Sources of pathogens and their prevention; Importance of biofilms, their role in transmission of pathogens in dairy products and preventive strategies.

Practical

- Grading of raw milk based on SPC, coliforms and dye reduction tests.
- Effect of different storage temperatures on microbiological quality of fluid milk.
- Tests for mastitic milk and brucellosis.
- Microbiological quality evaluation of cream and butter for coliforms, yeasts and moulds, lipolytic and proteolytic bacteria.
- Detection of *Cronobacter sakazakii* in infant dairy foods.

- Microbial evaluation of burfiand pedafor SPC, *S. aureus*, yeast and mould counts.
- Detection of *Bacillus cereus*, *Salmonella,Shigella* and coagulase positive staphylococci in milk powder.
- Evaluation of ice cream for coliforms and *Escherichia coli.*
- Microbiological quality of paneer.
- Enumeration of aerobic and anaerobic spores in condensed, sterilized and dried milks.
- Line testing for determining the source of contamination of dairy products.
- Detection of toxins (staphylococcal, aflatoxins/mycotoxins) in dairy foods

Suggested Reading

- Eozer B. 2014. *Dairy Microbiology and Biochemistry: Recent Developments*. CRC Press, USA.
- Law BA. 2012. *Microbiology and Biochemistry of Cheese and Fermented Milks*. Springer Publisher.
- Quin M. 1989. *Applied Microbiology in the Dairy Industry*. Hobsons Publishing PLC.

(AST 502) Data Analysis Using Statistical Packages 3(2+1)

Theory

Unit I

Introduction to various statistical packages: Excel, R, SAS, SPSS. Data Preparation; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

Unit II

Test for normality; Testing of hypothesis using chi-square, t and F statistics and-Ztest.

Unit III

Data preparation for ANOVA and ANCOVA, Factorial Experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.

Unit IV

Analysis of mixed models; Estimation of variance components; Correlation and regression analysis, Probit, Logit and Tobit Models.

Unit V

Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Neural networks.

Practical

- Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data
- Testing the hypothesis for one sample t-test, two sample t-test, paired t-test, test for
- large samples - Chi-squares test, F test, one-way analysis of variance;
- Designs for Factorial Experiments, fixed effect models, random effect models, mixed
- effect models, estimation of variance components;
- Linear regression, Multiple regression, Regression plots
- Discriminant analysis - fitting of discriminant functions, identification of important
- variables
- Factor analysis. Principal component analysis - obtaining principal component.

Suggested Reading

- Anderson C.W. and Loynes R.M. 1987. The Teaching of Practical Statistics. John Wiley.
- Atkinson A.C. 1985. Plots Transformations and Regression. Oxford University Press.
- Chambers J.M., Cleveland W.S., Kleiner B and Tukey P.A. 1983. Graphical Methods for Data Analysis. Wadsworth, Belmont, California.
- Chatfield C. 1983. Statistics for Technology. 3rd Ed. Chapman & Hall. Chatfield C. 1995. Problem Solving: A Statistician's Guide. Chapman & Hall.
- Cleveland W.S. 1985. The Elements of Graphing Data. Wadsworth, Belmont, California.
- Ehrenberg ASC. 1982. A Primer in Data Reduction. John Wiley.
- Erickson B.H. and Nosan Chuk T.A. 1992. Understanding Data. 2nd Ed. Open University Press, Milton Keynes.

- Snell E.J. and Simpson HR. 1991. Applied Statistics: A Handbook of GENSTAT Analyses. Chapman and Hall.
- Sprent P. 1993. Applied Non-parametric Statistical Methods. 2nd Ed. Chapman & Hall.
- Tufte ER. 1983. The Visual Display of Quantitative Information. Graphics Press, Cheshire, Conn.
- Velleman PF and Hoaglin DC. 1981. Application, Basics and Computing of Exploratory Data Analysis. Duxbury Press.
- Weisberg S. 1985. Applied Linear Regression. John Wiley.
- Wetherill GB. 1982. Elementary Statistical Methods. Chapman & Hall.

(PGS 503)- Agricultural Research, Research Ethics and Rural Development Programmes 1 (1+0)

Theory:

UNIT I

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions;

UNIT II

Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centers (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT III

Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT IV

Concept and connotations of rural development, rural development policies and strategies. Rural development Programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati-Raj Institutions, Co-operatives, Voluntary Agencies/ Non-Governmental Organizations.

UNIT V

Critical evaluation of rural development policies and Programmes. Constraints in implementation of rural policies and Programmes.

Suggested Readings

- Bhalla GS and Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
- Punia MS. Manual on International Research and Research Ethics. CCS Haryana Agricultural University, Hisar.
- Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publ.
- Singh K. 1998. Rural Development - Principles, Policies and Management. Sage Publ

(PGS 504) Library and Information Services 1(0+1)

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/ Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; eresourcesaccess methods.

3rd Semester

DSC-507 Design of Dairy and food Process Equipment 3(2+1)

Theory

Unit I

Design of vessels: codes and regulations, Design for pressure and temperature, loading; allowable stress, minimum thickness after forming, design for internal and external pressure, cylindrical and spherical shells, formed heads, reinforcement openings; fabrication requirements, inspection, tests and non-destructive examination, pressure tests, design and stress evaluation**,** design problem.

Unit II

Design of storage vessels/ tanks, horizontal and vertical tanks, design of insulated and un-insulated tanks, nozzles and mountings, Design problems.

Unit III

Design of high-pressure vessels: constructional features, material for high pressure, multi shell construction, solid walled vessel. Fundamentals of CAD/ CAM for design of dairy and food processing equipment

Unit IV

Supports for vessel: bracket support or Lug support, web (gusset plates), skirt support, skirt design, skirt bearing plate, saddle support, Design problems.

Unit V

Heat exchangers: shell and tube heat exchangers, construction codes, general design considerations, U- tube heat exchangers, double pipe exchanger, scraped surface exchanger, spiral tube exchangers, joints; welded tube joints, baffles and tube bundles, tube sheet, double tube sheet construction; plate type heat exchanger; air cooled heat exchangers; Computer software for design of heat exchanger, Design problems.Design of reactor vessel: material of construction, agitation, classification, heating systems, design consideration, tank coils, design of agitation system components, baffles, power requirement for agitation, Hygienic engineering design.

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Practical

- Design of storage tanks and silos
- Design of supports for silos and tanks
- Design of high pressure vessels
- Design of plate heat exchanger
- Design of scraped surface heat exchanger

  Design of air cooled heat exchangers
- Computation of power requirement of agitators
- Exercises on use of CAD/CAM software for design of heat exchangers
- Use of computational software for design of heat exchangers

Suggested Reading

- Evans FL. 2016. *Equipment Design Handbook for Refineries and Chemical Plants*. Gulf Publishing, Houston, Texas. ISBN-13: 978-0872012660.
- Farrall AW. 2018. *Engineering for Dairy and Food Products*. 3rd Edition, MedTech. ISBN- 13: 978-9386800718.
- Kessler HG. 1981. *Food Engineering and Dairy Technology*. Verlag A. Kessler.
- Mahajani VV and Umarji SB. 2016. *Joshi's Process Equipment Design*. 5th Edition, Laxmi Publications. ISBN-13: 978-9351380191.
- Saravacos GD and Kostaropoulos AE. 2012. *Handbook of Food Processing Equipment*. Springer. ISBN-13: 978-1461352129.

DSC-508 Market Milk Processing and Dairy Plant Practices 3(2+1)

Theory

Unit I

Organization of procurement and pricing plans of raw milk - Operation of automatic milk collection stations - Reception of milk at Raw Milk Reception Dock (RMRD)- Assessing raw milk quality - Sanitary handling of milk - Milk standards and legislations.

Unit II

Unit operations in milk processing plants - Clarification – Bactofugation - Different chilling methods - Standardization - Homogenization (theories, methods and effects) - Heat treatments (thermization, boiling, pasteurization, sterilization (UHT and In-container) - Separation technologies (Microfiltration, Ultrafiltration, reverse osmosis, diafiltration, nanofiltration etc.).

Unit III

Distribution methods for liquid milk - Consumer pricing - Traceability - Handling of unsold and returned milk- - Adulteration of milk and detection - Residues in milk and preventive steps

Unit IV

Fortified, special and functional market milk - A1 and A2 milk Design and layout of dairy plants of different capacities - Dairy by-products - Treatment of Dairy Effluents.

Practical

Platform tests - Principles of rapid milk analyzers including milko-tester and operation of automatic milk collection stations - Raw milk quality, somatic cell count, bacteriological count - Estimation of homogenization efficiency - Assessment of efficiency of pasteurization, sterilization and boiling- Detection of adulterants.

(DSC-509) Advanced in Traditional Indian Dairy Product 2(1+1)

Theory

Unit I

Global prospects and export potential of traditional Indian dairy products.

Unit II

Differences in quality of traditional dairy products from cow, buffalo, goat, camel, and sheep milks; Process innovations in commercial production of heat-desiccated, coagulated and fermented traditional dairy products; Mechanized production of traditional milk-based sweets; Automation for manufacture of ghee, *paneer*, *Dahi*, *lassi* and traditional sweetmeats.

Unit III

Composite traditional milk products; Application of membrane technology and microwave processing for industrial production of traditional Indian dairy products.

Unit IV

Technologies for region specific traditional Indian dairy products and their value addition, their application as a vehicle for delivering functional ingredients; Manufacture of dietetic traditional dairy products.

Unit V

Techno-economic aspects for establishing commercial units for traditional products.Convenience traditional dairy products; Food safety issues; Shelf life extension of food using newer techniques; Novel packaging and preservatives.

Practical

- Production of reduced calorie, composite and functional traditional Indian dairy products.
- Microwave heating of traditional Indigenous milk delicacies for shelf life extension.
- Membrane technology for improving the quality of traditional Indigenous products made from cow and buffalo milk.
- Preparation of feasibility report for establishing commercial units for traditional dairy products.

Suggested Reading

- Aneja RP, Mathur BN, Chandan RC and Banerjee AK. 2002. *Technology of Indian dairy products.* A Dairy India Publication.
- Goyal MR, Kumar A and Gupta AK. 2018. *Novel Dairy Processing Technologies: Techniques, Management, and Energy Conservation*. CRC Press.
- Puniya AK. 2015. *Fermented Milk and Dairy Products;* CRC Press/Taylor and Francis (ISBN 9781466577978)
- Shrott C and O'Brien. 2003. *Handbook of Functional Dairy Products*. CRC Press
- *TetraPak Dairy Processing Handbook.* 2015. www.dairypeocessinghandbook.com.

(PGS 505) Technical Writing and Communications Skills 1(0+1)

Practical (Technical Writing)

- Various forms of scientific writings- theses, technical papers, reviews, manuals, etc.;
- Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion);
- Writing of abstracts, summaries, précis, citations, etc.; Commonly used abbreviations in the theses and research communications;
- Illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations;
- Writing of numbers and dates in scientific write-ups;
- Editing and proof-reading;
- Writing of a review article;
- Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks);
- Error analysis (Common errors), Concord, Collocation, Phonetic symbols and transcription;
- Accentual pattern: Weak forms in connected speech;
- Participation in group discussion;
- Facing an interview;
- Presentation of scientific papers.

Suggested Readings

- Barnes and Noble. Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language*.
- *Chicago Manual of Style*. 14th Ed. 1996. Prentice Hall of India.
- *Collins' Cobuild English Dictionary*. 1995.
- Harper Collins. Gordon HM and Walter JA. 1970. *Technical Writing*. 3rd Ed.
- Holt, Rinehart and Winston. Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English*. 6th Ed. Oxford University Press.
- James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.
- Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East- West Press.
- Mohan K. 2005. *Speaking English Effectively*. MacMillan India.
- Richard WS. 1969. *Technical Writing.*
- Sethi J and Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.
- Wren PC and Martin H. 2006. *High School English Grammar and Composition*. S.

4th SEMESTER

(DSC-511)	**Master's Seminar**	**1(0+1)**
(DSC - 511 A)	**Master Research**	**30**

Or

(DSC - 511B) IDEA (Internship for Development of Entrepreneurship in Agriculture) 30