

MAHATMA GANDHI UNIVERSITY
PRIYADARSHINI HILLS, KOTTAYAM – 686 560



RESTRUCTURED CURRICULUM
FOR
POST GRADUATE PROGRAMME
IN
M.Sc. AQUACULTURE AND FISH
PROCESSING

(Effective from 2019 Admission onwards)

M.Sc. Aquaculture and Fish Processing

Scope of the Programme

The program is designed as a four semester, two year programme under the Credit and Semester System. The programme will cater to the higher study opportunity for under graduate programmes in the related fields, in this university and other universities within the country and abroad. The fishing industry is in need of highly skilled man power and this programme will create the necessary skill sets among the aspiring students. The general skill sets attained will relate to Fish Biology, Microtechniques, Aquaculture and Fish Processing Technology. The focus areas of this programme are Fish Capture Technology, Fish Processing Technology and Microbiology & Quality Control. Special emphasis is given for hands on experience for the students with the inclusion of two practical papers in each semester. Courses offered in Semester I include Taxonomy and Fishery Biology; Biophysics, Instrumentation, Microtechniques and Research Methodology; Biostatistics & Computer Applications. Two practical papers are offered in semester one. Practical paper one covers aspects of Taxonomy and Biology of Finfish and Shellfish and practical paper two covers Instrumentation, Microtechniques, Biostatistics, Computer Application and Aquaculture Engineering. In Semester II the courses offered are Aquatic Biology and Ecology; Biochemistry and Nutrition; Physiology, Endocrinology and Pathology; Genetics and Biotechnology. Semester II also offered two practical papers. The first practical paper focus on Aquatic Biology, Physiology, Pathology, Genetics & Biotechnology while the second practical paper focus on Biochemistry and Nutrition. The courses offered in Semester III are Culture of Finfishes, Molluscs and Sea Cucumbers; Ornamental Fish Culture, Crustacean Culture and Seaweed Culture; Aquaculture Economics, Management and Extension. Of the two practical papers offered, the first paper include topics on Culture of Finfishes, Molluscs and Sea Cucumbers, Crustaceans and Seaweeds while the second practical is on Aquaculture and Aquaculture. The specialization papers in Semester IV include one theory paper in Fish Processing Technology and one practical Paper in Post Harvest Technology, Microbiology and Quality Control. Moreover, the students have to select the elective papers from the table given below as an essential part of the curriculum. In addition the students have to undergo On Job Training in a recognized institution offering such training or in reputed fish processing plants with the aim of skilling the students to work in the seafood industry. The students also have to complete and submit M.Sc. Project Work Report. Care has been taken to enhance the knowledge base of the students through the inclusion of more number of topics in the courses offered and to empower the skill base of the students through the practical papers. On completion of the programme the students are ready for pursuing a career in the industry as well as government jobs or for pursuing research.

M.Sc. Aquaculture and Fish Processing - Abstract of the Programme

	Code	Course	Hours/ Week	Total Hours	Credit
SEMESTER-I	AQ020101	Taxonomy and Biology of Commercial and Cultivable Finfishes and Shellfishes	5	90	4
	AQ020102	Biophysics, Instrumentation, Micro techniques and Research Methodology	5	90	4
	AQ020103	Biostatistics and Computer Application	5	90	4
	AQ020104	Taxonomy and Biology of Finfish and Shellfish	5	90	3
	AQ020105	Instrumentation, Microtechniques, Biostatistics, Computer Application and Aquaculture Engineering	5	90	3
	TOTAL			25	450
SEMESTER- II	AQ020201	Aquatic Biology and Ecology	5	90	4
	AQ020202	Biochemistry and Nutrition of Finfish and Shellfish	5	90	4
	AQ020203	Physiology, Endocrinology and Pathology of Finfish and Shellfish	5	90	4
	AQ020204	Genetics and Biotechnology	5	90	4
	AQ020205	Aquatic Biology, Physiology, Pathology, Genetics and Biotechnology	2.5	45	2
	AQ020206	Biochemistry and Nutrition of Fin Fish and Shell Fish	2.5	45	2
TOTAL			25	450	20
SEMESTER- III	AQ020301	Culture of Finfishes, Molluscs and Sea Cucumbers	5	90	4
	AQ020302	Ornamental Fish Culture	5	90	4
	AQ020303	Crustacean and Seaweed Culture	5	90	4
	AQ020304	Aquaculture Economics, Management and Extension	5	90	4
	AQ020305	Culture of Finfishes, Molluscs and Sea Cucumbers, Crustaceans and Seaweeds	2.5	45	2
	AQ020306	Aquaculture Economics and Aquariculture	2.5	45	2
TOTAL			25	450	20
SEMESTER- IV	AQ020401	Fish Processing Technology	5	90	4
	AQ020402	Post Harvest Technology, Microbiology and Quality Control	5	90	2
	ELECTIVES	GROUP A / GROUP B	5	72	3
	ELECTIVES	GROUP A / GROUP B	5	72	3
	ELECTIVES	GROUP A / GROUP B	5	72	3
	AQ020403	Project*	-	-	2
	AQ020404	Viva Voce**	-	-	2
AQ020405	On Job Training ***	-	-	3	
TOTAL			25	396	22
Grand Total					80

	Groups	Code	Course	Hours/Week	Total Hours	Credit
ELECTIVES (Credit 3*3=9)	GROUP A	AQ820401	Aquaculture and Ecosystem Management	5	72	3
		AQ820402	Aquaculture Engineering	5	72	3
		AQ820403	Applied Genetics in Aquaculture	5	72	3
	GROUP B	AQ830401	Fish Nutrition and Feed Technology	5	72	3
		AQ830402	Fishing Technology	5	72	3
		AQ830403	Microbiology and Quality Assurance	5	72	3

* Project may be undertaken either under the faculty of the Department or under an external faculty in collaborative guidance approved by the Department. Review works may be avoided. A paper published by the candidate as the first author in a peer reviewed national/international journal can be considered as equivalent to dissertation. Each student is expected to make a final powerpoint presentation of their project work as part of the internal evaluation.

**A comprehensive Viva Voce covering the entire topics in the Programme

***A training for not less than TWO WEEKS and not more than 30 days must be attended in a reputed fish processing plant or government/ research institution and a certified report along with attendance certificate may be produced .

**DETAILED SYLLABUS
SEMESTER I**

	Code	Course
SEMESTER-I	AQ020101	Taxonomy and Biology of Commercial and Cultivable Finfishes and Shellfishes
	AQ020102	Biophysics, Instrumentation, Micro techniques and Research Methodology
	AQ020103	Biostatistics and Computer Application
	AQ020104	Taxonomy and Biology of Finfish and Shellfish
	AQ020105	Instrumentation, Microtechniques, Biostatistics, Computer Application and Aquaculture Engineering

AQ020101 Taxonomy and Biology of Commercial and Cultivable Finfish and Shellfish

Credit : 4

90 Hrs

Module I: Morphology & Taxonomy of fin fish and shell fish 45hrs

1.1 Study of external morphology of a typical elasmobranch, teleost, prawn, lobster, crab, bivalve, gastropod and cephalopod. **8hrs**

1.2 Study of scales, skin, teeth, mouth and fins and their use in taxonomy of fin fishes. **6hrs**

1.3 Taxonomy of commercially important fin fishes of families of the orders: Clupeiformes, Perciformes, Cypriniformes, Siluriformes, Pleuronectiformes. **16hrs**

1.4 Taxonomy of commercially important shell fishes of prawns, crabs, lobsters, bivalves, gastropods and cephalopods in India. **9hrs**

1.5 Methods of Biosystematics : Classical and modern methods-Typological, Phenetics, Evolutionary, Phylogentic, Cladistics and Molecular Taxonomy. Phylocode, Tree of Life and Bar-coding of Life. **6hrs**

Module 2 Biology of Fin fishes and Shell fishes 45hrs

2.1 Digestive system: Structure, function and physiology of digestive system and associated glands. Food and feeding habits of finfish and shellfish. **6hrs**

2.2 Respiratory system: Structure and function of respiratory system and accessory respiratory organs in fin fishes. Respiration in prawns and bivalves. **6hrs**

2.3 Circulatory systems: Structure and function of circulatory system, Blood, blood cells, plasma, and plasma proteins in fin fishes. **4hrs**

2.4 Excretory system: structure and functions, osmoregulation in fishes and prawns. **3hrs**

2.5 Nervous system: Brain and nerves of fin fish and shell fish.

3hrs

2.6 Endocrine system: Structure and function of endocrine glands of fishes. Neuroendocrine system of prawns. Role of hormone in relation to reproduction in fishes and prawns.

6hrs

2.7 Reproductive system: Structure and function of reproductive systems of finfishes, prawns and bivalves. Gametogenesis- spermatogenesis and oogenesis, ovulation and fertilization. Gonadosomatic index. Parental care in fin fishes.

6hrs

2.8 Age and growth: Principles of age determination. Scale method. Otolith method. Other skeletal parts as age indicators. Length-frequency method.

5hrs

Module 3 Distribution of commercially important finfish and shellfish in Indian waters

Schooling, orientation and migration. Definition of mud banks, wedge bank and parr. Upwelling and its importance to fisheries. Distributional shifts of fishery stock, climate change.

6 hrs

References

J. R. Norman & W.P.C. Tenison. 1963 History of fishes. Asian Publishing Hse, Delhi

Karl F. Lagler, John e. bardach, RobertR.Miller1969 Ichthyology. John Wiley & Sons, New York

Munro I.S.R. (1982) The Marine and Fresh water fishes of India and Ceylon. Sony Reprints Agency, New Delhi

Kapoor V.C. (1991) Theory and practice of Animal Taxonomy. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.

Santhosh Kumar and Manju Tembhre (1996) Anatomy and Physiology of fishes. Vikas Publishing co.

Kotpal Mollusca

Kotpal. Arthropoda

EkambaranathIyer. Invertebrate Zoology

FAO species identification key.

AQ020102 Biophysics, Instrumentation, Micro-techniques and Research Methodology
Credit : 4 **90 Hours**

Biophysics **18Hrs**

Module 1 Diffusion and Osmosis **8 hrs**

Diffusion, concentration gradient and Fick's Law, diffusion coefficient, Stocks-Einstein equation, pressure gradient and Graham's Law, Gibbs-Donnan equilibrium. Osmosis, Vant Hoff's Law, Osmotic concentration and osmotic pressure, Biological significance of osmosis in fishes.

Module II Biophysics of Cell Membrane **10hrs**

Physics-chemical properties of cell membrane, membrane receptors, factors affecting the passage of materials across cell membranes.

Instrumentation **38hrs**

Module III Refractometry **12hrs**

Calorimetry, spectrophotometry (U.V. visible, infrared and double beam), pH and, Oxygen probe, conductivity meter, salinometer and refractometer, atomic absorption spectrophotometer, Mass spectroscopy and LC-MS.

Module IV Chromatography **10hrs**

Chromatography, adsorption and partition chromatography, ion exchange and affinity chromatography, high performance (pressure) liquid chromatography, gel filtration chromatography.

Module V Electrophoresis **8hrs**

General principles and different gel materials for electrophoresis, different methods of electrophoretic techniques, Isoelectric focusing.

Module VI Microscopy **8 hrs**

Principles of microscopy, bright field, dark field and phase contrast microscopy; fluorescence microscopy, microphotography, electron micrograph, principles of electron microscopy and ultra-structure studies using electron microscopy.

Microtechniques **10hrs**

Module VII Microtechniques **10 hrs**

Fixation of invertebrates and vertebrates, tissues, organs. Dehydration methods, embedding, clearing and sectioning. Staining of sections, preparation of whole mounts. Histochemical methods for location of carbohydrates, lipids and protein fixation and processing of tissues for electron microscopy studies.

Research Methodology

24hrs

Module VIII Introduction

8hrs

Meaning and importance of research, Types of research-selection and formulation of research problem. Research design-need-features, different research designs, concepts relating to research design. Analysis of literature review, primary and secondary sources, web sources critical literature reviews.

Module IX Data Collection and Analysis

6 hrs

Collection of primary and secondary data, selection of appropriate methods of data collection, data preparation, important steps, types of analysis.

Module X Interpretation and Report Preparation

10hrs

Meaning of interpretation, techniques of interpretation, and precautions in interpretation. Significance of report writing, different steps in report writing. Types of reports; technical and popular. Lay out of research reports, preliminary pages, main text, and end matter. Reproduction of published materials-plagiarism-citation and acknowledgement, reproducibility and accountability.

References

- Baker, E.J., and Silverion R.F., 1978. Introduction of Medical laboratory techniques ELBS.
- Das, D. 1991. Biophysics and Biophysical chemistry. Academic publishers, Calcutta.
- Ernster, L (ed.). 1985. Bioenergetics, Elsevier, New York Foyer,
- C.H. 1984. Photosynthesis, Wiley, New York.
- Hoppe, W.*et al.*,(Eds.) Biophysics. Springer Verlag, Berline
- Leninger, A.L. 1971. Bioenergetics. W.A.benjamin, London.
- Narayanan, P. 2000. Essentials of Biophysics, New Age International pvt. Ltd. Publishers, ND.
- Nicholls, D.G. and Ferguson, S.J. 1992. Bioenergetics, Academic Press, New York.
- Pearse A.G.F., 1980. Histochemistry Vol. I & II. Churchill Livingston, New York.
- Roy, A.N. 1996. A test book of Biophysics, New Central Book agency Pvt. Lts. Calcutta.
- Sadhu, G.S. 1990. Research Techniques in biological Sciences, Anmol Publications, New Delhi.
- Weesner, F.M., 1960. General Zoological Microtechniques. The Willian and Willians Company, Baltimore.

AQ020103 Biostatistics and Computer Application

Credit : 4 **90 hrs**

Biostatistics. **42hrs**

Module I Collection, compilation and analysis of the data **8 hrs**

Primary and secondary data- formation of length and weight frequency distribution, measures of central tendency-Mean, median and mode. Measures of dispersion – range, quartile deviation, mean deviation and standard deviation. Absolute and relative measures of dispersion.

Module II Correlation and Regression Analysis **8 hrs**

Scatter diagram- Karl Pearson's coefficient of correlation- Spearman's Rank Correlation coefficient-coefficient of determination Regression analysis-Linear regression equations and their uses. Length – weight relationship and von Bertalanffy growth equation.

Module III Probability and Theoretical Distribution **8 hrs**

Frequency approach and Axiomatic approach to probability - Mutually Exclusive and independent events - Addition and Multiplication theorems - Binomial, Poisson and Normal distribution

Module IV Statistical quality control **6 hrs**

Process control and product control – control chart for variables and attributes – mean and range charts, fraction defective chart ('p' chart) and 'c' charts – sampling inspection plans.

Module V – Theory of Sampling and Inference **12 hrs**

Population of sample, determination of the sample size – sampling techniques – estimation of marine fish landings in India. Null and alternative hypothesis-two types of errors in testing of hypothesis – large and small sample tests – 'Z', 't', X^2 and F-tests- Analysis of variance Techniques – Single factor – ANOVA

Computer Application **48hrs**

Module VI Basics of Computers **8 hrs**

Types of Computers. Binary Number System, Digital and Analog systems. Hardware/Software/Firmware. Basics of Computer Functioning- Booting; Formatting; File, File Extensions; Temporary Files; Folder; GUI, Icon; Installation of Programs, Commands, Bios-setup, Date and Time, Memory Partitions, Registry, Default Operations; Defragmentation (Brief account only).

Module VII Hardware Basics **9 hrs**

Memory -Classification and Types of memory; memory devices; Units. Input Devices -Types, working and functions. Output Devices –Types, working and functions. CPU components - Processors, Mother boards,

SMPS, Accessory Cards – Graphic /Sound/ Networking/Bluetooth/Wifi (Brief account only).

New Generation Computers - Servers, Laptop; Palmtop; Cyborgs; Robotics, Zoobotics (Brief account only).

Module VIII Software Basics

12 hrs

System Software/Operating System -System Files; Working of OS; DOS, Widows, Linux and UNIX (Brief account only).

Application Software -Programs and Packages, Calculator, MS Paint, MS Word, MS Excel, MS PowerPoint, Publisher, Acrobat Reader, E Book Reader, Explorer, Photoshop.

Virus and Antivirus (Brief account only).

Statistical Software (MS Excel, PH Stat, SPSS, R).

Databases -MS Access (Brief account only).

Module IX Computer Language and Programming

6 hrs

Computer language -Classification and types, HTML, C and Java Programming concepts -Algorithm, Codes (Brief account only).

Module X Networking, Internet and Information Technology

9hrs

Computer Communication -Network Topology, Media of networking, Networking.

Protocols, PAN, LAN, WAN, MAN, INFLIBNET, Modem and Gateway.

Internet and Internet Services -World Wide Web, Uploading, Downloading, Hosting, Portal, Search Engines, Firewall.

Global Information System -BIOSIS, Medline and Medlars, AGRIS; E Journals and E Books Publishing. Cyber Crime and Cyber Laws (Brief account only).

Module XI Computerised information systems in Fisheries

4hrs

Remote sensing applications, GPS, Statistical data analysis packages, Aquaculture softwares.

References

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Thomas, R.M. 1992. DOS5, BPB publishers, New Delhi.
Gupta, S.P. 1998. Statistical method, Sultan Chand and Sons, New Delhi.
Gupta, C.B.1996. An Introduction to Statistical methods. Vikas Publications House Pvt, Ltd. New Delhi.
Srestha, H.B.1989. Elementary statistical methods, Orient Longman Ltd, Calcutta.

AQ020104 Taxonomy and Biology of Finfish and Shellfish

Credit : 3

90 Hrs

Practical 1 Study on the morphology -scales, teeth, tails and fins of - commercially important Fin fish.

Practical 2 Study on the morphology of shell fishes-crustaceans and molluscs.

Practical 3 Dissection of alimentary canal and internal organs (Viscera) of a typical teleost fish and calculation of RGL.

Practical 4 Dissection of alimentary canal of a prawn.

Practical 5 Identification of commercially important fin fishes of the order Clupeiformes, Cypriniformes, Perciformes, Siluriformes, Pleuronectiformes

Practical 6 Qualitative and quantitative analysis of gut contents. Index of preponderance.

Identification of fish bones and study of skeletal system in fishes, a minimum of one cartilaginous fish and one bony fish.

Practical 7 Identification of commercially important crustaceans

Practical 8 Identification of commercially important molluscs.

Practical 9 Determination of gonadosomatic index, fecundity and its relationship with length and weight.

Practical 10 Identification of eggs, larvae and post larvae of commercially important species of fishes, crustaceans and mollusks.

AQ020105 Instrumentation, Microtechniques, Biostatistics, Computer Application and Aquaculture Engineering.

Credit : 3

90 Hrs

Instrumentation

Practical 1 Chromatography (Paper/TLC) for the separation and identification of amino acids.

Practical 2 Polyacrylamide gel electrophoresis/paper electrophoresis for the separation of proteins.

Practical 3 Conductivity meter, salinometer, refractometer demonstration.

Microtechniques

Practical 5 Micrometry

Practical 6 Phase contrast microscope

Practical 7 Camera Lucida

Practical 8 Micro photography

Practical 9 Preparation of micro slides including whole mounts for evaluation during practical examination covering, fixation, dehydration, clearing, embedding of tissues and preparation of blocks, sectioning, cutting the section, staining and mounting.

Practical 10 Preparation of whole mounts.

Biostatistics and Computer Applications

Practical 11 Problems in tests of significance(χ^2 , t, z)

Practical 12 Basic concepts of sampling and estimation of marine fish landings. Practical 13 Basic concepts in design of experiments.

Practical 14 Study of computer components.

Practical 15 Microsoft Windows; MS word; MS Excel; MS PowerPoint;

Practical 16 Letter drafting and mail merging in computer.

Practical 17 Use of internet and communication system.

Aquaculture Engineering

Practical 18 Visit to aquafarms and drawing the layout of ponds, dikes and sluices.

Practical 19 Earthwork Calculations

Practical 20 Calculation of daily and monthly water requirements.

Practical 21 General design for the construction of raceways, cages and pens.

Practical 22 General design of shrimp hatcheries.

Practical 23 Working of different aquaculture equipment including hand tools.

Practical 24 Grain size analysis of the soil.

SEMESTER 2

AQ020201	Aquatic Biology and Ecology
AQ020202	Biochemistry and Nutrition of Finfish and Shellfish
AQ020203	Physiology, Endocrinology and Pathology of Finfish and Shellfish
AQ020204	Genetics and Biotechnology
AQ020205	Aquatic Biology, Physiology, Pathology, Genetics and Biotechnology
AQ020206	Biochemistry and Nutrition of Fin Fish and Shell Fish

AQ020201 Aquatic Biology and Ecology

Credit : 4

90 hrs

Module I: Physical and chemical characteristics of water 17hrs

Role of physical parameters like depth, temperature, salinity, light, turbidity, and wind in ponds. Circulation and mixing patterns in ponds. Physical characteristics in relation to open sea farming. Effect of monsoon on pond physical conditions. Seasonal and diurnal variation in pond. Chemical characteristics with reference to carbon dioxide system, dissolved oxygen distribution.

Module II Aquatic Microbiology 24hrs

Classification of Aquatic microorganisms. Sampling, isolation and purification of major groups of microbes from culture ecosystems. Identification and enumeration of major microbial groups, types of bacteria, fungi, actinomycetes in culture systems. Growth and reproduction in bacteria, microbial population in relation to physical, chemical and biological characteristics in ponds. Pathogenic bacteria in culture systems. Role of microbes in regeneration of nutrients and hydrogen sulphide production in ponds, special groups of bacteria relevant in culture systems.

Module III Aquatic Biology 17hrs

Aerobic and anaerobic degradation of organic matter in pond bottom. Sludge accumulation, water quality management. Primary and secondary productivity in ponds, benthic productivity. Macro and micro benthos including benthic algae in ponds. Ecological energetic of ponds. Effect of organic/inorganic fertilizers on pond productivity. Carrying capacity of culture systems. Lotic and lentic aquatic systems. Eutrophication.

Module IV Aquatic environment and Fisheries Oceanography 22hrs

Rivers of Kerala. Lakes, Characteristics of estuaries, classification, horizontal stratification, estuarine communities, adaptation. Major estuaries of India. Physico-chemical characteristics of marine environment, classification thermal stratification, marine communities. Objective, scope and relation to fishery science, major oceans, chemical composition of sea water. **Mud banks of Kerala. Monsoon Trawl bans.**

Module V Environment management 10 hrs

Introduction of exotics and escape of farmed fish, Pathogens in aquatic environment, Safety of aquaculture products, assessment of probiotic impact in aquaculture.

References

- Pushpangadhan.P and Nair, K.S.S. 1997. Biodiversity and Tropical forests. State Committee for Science and Environment (STEC), Trivandrum.
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- Keith Swerdup and Virginia Armbrust.2008. Introduction to the World's Oceans.
- Krishna Iyer. 1958. Water Resources of Kerala. P.W. D. Kerala.

AQ020202 : Biochemistry and Nutrition of fin fish and shell fish

Credit : 4

90 hrs

Biochemistry

52hrs

Module I Introduction

4hrs

Atoms, molecules and chemical bonds. Water: biological importance, pH and acid - base balance. Buffers - biological importance.

Module II Carbohydrates

10hrs

Monosaccharides & Reactions of Monosaccharides: Classification and nomenclature, Biological importance, Structural representations of sugars- Acetal and hemiacetal, ketal and hemiketal linkages, Glucose, fructose, galactose, mannose and ribose. Isomerism - structural isomerism and stereoisomerism, optical isomerism, epimerism and anomerism. Mutarotation and inversion of sugars. Oxidation, reduction, ester formation, osazone formation. Glycosidic bond. Disaccharides: Polysaccharides; Heteropolysaccharides.

Module III Proteins

10 hrs

Structure, classification and properties of amino acids. Amphoteric properties of amino acids, pK value and iso-electric point of amino acids. Peptide bond formation and peptides. Reactions (due to carboxyl group, amino group and side chains). Colour reactions of amino acids and proteins. Primary structure of protein (*e.g.* insulin). Classification and properties of proteins.

Conformation of proteins- chemical bonds involved, Secondary structure- Alpha helix, Collagen helix, Beta pleated sheet, Ramachandran angles and Ramachandran map.

Fibrous proteins- examples (Keratin, Collagen, Elastin, Resilin, Fibrous muscle proteins). Chaperons.

Tertiary structure- *e.g.* Myoglobin. Quaternary structure - *e.g.* Haemoglobin.

Module IV Lipids

10hrs

Classification of lipids: simple, compound and derived lipids. Biological importance of lipids. Fatty acids: classification, nomenclature.

Simple fats: Triacylglycerol (Triglycerides) - Physical properties. Reactions- Hydrolysis, Saponification, Rancidity. Acid number, Saponification number, Iodine number, Polenske number and Reichert- Meissl number of lipids. Waxes.

Compound lipids; Derived Lipids, Steroids: Biologically important steroids. Lipoproteins.

Prostaglandins- structure, types, synthesis and functions.

Module V Nucleic Acids

10hrs

Structure of nucleic acids and nucleotides: Structural organization of DNA (Watson -Crick model) Characteristic features of A, B, C and Z DNA. Structural organization of tRNA; Protein-nucleic acid interaction. DNA regulatory proteins, folding motifs, conformation flexibilities, denaturation, renaturation. Biological roles of nucleotides and nucleic acids.

Module VI Enzymes**8hrs**

Classification- (I.U.B.system), co-enzymes, iso-enzymes, ribozyme. Enzyme specificity. Mode of action of enzymes. Formation of enzyme substrate complex. Lowering of activation energy, Various theories, Active site.

Enzyme kinetics: Michaelis-Menten equation. Km value and its significance. Enzyme velocity and factors influencing enzyme velocity. Kinetics of enzyme inhibition, suicide inhibition and feedback inhibition.

Enzyme regulation: Allosteric regulations- Key enzymes, Covalent modification. Enzyme engineering.

Nutrition**38hrs****Module VII Nutritional physiology****14hrs**

Principles of nutrition. Adaptations to various types of feeding in finfish, crustaceans and molluscs. Mechanism of food capture, nutritional bioenergetics in finfish and shellfish. Nutritional requirements: Gross protein requirements, nitrogen balance; essential and non-essential amino acids and their quantitative requirements, protein quality and sources; lipids, their functions; essential fatty acids, phospholipids and sterol requirements; protein sparing action of lipids, negative aspects of lipids, carbohydrates; their sources and utilization. Water and fat soluble vitamins; their positive functions, minerals, recommended dietary allowances, deficiency and hyper dosage syndromes.

Module VIII Feeds**9hrs**

Feed ingredients Classification of feed stuff. Anti-nutritional factors in feed ingredients and their effect on finfish and shell fish. Additives in fin fish and shell fish feed. Feed formulation strategies and methods. Feed manufacture process; storage and quality control of feeds.

Module IX Larval Nutrition**9hrs**

Nutritional requirements of finfish, crustacean and molluscan larvae. Nutritive value of phytoplankton and their mass culture. Nutritive value of cladocerans and rotifers; their mass culture. Live and artificial feed, nutritive value of artemia; their mass culture and cyst production; micro diets for larvae. Recent advances in larval nutrition.

Module X Nutritional Disease & Feed Management**6hrs**

Nutritional diseases of cultured varieties of fishes, mollusks and crustaceans and control measures. Feeding strategies. Chemical methods of evaluation; biological methods of evaluation. PER, BV, NPU, NPR, FCR/FCE. Feed dispensing methods.

References

Das, D. 2000. Biochemistry. Academic Publishers, Calcutta

Garrett, R.H. and Grisham, C.M. 1995. Biochemistry. Saunders college of Publishing, New York.

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Winbrege, (1960)Rate of Metabolism and Food Requirements in Fishes. Fisheries Research Board of Canada.

ShimenoSadao,(1982) Studies on Carbohydrate Metabolism in Fish Amerind Publishing Company, New Delhi.

Cowey, C. B. et al. (Eds)(1985), Nutrition and Feeding in Fishes, Academic Press, London.

AQ020203: Physiology, Endocrinology and Pathology of finfish and shellfish

Credit : 4

90 hrs

Module 1 Physiology

32hrs

1.1 Introduction

6hrs

Swimming and buoyancy in fishes. Muscle physiology: body waves, energetics. Physiological aspects of dynamic and static lift. Mechanism of gas exchange in air bladder.

1.2 Food and feeding biology

10hrs

Components of balanced food, Ingestion of food and feeding mechanism. Digestive system and glands. Physiology of Digestion: Digestion of carbohydrates, lipid and proteins. Digestive enzymes and regulation of their secretions, Absorption and assimilation of nutrients, Role of hormones in the regulation of digestion, Factors affecting digestion and transport of nutrients.

1.3 Physiology of Respiration

10hrs

Physiology of respiration, mechanism of gas exchange. Branchial pump. Gill ventilation. Composition of fish blood and respiratory pigments. Aerial respiration. Ammonia quotient, Chloride cells and role in respiration, Respiratory metabolism, energy budget.

1.4 Sense organs in fishes

6hrs

Lateral line system, acoustic system, vision, electro-receptors, electric organs. Physical nature and chemical basis of bioluminescence, chromatophores, sense organs in shell fish.

Module 2 Endocrinology

24hrs

General morphology, structure and function of neurosecretory system of crustaceans. Reproductive systems and secondary sexual characters, process of gametogenesis, neuroendocrine control of reproduction, hermaphroditism, parasitic castration. Neurosecretory and endocrine systems in fishes and shell fishes- their organization, morphology. Structure of sinus gland complex. 'x' organ, 'y' organ and androgenic gland in crustaceans. Pituitary and endocrine organs of fish, pituitary hormones- Their storage, release and control of reproduction. Molting, growth and reproduction in crustaceans, induced maturation and spawning in finfish, crustaceans and mollusks, induced ovarian maturation and spawning through physical, chemical and biological method. New generation drugs, Hypophysation in finfish. Eyestalk ablation techniques-its principles and application in crustacean hatcheries.

Module 3 Pathology

34hrs

Introduction. Definition of terms, classification of disease, causes of diseases, aetiology, role of abiotic and biotic factors, Intrinsic factors, extrinsic factors, role of stress in disease process.

5hrs

Nonspecific immunity: agglutinin and precipitins, C-reactive protein, complement in fish, phagocytosis: acquired immunity; cell mediated

immunity-Role of thymus, T-cell; receptors. Mechanism of cell mediated immunity, cytokines, T-helper function, role of macrophages, recirculation and ecotaxis of T-cell; T-cell markers.

6hrs

Humoral immunity-origin of B-cell, differentiation of B-cells into plasma cells, T and B-cell interaction, antigenic stimulation; memory cells, structure of antibody; types of antibody; types of antibodies produced in fish. Immunization in fish and vaccination.

5hrs

Basic vascular and cellular alterations, cell metabolism and cell growth, necrosis, inflammation; defenses of the body against injury, healing and neoplasms.

4hrs

Microbial disease- Viral, Bacterial and Fungal Diseases and their control.

5hrs

Parasitology.Parasitic diseases and their control.

4hrs

Nutritional status, Nutritional diseases, toxic diseases, prophylactic and control measures, biological and chemical treatment of disease. Integrated disease management.

3hrs

Biosecurity requirements and establishment of biosecurity in shrimp aquaculture.

2hrs

References

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AQ020204: Genetics and Biotechnology

Credit : 4 **90hrs**

Genetics **44hrs**

Module 1 Introduction to Genetics **12hrs**

Fish cytogenetics, principles of genetics techniques in cytogenetics. Evolution of fish Karyotypes sex linked genes and sex. Limited phenotypes, quantitative phenotypes, pleiotropy, recent trends in genetic mutations. Types of mutations and mutagens. Gene expression and regulation.

Module 2 Endocrine and molecular control of genetics **10hrs**

Enzymology of steroid production in fishes; cell types involved in sex steroid production; receptor mediated action of sex steroids; hormonal control of vitellogenesis; hormonal control of sexual maturation; neuroendocrine control of gonadal development.

Module 3 Hybridization **6hrs**

Types of hybridization, naturally occurring and artificially produced cyprinid hybrids. Cultural traits of hybrids.

Module 4 Genetic improvement **6hrs**

Selective breeding, domestication and strain evaluation.

Module 5 Genetic manipulation **10hrs**

Sex-reversal and sex control, role of steroids in sex reversal, chromosomal manipulate, polyploidy. Androgenesis and Gynogenesis, cryopreservation of gametes, gametic manipulation.

Biotechnology in Aquaculture **46hrs**

Module 6 Genetic Engineering and Biotechnology in Aquaculture
8hrs

Concept and techniques in the production of SPF, SPR and hi- health stocks in crustacean aquaculture; transgenics and GMO's in aquaculture- reporter genes, AFP, disease resistance genes, growth hormone gene and their regulation; gene transfer mechanisms, gene cloning.

Module 7 Biotechnological Advancements **14hrs**

Marker assisted selection, markers and their role in aquaculture biotechnology, DNA markers- RAPD, AFLP, RFLP, phenotypic markers, protein markers; microsatellite markers in fisheries research; linkage mapping; chromosomal engineering; gamete transfer mechanisms in crustaceans; artificial insemination and in-vitro fertilization in fishes and shellfishes; cryopreservation and its applications; biotechnological

applications in pearl culture – genetic improvement, improvements in surgical techniques, biomineralization of nacre. General principles of cell and tissue culture, culture of primary cells secondary culture (subcultures) and cell lines, Fish cell culture development of cell lines and their applications.

Module 8 Biotechnology and Aquatic Animal health management 12hrs

Development and application of probiotics, prebiotics, bioremediators, immunostimulants, immunomodulators and vaccines – biofilm vaccines, DNA vaccines, recombinant vaccines; PCR in aquatic animal health management- designing primers for PCR, Hybridoma techniques; PAB's and MAB's in aquatic animal health management, Diagnostics and their application in aquaculture health management – immunodiagnostics, nucleic acid based diagnostics.

Module 9 Introduction to Bioinformatics 6hrs

History, definition, scope and applications; Fields related to bioinformatics. Data base: mining tools, submission of DNA sequences; Sequence alignment and database searching, similarity search, FASTA, BLAST. Information networks: internet; Gene bank sequence database, EBI-net; NCBI, Genome net.

Module 10 Marine Bioresources 6hrs

Bioactive compounds from the sea, marine natural products and metabolites. Microbes, micro and macro algae, diatoms, echinoderms, bryozoans, soft corals, sponges

References

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- Thomas, P.C. 1998. Shrimp Seed Production and Farming. Cosmo Publication.

AQ020205: Aquatic Biology, Physiology, Pathology, Genetics & Biotechnology

Credit : 2

Hours 90

Aquatic Biology

Estimation of oxygen
Estimation of salinity
Determination of primary production.
Identification of Plankton
Aquatic microbiology
Enumeration of bacteria, bacterial staining

Pathology

Study of various diseases of Finfish and shell fish. Bacterial, fungal, viral and parasitic. Identification of parasites. Treatment methods for fish diseases.

Physiology

Dissection of neuroendocrine organs of a candidate species.

Genetics & Biotechnology

Demonstration of Preparation of chromosome from a fish. Internet search: retrieving information from different data base like NCBI, protein information sources. Preparation of data base; Searching by similarity; Accessing and submission to gene banks; FASTA, BLAST.

AQ020206 : Biochemistry & Nutrition of Fin Fish and Shell Fish

Credit : 2

Hours 90

Biochemistry

Colourimetric estimation of glycogen and glucose.
Estimation of soluble protein in fishes and prawns
Estimation of fish lipids
Proximate composition of fin fish and shell fish.
Estimation of soluble proteins, Biurete and Lowry's method

Nutrition

Identification of common feed ingredients.

Demonstration of determination of lipid quality

Determination of moisture, lipid and ash in certain feed ingredients.

Determination of crude protein

Determination of gross energy of a few ingredients;

Feed formulation exercise

Preparation of a compound feed.

Preparation of purified diet for a prawn/fish (Demonstration).

SEMESTER 3

AQ020301	Culture of Finfishes, Molluscs, and Sea Cucumbers
AQ020302	Ornamental Fish Culture
AQ020303	Crustacean and Seaweed Culture
AQ020304	Aquaculture Economics, Management and Extension
AQ020305	Culture of Finfishes, Molluscs and Sea Cucumbers, Crustaceans and Seaweeds
AQ020306	Aquariculture, Aquaculture Economics

AQ020301: Culture of Fin Fishes, Molluscs and Sea Cucumbers

Credit 4

90 hrs

Module 1 Fin Fish Culture

38hrs

Overview of fin fish culture in the world – major species cultured, country-wise production. Fin fish culture in India- historical background and recent advances.

Marine, brackish water and fresh water species cultured, characteristics and criteria for selection of species for mariculture. Seed production, natural seed resources, their distribution, abundance, collection and transportation. Hatchery technology, brood stock management and breeding under controlled conditions. Induced breeding, egg incubation, larval rearing, and production of seed (nursery phase).

Different kinds of grow out culture systems, their advantages and disadvantages. Traditional and improved farming practices. Operational details of monoculture and polyculture. Fin fish culture in pens and cages, raceways, running water systems, sea ranching of fin fish, integrated farming.

Aquaponics; Recirculatory Aquaculture Systems ; Biofloc Technology in Aquaculture

Aquaculture Stewardship Council, Ecolabelling, Marine Stewardship council.

Module 2 Sea Cucumber Culture

14hrs

Present status of sea cucumber culture in the world. Natural resources and recent advances in breeding.

Seed production, culture and conservation of sea cucumbers in India. Processing of sea cucumbers.

Module 3 Molluscan Culture

38hrs

Overview of culture of Molluscs in the world. Major species of oysters, mussels, clams, cockles, scallops, gastropods in aquaculture.

Culture systems and principles. Modern development, their distribution and abundance, collection techniques.

Hatchery production of seed, brood stock management, induced maturation and spawning, larval rearing techniques, spat settlement and spat collection, water quality, disease control and transportation of seed.

Oyster farming-site selection, farm structure, farming techniques monitoring growth and condition index, control of predators and harvesting of edible oyster and pearl oysters.

Techniques of Mabe or image pearl production, pearl sac theory and pearl production.

Biofouling in oyster farms and control measures.
Mussel culture methods, harvest methods and sea ranching.
Abalone culture.

Depuration of bivalves, principles and methods.

References

- Pillai T.V.R.(1988),Aquaculture Principles And Practices . Fishing News Books.
- Naresh Kumar Agarwal (1996) Fish Reproduction, APH Publishing Corporation, New Delhi.
- Pillai T.V.R.(2005) Aquaculture Principles and Practices, Blackwell Publishing Ltd.
- Menon.N.G. and Pillai.P.P (eds)(2001). Prespectives in Mariculture. The Marine Biological Association of India Publication.
- James,P.S.B.R and Narasimham,K.A (1993). A Hand Book on Aqua Farming
- Santhanam R Sukumaran.N and Natarajan .A(1987). A Manual of Fresh Water Aquaculture. Oxward and IBH.
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AQ020302: Ornamental Fish Culture

Credit : 4

90hrs

Module I Construction of home/public aquarium

20

Hrs

- 1.1 Materials used - wooden and metal frames, frameless tanks.
- 1.2 Sealants and gums.
- 1.3 Aerators and filters.
- 1.4 Handnets and other equipments.
- 1.5 Water quality requirements.
- 1.6 Temperature control.
- 1.7 Design and construction of public freshwater and marine aquaria.

Module 2 Setting up of aquarium

5

Hrs

- 2.1 Gravel/pebbles and other materials
- 2.2 Aquarium plants
- 2.3 Ornamental objects and fishes
- 2.4 Selection of species.

Module 3 Freshwater ornamental fishes

25hrs

Fresh water aquarium fish culture.

Breeding of Gold fish, Koi, Angel fish, barb, Fighter, Gourami, Livebearers, clown fish, Damsels, Butterfly fish, Seahorse.

Bulk production of ornamental fishes

Nutrition and feeds of aquarium fishes.

Establishment of a commercial ornamental fish culture unit.

Common diseases of aquarium fishes and management.

Module 4 Marine ornamental fishes

10 Hrs

- 6.1 Habitat and collection from nature.
- 6.2 Methods of collection.
- 6.3 Transportation of live fish.
- 6.4 Use of sedatives.
- 6.5 Other ornamental organisms - anemones, lobsters, shrimps, octopus, starfish etc.

Module 5 Nutritional requirements of aquarium fishes

10 Hrs

- 3.1 Different kinds of feeds.
- 3.2 Culture of food organisms.
- 3.3 Preparation of dry feeds.
- 3.4 Feeding methods.

Module 6 Aquarium Management

10 Hrs

- 4.1 Cleaning the aquarium
- 4.2 Maintenance of water quality.
- 4.3 Control of snail and algal growth.
- 4.4 Common diseases of aquarium fishes; diagnosis and treatment.

Module 7 Freshwater Plants

10Hrs

- 7.1 Taxonomy and morphology.
- 7.2 Multiplication of aquarium plants. - Different methods.

7.3 Provision of nutrients and optimum environmental conditions for their growth.

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- Panayotou, T. 1982. Management concept for small scale fisheries economic and social aspects.
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- T.V.Anna Mercy *et al.*, 2007. Ornamental Fishes of the Western Ghats of India. NBFGR publication, Lucknow.
- T.V.Anna Mercy 2000. An Aquairum at your Home (Malayalam).
- Dey V.K.A. 1997. A hand book on Aquafarming ornamental fishes. MPEDA, Cochin.
- Herber J Axelrod, Leonard P. Schultz. Handbook of Tropical Aquarium fishes, TFH, USA

AQ020303 Crustacean culture and Seaweed Culture

Credit 4

90 Hours

Module 1 Crustacean culture

45hrs

Overview of crustacean culture in the world.

Major species cultured, technologies and problems of crustacean culture in India.

Historical background and recent advances; species cultured, potential species and characteristics of their suitability for aquaculture.

Shrimp/prawn seed production-natural seed resources, their distribution and abundance, collection and transportation, hatchery production of seed, brood stock management and breeding under controlled conditions, larval rearing techniques and mass production of seed.

Recent advances in seed production technology for crabs and lobsters, nursery phase.

Different kinds of grow out culture systems, traditional prawn culture practices and modern farming techniques; extensive, semi-intensive, intensive and super intensive shrimp farming, cages, pens and recirculating systems. Sea ranching of prawns. Specific Pathogen Free shrimp, culture of *Fenneropenaeus vannamei*.

Culture practices and potentials for crabs and lobsters.

Module IV Sea weed culture

45hrs

Taxonomy of economic seaweeds, seaweed morphology, reproduction and life cycle; growth of seaweeds and factors affecting it.

Seaweed culture in India- site selection, determining growth pattern and environmental monitoring; causes of mortality; small scale and commercial scale culture operations.

Utilization of seaweeds; post – harvest technology of cleaning, washing and storage; chemical composition of seaweed; processing and extraction of algin, alginic acid and alginates, processing and extraction of agar, mannitol and carrageenan.

References

Lackey, RLTA Nielson 1980. Fisheries management Balckwell Sci. Pub. Oxford.

Panayotou, T. 1982. Management concept for small scale fisheries economic and social aspects.

Fish.Technical paper No. 228 RME.

Peter W.Scot 1966. Complete Aquarium. Dorling Kindestey, London.

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Herber J Axelrod, Leonard P. Schultz. Handbook of Tropical Aquarium fishes, TFH, USA

AQ020304: Aquaculture Economics, Extension and Management

Credit 3

90hrs

Module I Aquaculture Economics

30hrs

Application of production economics in aquaculture. Law of diminishing returns; definition and application, marginal analysis-total products, average product, marginal product curves and formulae. Producer decision criteria, profit maximisation.

Cost fractions-determining maximum profit level of production, opportunity costs, fixed costs, variable costs, full costs, revenue function, total average marginal-production function in aquaculture. Investment financial planning and market analysis; investment-definition, autonomous and induced investment; choice and formulation of aquaculture investment projects, factors influencing investments and decisions, enterprise budget and partial for aquaculture enterprises. Income cash flow and statements. Ration analysis; supply and demand functions for aquaculture products. Consumer surveys for aquaculture products; market analysis and questionnaire design.

Module 2 Aquaculture Extension in Different Countries

10 hrs

Understanding fisheries and aquaculture extension and development systems in South Asian countries and South East Asian countries - Thailand, Indonesia, Malaysia, Vietnam, Myanmar, China; Extension system in Japan; Linkages between Research and Development system in these countries; Status of fishing communities in these countries.

Module 3 International Fisheries Development organizations 20 hrs

Analysing mission, approaches and achievements of fisheries development organizations: World Fish Centre, International Collective in Support of Fish Workers (ICSW), International Fishmeal and Oil Manufacturers Association (IFOMA), Asian Fisheries Society (AFS), National Marine Fisheries Service of USA, Fisheries Division of FAO, World Fish Forum, Asia-Pacific Fisheries Commission (APFIC), Committee for Inland Fisheries and Aquaculture of Africa (CIFAA) Commission for Inland Fisheries of Latin America (COPESCAL), European Inland Fisheries Advisory Commission (EIFAC), General Fisheries Commission for the Mediterranean (GFCM), Indian Ocean Tuna Commission (IOTC), Regional Commission for Fisheries (RECOFI), Western Central Atlantic Fishery Commission (WECAFC)

Module 4 National Fisheries Development organizations

10 hrs

Institutes under ICAR, CSIR, NABARD, Ministry of Agriculture and Ministry of Commerce, Aquaculture Authority of India, NRSA, INCOIS etc. State organizations like Matsyafed, FFDA, BFFDA, ADAK, FIRMA and State Fisheries Department

Module 5 Aquaculture Management

20hrs

Management of hatcheries and farms. Availability of manpower and skilled labour in India.

Personal requirements and management. Material management. Financial management.

Poaching and natural calamities. Water quality control for hatcheries and farms.

Criteria and nature of data input needed for preparation of feasibility reports on hatcheries and on fish feed mill.

Environmental Impact Assessment and Management in Aquaculture

References

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Technological Change and the Development of Marine Fishing Industry in India 1994 Daya Publishing House, New Delhi.

The Marine Products Exports Development Authority Hand Book on Aqua Farming Shrimp ,Lobsters , Mud crab 1993.

MPEDA. Hand Book on Aqua Farming Seaweed, Seurchin ,Seacucumber 1993.

MPEDA. Hand Book on Aqua Farming Seafishes.

MPEDA . Hand Book on Aqua Farming Indian Lobsters .

Srivastava .U.K.,Dholakia ,B.H. and Vathsala ,S. (1987)Brackish water Aquaculture Development in India. New Delhi Concept Publishing Company.

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Devadasan K., Mukundan M.K., Antony P.D. and Jose Joseph (1974) Nutrients and Bioactive Substances in Aquatic Organism. SOFT(I).

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T.S.Gopalakrishna Iyer, Kandoran M.K., Mary Thomas and Mathew P.T. (2000) Quality Assurance in Sea Food processing CIFT

AQ020305 : Culture of Fin Fishes, Molluscs, Sea Cucumber, Crustaceans and Sea Weeds.

Credit 2

Hrs 90

Module I

Identification of cultivable fin fish, Collection and identification of fish seed from nature, observe techniques of induced and larval rearing, field observation on culture operation of fin fish in ponds, Identification of cultivable species of sea cucumbers and their larvae. Visit to a sea cucumber farm. Observation on sea cucumber breeding and larval rearing techniques.

Module II

Setting up of spat collectors, identification of nanoplanktors, estimation of growth and condition index in oysters. Pearl oyster surgery for nucleus implantation, depuration of oysters, field visit to a mussel or oyster farm and observe culture practices, collection and identification of foulers and predators in an oyster farm.

Module III

Observation of induced breeding, spawning and egg hatching and rearing of nauplius to post larvae, observation on prawn filtration practice , participation in modern prawn culture operation and assessing growth and production rates.

Module IV

Identification of economic sea weeds and their reproductive bodies. Field study of distribution and zonation of sea weeds, collection of sea weed material. Visit to small scale sea weed farm.

AQ020306 : Aquariculture, Aquaculture Economics

Credit 2

Module I Aquariculture

Identification of economically important aquarium fishes

Identification of aquarium plants

Identification of ornamental invertebrates

Construction and maintenance of aquarium

Setting up of aquarium tanks.

Breeding and rearing of commercially important ornamental fishes in hatchery. Live feed culture.

Module II Aquaculture Economics

Preparation of schedule for collecting data on: Market survey.

Field level data collection

Sampling examples of PCM/IRT/NPD.

Analysis and interpretation of data.

SEMESTER IV

AQ020401	Fish Processing Technology	5	90	4
AQ020402	Post Harvest Technology, Microbiology and Quality Control	5	90	4

	Groups	Code	Course	Hours/Week	Total Hours	Credit
ELECTIVES (Credit 3*3=9)	GROUP A	AQ820401	Aquaculture and Ecosystem Management	5	72	3
		AQ820402	Aquaculture Engineering	5	72	3
		AQ820403	Applied Genetics in Aquaculture	5	72	3
	GROUP B	AQ830401	Fish Nutrition and Feed Technology	5	72	3
		AQ830402	Fishing Technology	5	72	3
		AQ830403	Microbiology and Quality Assurance	5	72	3

AQ020401 : Fish Processing Technology

Credit 4

90hrs

Module I - Freezing Technology of fish

30 Hrs

Refrigeration, refrigeration load, refrigerants, cold storage of fish. Crystallization, freezing curves for pure water and water in fish, physical and chemical changes on freezing, effect of freezing on location and size of ice crystals.

Technological aspects of freezing: Slow freezing and quick freezing, Air blast freezing, tunnel freezing, fluidized bed freezing, spiral freezing, immersion freezing, contact plate freezing, cryogenic freezing and high pressure freezing.

Freezing on board fishing vessels, IQF freezers, selection of a freezing method, cold store and cold storage, chemical, physical and sensory changes during freezing and cold storage. Chemical treatment of fish prior to freezing, TTT and PPP factors, packing of frozen products, processing and freezing of frozen sea food products for export from India.

Module II Canning of Fish

20Hrs

Principles of canning: Heat transfer in canned fish, thermal destruction of bacteria, D and D0value, F0 value, Z value, determination of process time, cook value, Aseptic packing, containers for canning, unit operations, equipment used for canning, canning of sardine, tuna, and prawns. Retort pouch packaging. Waste management in canning industry, defects of canned product

Module III Curing and Drying of Fish

10Hrs

Water content and water activity, water activity and microbial spoilage, drying of fish, constant rate and falling rate drying period, salting and salting methods, drying methods for fish, packaging and storage. Quality problems and solutions. Maillard reaction, lipid oxidation, microbial, fungal and insect's infestation. Packaging of dried products.

Module IV Fish By- Products

10Hrs

Mince and surimi, freezing and storage. Fish protein concentrate, fish meal and oil, fish liver oil, fish hydrolysate, fish silage, Caviar, gelatin, glue, pearl essence, dehydrated jelly fish, squalene, fish maws and isinglass, Ambergris, Beche de mer.

Chitin, chitosan, and glucosamine hydrochloride, Utilization of prawn waste and fish processing waste.

Processing and extraction of algin, alginic acid, alginates, agar, manitol, and carragernan.

Module V Value Added Fish Products

10Hrs

Coated fish products, batter, bread crumbs, and general procedure for preparation of battered and breaded products, objectives, packaging and storage, equipment for making coated products, quality of coated products.

Types of coated products: coated fish fillets, fish fingers, coated shrimp products, moulded products, fish cutlets, fish balls, fish burger (patties). Seafood analogues and imitation products.

Module VI Other Methods of Preservation

10Hrs

Fermented fish products, fish sauce, fish paste, fish sausage.

Radiation preservation, principles of radiation, ionizing radiations and their sources, units, applications of radiation, Shelf life extension, radappertization, radurisation, radicidation and radiation doses for irradiation of different fish products. Safety of irradiated fish. Hurdle technology.

Smoking: objectives, smoke production, smoke components, quality, safety and nutritive value, processing and equipment.

Freeze drying of fish: Accelerated freeze drying. Packaging of freeze dried products.

Modified Atmospheric Packaging.

References

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AQ020402 : Fish Processing Technology, Microbiology & Quality Assurance

Credit : 3

Hours 90

Fish Processing Technology

Curing of fish (salting and drying).

Determination of moisture and salt content.

Production of frozen fishery products- dressed fish, fillets, minced fish, surumi,

Production of prawn products- whole prawns, HL, PUD, PD, Butterfly prawns.

Packaging of frozen prawns. Block frozen products, IQF products.

Freezing of marine products. Plate freezing, IQF freezing.

Production of canned products.

Value addition – Fish finger, Fish cutlet, fish balls and fish burger.

Fishery by-products - Fish meal, fish oil, chitin, chitosan, shark fin rays. Fish pickle, smoked fish products.

Microbiology and Quality Assurance

Methods for analysis of bacterial quality and chemical parameters.

Laboratory techniques to detect and identify pathogens in process water and processed fishery products - *E.coli*, *Streptococcus*, *Staphylococcus aureus*, *Salmonella*, *Vibrio sp.*, *Listeria monocytogenes*.

Water quality analysis. Colour, turbidity, odour, pH, dissolved solids, alkalinity, hardness, sulphate, chloride, metals like iron.

Evaluation of sanitary condition of fish processing plants.

Quality evaluation of dried fish, canned fish and frozen products.

Visit to Processing Plant and Effluent Treatment Plant.

AQ820401 Aquaculture and Ecosystem Management
Credit 3

Hours 72

Module 1 Introduction

12 Hrs

Aquaculture and ecosystem relationship: Ecosystems and productivity, biotic interaction within ecosystems and ecological homeostasis.

Module 2 Climate

10 Hrs

Weather elements of concern in aquaculture, Green house gases, global warming and their impact.

Module 3 Impact of environment on aquaculture

10 Hrs

Raw water source, physical and chemical characteristics, contaminants and pollutants (algae, pathogens, heavy metals, pesticides) and their effect on productivity.

Module 4 Impact of aquaculture on environment

10 Hrs

Waste water discharge, its quality and quantity; impacts of effluents on ecosystems, chemical degradation of soil and water.

Module 5 Environment monitoring

15 Hrs

Problems and preventive measures of antibiotic and drug residues, salination of soil and water, Eutrophication, Environment impact assessment and environmental audit, Biosensors in aquatic environment, toxicity assessment, Ecolabelling and traceability.

Module 6 Environment management

15 Hrs

Introduction of exotics and escape of farmed fish, Pathogens in aquatic environment, Safety of aquaculture products, Role of microbes in aquatic environment; assessment of probiotic impact in aquaculture.

References

Holmer M, Black K, Duarte CM, Marba N & Karakassis I. (Eds.). 2008. *Aquaculture in the Ecosystem*. Daya Publ. House.

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Midlen & Redding TA. 1998. *Environmental Management for Aquaculture*. Chapman & Hall.

Nikolsky GV. 2008. *The Ecology of Fishes*. Academic Press.

Upadhyay AR. 2004. *Aquatic Plants for the Wastewater Treatment*. Daya Publ. House.

AQ820402 Aquaculture Engineering

Credit : 4

72 Hrs

Module I Selection of Site

8 Hrs

Selection of Site for aquaculture – General considerations, Freshwater, brackish water and mariculture systems., water quality, soil characteristics, biological aspects, topography, climatic factors, socio-political factors, and infrastructure facilities.

Module II Surveying and Estimation of Area

8 Hrs

Surveying – General study of chain survey, plain table survey, contouring and leveling. General principles of Theodolite survey Calculation of area of land by trapezoidal and Simpsons rule. Importance of engineering survey.

Module III Design of Farms

8 Hrs

Design and construction of aquafarms – type of ponds, shape, size and their orientation from meteorological point. Design of various components of aquafarms – peripheral dykes, secondary dykes, feeder canals, drainage canals, water intake and outlet systems – seawater intake systems, sluice gate, monks and spillways. Calculation of earthwork for constructing ponds and requirement of water during water exchange.

Modul IV Soil

7 Hrs

Types of soil, different properties of soil, soil sampling methods, structure and textural classification, grain size distribution, bearing strength, prevention of erosion. Methods of soil compaction and seepage reduction.

Module V Design of Modern Aquaculture Systems

6 Hrs

Design and construction of enclosures for mariculture operations, pens, cages, raceways, flow through systems and re-circulatory systems. Selection of materials for mariculture facilities. Sea farming, site selection and structures. Cage farming

Module VI Aquaculture Equipment

8 Hrs

Equipment used for water treatment, filters, ultraviolet light, ozone, heating and cooling and other processes of disinfection. Role of aeration in culture ponds.- paddlewheel aerators, cascade aerators, aspirators, compressors and blowers. Different types of pumps in aquaculture – vertical, centrifugal, jet and propeller pumps

Module VII Aquaculture Automobiles

5 Hrs

Weed cutters and harvesters, bulldozers, excavators, rollers, and refrigerated vans and mechanized fish harvesters.

Module VIII Hatcheries

8 Hrs

Design of shrimp hatcheries – selection of site, source of water, water treatment. Disinfection, heating and cooling equipments in hatcheries. Design of hatchery building, water supply and drainage systems, inlets and outlets, aeration grid, FRP tanks, cement tanks and waste water treatment.

Module IX Aquaculture projects**8 Hrs**

Preparation of aquaculture projects, estimation of efficiency, management of pond and hatchery machineries. New technologies in aquaculture engineering. Tank basins and other closed production unit.

Module X Feeding Systems**6 Hrs**

Different types of feeding equipment – automatic and demand feeders, feed control systems, dynamic feeding systems. Adjustment of pH, removal of particles, Ammonia removal.

References

Thomas B Lawson. Fundamentals of Aquaculture Engineering
Wheaton, F.W. Aquaculture Engineering 1942 Wiler Interscience publication
Santhosh Kumar Garg. Water supply Engineering
Bose *et. al.* Coastal Aquaculture Engineering
Odd-IvarLekang . Aquaculture Engineering
Pillay, TVR and Kutty. M N. Aquaculture: Principles and Practices
Michael B.T and Thomas L. Aquaculture water reuse systems 8. Syda Rao *et al.* Cage farming

AQ820403 Applied Genetics in Aquaculture

Credit 3

Hours 72

Module 1 Introduction

6 Hrs

Origin and advancement in genetics; physical basis of heredity; genetic correlation, domestication and local adaptation.

Module 2 Chromosome manipulation

9 Hrs

Ploidy induction methods - triploidy and tetraploidy, advantages and disadvantages of polyploids, androgenesis and gynogenesis.

Module 3 Sex determination

7 Hrs

Sex differentiation and sex reversal in fishes, sex control and its role in aquaculture.

Module 4 Selection

7 Hrs

Scope, application and methods of selection, marker assisted selection-biochemical and molecular markers. Molecular tools for stock differentiation for selection.

Module 5 Hybridization

Heterosis, hybrid vigour, introgression.

6 Hrs

Module 6 Inbreeding

7 Hrs

Methods of estimation, inbreeding depression and consequences, measures to reduce inbreeding in hatcheries.

Module 7 Conservation genetics

7 Hrs

Genetic resources of India and conservation, endangered species, cryopreservation of fish gametes.

Module 8 Cytogenetics

7 Hrs

Importance and karyotyping.

Module 9 Fish breeding

8 Hrs

History and advancement of fish breeding, mode of reproduction, basic breeding methods and breeding programmes and goals.

Module 10 Genetic management strategies

8 Hrs

Environmental impacts, Lessons from the green revolution, Bioprospecting, GMOs and their detection.

References

- Carvalho GR & Pitcher TJ. (Eds.). 1995. *Molecular Genetics in Fisheries*. Chapman & Hall.
- Falconer DS & Mackay. 1996. *Introduction to Quantitative Genetics*. 4th Ed. Longman.
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Thorpe JE, Gall GAE, Lannan JE & Nash CE. (Eds.). 1995. *Conservation of Fish and Shellfish Resources, Managing Diversity*.

AQ830401 Fish Nutrition and Feed Technology
Credit 3

Hours 72

Module 1 Protein nutrition of fish and shellfish

10 Hours

Introduction, function and metabolism of protein, amino acids and their classification, specific function, protein deficiency symptoms, evaluation criteria of dietary protein.

Module 2 Lipid nutrition

8 Hours

Introduction, function, metabolism, Fatty acids and their classification, specific functions of essential fatty acids, deficiency symptoms, evaluation of lipid quality.

Module 3 Carbohydrate nutrition:

8 Hours

Introduction, function, metabolism, improvement of carbohydrate utilization by fish.

Module 4 Vitamin and mineral nutrition

8 Hours

Introduction, classification, source, functions, deficiency symptoms.

Module 5 Energy nutrition

10 Hours

Definition, energetics, expression of energy value of feed (gross energy, digestible energy, metabolizable energy, net energy), partitioning of energy, protein energy ratio.

Module 6 Larval nutrition

10 Hours

Importance of live feed and artificial feed, Different types of feed available for larvae, constraints and scope; Larval gut morphology and mode of nutrition.

Module 7 Brood stock nutrition

Nutrients required for reproduction, egg and sperm quality.

8 Hours

Module 8 Feed additives

Classification, function, and specific use for economic and quality fish and shellfish production.

10 Hours

References

- ADCP (Aquaculture Development and Co-ordination Programme). 1980. *Fish Feed Technology*. ADCP/REP/80/11. FAO.
- Cyrino EP & Bureau D & Kapoor BG. 2008. *Feeding and Digestive Functions in Fishes*. Science Publ.
- D' Abramo LR, Conklin DE & Akiyama DM. 1977. *Crustacean Nutrition: Advances in Aquaculture*. Vol. VI. World Aquaculture Society, Baton Rouge.
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- Hertrampf JW & Pascual FP. 2000. *Handbook on Ingredients for Aquaculture Feeds*. Kluwer.
- Houlihan D, Boujard T & Jobling M. 2001. *Food Intake in Fish*. Blackwell.
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AQ830402 Fishing Technology

Credit 3

72hrs

Module 1 Fishing Crafts

20hrs

- 1.1 FAO Classification; Types of Marine and Inland Fishing Vessels. 4hours
- 1.2 Materials and methods of construction and deck layout of fishing vessels
7hours
- 1.3 Marine Diesel Engines and determinants in selection. 5hours
- 1.4 Biofouling, Corrosion and Maintenance. 4hours

Module 2 Fishing Gears

22hrs

- 2.1 Classification of fishing gears. 2Hours
- 2.3 Principles and methods of capture for different fishing gears. 4Hours
- 2.4 Natural and Synthetic fishing gear materials and principles of construction
4Hours
- 2.5 Design and construction of active and passive commercial fishing systems
7Hours
- 2.6 Fishing accessories – Fishing gear accessories; Hooks and Baits; Fishing
Rods; Fish finding devices. 5Hours

Module 3 Navigation, Seamanship and Rope work

Navigation

10 Hours

- 3.1 Introduction; Navigation charts and Chart work
- 3.2 Navigation Communication : Distress-Urgency-Safety Calls, Transmission
Procedure, Control of Distress Traffic, Distress Signals, International Code of
Signals (Signal flags)
- 3.3 Navigation Essentials : Weather forecasts from daily observations; Sky and
Weather Notation – Beaufort’s Weather Notation, Beaufort’s Wind Scale; Lights
and Shapes;
- 3.4 Modern Techniques : Pilotage, Celestial Navigation, Radio Navigation,
Radar Navigation, Satellite Navigation.

Seamanship and Ropework

8Hours

- 3.5 Ropework
- 3.6 Ship handling and anchoring procedures
- 3.7 First Aid and Safety; Firefighting procedures
- 3.8 Response to Emergency

Module 4 Capture Fisheries Management

12 Hours

- 4.1 Principles of capture fisheries resource conservation and management
4Hours
- 4.2 Resource Conservation Devices – BRD; TED; FAD; 2Hours
- 4.3 Remote Sensing and its applications 2Hours
- 4.4 GIS in Fisheries 2Hours

References

- M.Shahul Hameed and Boopendranath. M. R. 2000. Modern fishing gear technology. Daya Publishing, New Delhi.
- K.P.Biswas. 1990. A text book of fish, fisheries and technology. Narendra Publishing house, N.Delhi.
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- John Garner 1957. How to make and set nets. Fishing news books Ltd. England.
- Brandt. A. V. 1984. Fishing Catching Methods of the World. Fishing news books printed, London 418pages.
- F.A.O. 1947. Otter board design and performance. FAO. Fishing manuals.

AQ830403 : Microbiology and Quality Assurance

Credit : 3

72hrs

Module 1 General Microbiology

12 hrs

Fundamental principles of bacteriology,-Morphology, size, reproduction and growth.

Bacterial spores, staining of bacteria, various staining methods Effect of environment on growth of bacteria-classification of bacteria.

Intrinsic and extrinsic parameters affecting microbial growth in food.

Module 2 Fish Microbiology

20hrs

Native bacterial flora of fish; Microbes causing fish spoilage; Spoilage microorganisms of fishery products; Psychrophilic and mesophilic microbes in processed fishery products. Effect of low temperature, high temperature, salting, drying and hurdle technology on bacteria. Fecal indicator organisms and bacterial pathogens viz. Pathogenic *E.coli*, *S. aureus*, Salmonella, Shigella, Pathogenic Vibrios, *L. monocytogenus*, *Clostridium* etc. in fish and fishery products. Microbial analysis of water. Fish contact surfaces, fish and fishery products including isolation and identification of various bacterial pathogens. Biological hazards in seafood.

Module 3 Quality Control

20hrs

General aspects of seafood quality and quality problems

Fish spoilage and quality assessment. Bacteriology of spoilage of fish and shellfishes Fecal indicator bacteria in fish and bacteria of public health significance.

Seafood toxins.

Quality of water and ice for seafood processing

Trace metals in fish and shellfish

Good manufacturing practices in seafood processing.

Module 4 Quality Assurance in Seafood Trade

20hrs

Safety foods. End product quality and process control.

Hazards analysis and critical control points in sea food industry.

National and International standards for fish and fish products

Quality management and ISO 9000 series of standards. Waste management

Prerequisite programmes, SOP, SSOP, GMP, BUREAU OF INDIAN STANDARDS (BIS), Product traceability and recall. Sanitizers, Detergents, Cleaning agents and Disinfectants.

References

Robinson, R.K 1985. Microbiology of frozen foods. Elsevier Applied Science publishers

Devadasan K, Mukundan, M.K, Antony P.D and Jose Joseph. 1997. Nutrients and bioactive substances in aquatic organisms. SOFT(I)

Bonnell, A. D. 1994. Quality assurance in sea food processing. Chapman and Hall, USA.

T.S. Gopalakrishna Iyer , Candoran M.K, Mary Thomas and Mathew P.T 2000. Quality assurance in sea food processing, CIFT

M.P.Doyle, L.K.Beuchat and T.J. Montyille (Eds.) 1997. Food Microbiology, Fundamentals and Frontiers. ASM press, Washington DC.

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T.S.G. Iyer, M. K. Kandoran, Mary Thomas and P.T. Mathew.(Eds.) 2002 Quality assurance in sea food processing. CIFT, Cochin (SOFTI).

CIFT Training Manual 2011. Sea food quality assurance. CIFT, Cochin.

Surendran P.K., Thampuran N, Nambiar V.N. and Lalitha K.V 2003. Laboratory manual on microbiological examination of sea food. CIFT, Cochin

James, J.M., Loessner, Martin J, and Golden D.A., (Eds.)2005. Modern food microbiology 7th edition. Springer , New York.