M.F.Sc. (Fish Nutrition and Feed Technology)

Course Structure – At a Glance

A	**MAJOR COURSES**			**20 Credits**
	A1	**CORE COURSES**		12 Credits
1	FNT 501	Fish Nutrition	2+1	
2	FNT 502	Digestion and Growth	2+1	
3	FNT 503	Feed Technology	2+1	
4	FNT 504	Nutritional Energetics	2+1	
	A2	**OPTIONAL COURSES**		8 Credits
1	FNT 505	Nutritional Requirement and Feeding Management	2+1	
2	FNT 506	Feed Ingredients and Additives	1+1	
3	FNT 507	Nutrition and Feeding of Crustaceans	2+1	
4	FNT 508	Protein Nutrition	1+1	
5	FNT 509	Lipid Nutrition	1+1	
6	FNT 510	Carbohydrate Nutrition	1+1	
7	FNT 511	Vitamin and Mineral Nutrition	1+1	
8	FNT 512	Nutraceuticals and Nutrigenomics	1+1	
B	**MINOR COURSES** (Courses outside major discipline / from other relevant disciplines)			**9 Credits**
C	**SUPPORTING COURSES** (Compulsory)			**5 Credits**
1	FST 501	Research Methodology	1+1	
2	FST 502	Statistical Methods	1+2	
		Total Course Work Credits		**34 Credits**
D	**MASTERS' SEMINAR**			**1 Credits**
1	FNT 591	Masters' Seminar	0+1	
E	**FIELD TRAINING**			**2 credits**
1	FNT 551	Field Training	0+2	
F	**MASTERS' RESEARCH**			**20 Credits**
	FNT 599	Masters' Research (Semester III)	0+10	
	FNT 599	Masters' Research (Semester IV)	0+10	
	Total M.F.Sc Program Credit Hours			**57 Credits**

FISH NUTRITION AND FEED TECHNOLOGY

Course Contents

FNT 501	**FISH NUTRITION**	**2+1**
Objective	The basic principles of fish nutrition and the function of individual nutrients.	
Theory		
Unit I	Protein nutrition: Introduction, function of protein, amino acids and their classification, specific function, protein deficiency symptoms, evaluation criteria of dietary protein (PER, NPU, BV EAAI, Chemical score).	
Unit II	Lipid nutrition: Introduction, function, Fatty acids and their classification, specific functions of essential fatty acids, deficiency symptoms, evaluation of lipid quality. Phospholipids, Steroids.	
Unit III	Carbohydrate nutrition: Introduction, function, improvement of carbohydrate utilization by fish.	
Unit IV	Vitamin and mineral nutrition: Introduction, classification, source, functions, deficiency symptoms.	
Unit V	Energy Nutrition: definition, concept and different forms of energy	
Unit VI	Importance of live feed in larval nutrition, larval gut morphology and mode of nutrition and formulated feed, Different types of feed available for larvae, constraints and scope; critical nutrients required for broodstock.	
Practical	Identification of Commonly used feed ingredients; Proximate analysis: Moisture, Crude Protein, Crude Lipid, Ash, Acid insoluble ash, Nitrogen free extract of feed and fish tissue, Fatty acid analysis, qualitative analysis of amino acids, Calcium, Phosphorus Vitamin C and content of feed.	
Suggested Readings	1. ADCP (Aquaculture Development and Co-ordination Programme). 1980. Fish Feed Technology, ADCP/REP/80/11.F.A.O., Rome. 2. De Silva, S. S. and Anderson, T. A. 1995. Fish Nutrition in Aquaculture, Chapman and Hall Aquaculture Series, London. 3. Guillame, J., Kaushik, S., Berqot, P. and Metallier, R. 2001. Nutrition and Feeding of Fish and Crustaceans, Springer Praxis Publishing, Chichester, U.K. 4. Halver J. E. 1989. Fish Nutrition, Academic Press, San Diego, Califonia. 5. Halver, J. E. and Hardy, R. W. 2002. Fish Nutrition. Academic Press, London. 6. Halver, J. E. and Tiews, K. T. 1979. Finfish Nutrition and Fishfeed Technology Vol. I and II Heenemann, Berlin.	

	7. - Hepher, B. 1988. Nutrition of Pond Fishes. Cambridge University Press, Cambridge. 8. - Lovell, R. T. 1998. Nutrition and Feeding of Fishes. Kluwer Academic Publishers.

FNT 502	**DIGESTION AND GROWTH**	**2+1**
Objective	Digestive system of fish and their function. Basic mechanism of feed intake and digestion process. Undertaking the concepts of growth	
Theory		
Unit I	Digestive system of fish: Digestive organs and their role; anatomy and histology of alimentary canal; Feed ingestion, feeding mechanism, gastro-intestinal motility.	
Unit II	Digestive system shellfish: Digestive organs and their role; anatomy and histology of alimentary canal; Feed ingestion, feeding mechanism, gastro-intestinal motility.	
Unit III	Digestion of proteins, lipids and carbohydrates; digestibility; methods: direct and indirect methods with advantage and disadvantages, factors affecting digestibility. gut micro flora and their role	
Unit IV	Metabolism: Absorption and transportation: absorption of energy nutrients, minerals and vitamins. Transport: types-active, passive and facilitated. Transport of nutrients in the body.	
Unit V	Regulation of digestion: hormonal regulation of digestion Appetite and satiation	
Unit VI	Growth: concept of growth, growth curve, correlation of growth with body weight and length, role of biotic and abiotic factors affecting growth.	
Practical	Dissection and examination of digestive organs; Histological preparation of digestive organs; Assays of enzyme activity of amalyse, proteases and lipases; *In vitro* digestibility studies.	
Suggested Readings	1. D' Abramo, L. R., Conklin, D. E. and Akiyama. D. M. 1977. Crustacean Nutrition: Advances in Aquaculture Vol. 6. World Aquaculture Society, Baton Roughe, L. A. 2. De Silva, S. S. and Anderson, T. A. 1995. Fish Nutrition in Aquaculture. Chapman and Hall Aquaculture Series, London. 3. Guillame, J., Kaushik, S., Berqot, P. and Metallier, R. 2001. Nutrition and Feeding of Fish and Crustaceans. Springer Praxis Publishing, Chichester, U. K. 4. Halver, J. E. and Hardy, R. W. 2002. Fish Nutrition. Academic Press, London. 5. Lovell, R. T. 1998. Nutrition and Feeding of Fishes. Kluwer Academic Publishers. 6. FAO training manual related to feed analysis.	

FNT 503	FEED TECHNOLOGY	2+1
Objective	Basic concept of feed formulation and different feed processing techniques.	
Theory		
Unit I	Feed formulation: General principles, different steps of feed formulation,	
	Pearson's method, quadratic equation linear programming, limitations. Computerized least cost formula and criterions for aquafeed formulation	
Unit II	Types of feed: Dry (pellets, flakes, powdered, micro-encapsulated, micro-bound and micro-coated diets) and non-dry, Farm made feeds-Experimental diets: Reference diet, purified and semi-purified diet}. Compact pellet feed, floating and slow sinking pellet feeds	
Unit III	Feed processing technology: Common processes in feed manufacture; Grinding, Dosing, Homogenization; Extrusion cooking; Complimentary processes; Drying, crumbling, coating; Use of binders; Feed manufacture productions with high energy diets vacuum coating with lipid. Equipments used in feed manufacture; Pulverizer, grinder, mixer, pelletizer, crumbler, drier, Extruder/ Expander, Vacuum coater, fat sprayer	
Unit IV	Feed storage: Hydro-stability of feed and their storage; Prevention of spoilage from rancidity, fungus and associated toxins; Fish disease vectors in feed and quality control; Feed value in relation to processing; Use of natural and synthetic carotenoids: Feed additives, Safety of farm fish products-harmful residues (pesticides, antibiotics, pollutants).	
Unit V	Effects of processing on the nutritional value of feeds, effect of processing on the availability and nutritional value of vitamins and trace minerals	
Unit VI	Quality control in fish feed manufacturing; Quality control procedures, raw materials, finished products; Geometrical, and physical feature; mechanical characteristics in air, Behavioural characteristics in water. Feed economics and evaluation criteria: FCR, AFCR, SGR, PRE, ERE, PER, NPU.	
Practical	Preparation of mineral and vitamin premix. Feed additives Binders water stability available lysine. Particle size determination of feed. Development of feed dispensers both for laboratory and pond feeding as part of project assignment.	
Suggested Readings	1. ADCP (Aquaculture Development and Co-ordination Programme). 1980. Fish Feed Technology, ADCP/REP/80/11.F.A.O., Rome. 2. D' Abramo, L. R., Conklin, D. E. and Akiyama, D .M. 1977. Crustacean Nutrition: Advances in Aquaculture Vol. 6. World Aquaculture Society, Baton Roughe, Los Angeles. 3. De Silva, S. S. and Anderson, T. A. 1995. Fish Nutrition in Aquaculture. Chapman and Hall Aquaculture Series, London. 4. Guillame, J., Kaushik, S., Berqot, P. and Metallier, R. 2001. Nutrition and Feeding of Fish and Crustaceans. Springer Praxis Publishing, Chichester, U.	

	K. 5. Halver, J. E. and Tiews, K. T. 1979. Finfish Nutrition and Fishfeed Technology Vol. I and II Heenemann, Berlin. 6. Halver, J. E. 1989. Fish Nutrition. Academic Press, San Diego, C. A. 7. Lovell, R. T. 1998. Nutrition and Feeding of Fishes. Kluwer Academic Publishers. 8. Muir, J. F., and Robert, D. (Eds.). 1968. Recent Advances in Aquaculture Vol.II., Blackwell Science. 9. New, M. B. 1987. Feed and Feeding of Fish and Shrimp. A Manual on the Preparation and Preservation of Compound Feeds for Shrimp and Fish in Aquaculture. ADCP/REP/87/26 F.A.O., Rome.

FNT 504	**NUTRITIONAL ENERGETICS**	**2+1**
Objective	Metabolism of different Nutritional energetics of macromolecules and interlinking of different energy producing pathways.	
Theory		
Unit I	Introduction to nutritional energetics: Energy budget equation, Energetic efficiencies and, energy flow in boiological systems; Gross energy, digestible energy, metabolizable energy, net energy, heat increment; Factors influencing ingestion, digestion, absorption, excretion, respiration, and metabolism and their effect. Specific Dynamic Action (SDA). Influence of feeding level on energy distribution	
Unit II	Energy requirement: Energy requirement of fish and factors influencing it; Estimation of energy content of feed components based on chemicals composition, indirect and direct methods.	
Unit III	Energetics of maintenance and methodology of estimating the maintenance requirement.	
Unit Iv	Production and growth; Energetics of growth: Relationship between feeding and growth; energy exchange in biological system; growth and maturation	
Unit V	Energetics of reproduction: Relationship between feeding and reproduction	
Unit VI	Interlinking of intermediary metabolic pathways; glycolytic-TCA Cycle-beta oxidation.-electron transport chain. Abiotic factors temperature salinity on energy needs and metabolism, factors affecting energy requirement. Effect of climate change on feed intake, growth and feed conversion.	
Practical	Estimation of gross and digestive energy of feed and feed ingredients; Estimation of digestibility of nutrients, Bomb- calorimetry; Energy budget equation based on experiential data supplied; Determination of standard metabolism in fish; End product estimation of aerobic and anaerobic carbohydrates metabolism; Enzyme assay of LDH, Fatty acid analysis of fish lipids	
Suggested Readings	1. Berg, J. M., Tymoczko, J. L. and Stryer, L. 2002. Biochemistry. W.H. Freeman and Company. 2. De Silva, S. S. and Anderson, T. A. 1995. Fish Nutrition in Aquaculture.	

	Chapman and Hall Aquaculture Series, London. 3. Devlin, T. M. 1997. Textbook of Biochemistry with Clinical Correlations. Wiley-Liss, Inc. 4. Evans, D. H. and Claiborne, J. B. 2006. The Physiology of Fishes. CRC Press. 5. Florkin, M. and Mason, H. S. 1963. Comparative Biochemistry. Academic Press, New York. 6. Halver, J. and Hardy, R. W. 2002. Fish Nutrition. Academic Press, London. 7. Houlihan, D., Boujard, T. and Jobling, M. 2001. Food Intake in Fish. Blackwell Science Ltd., London. 8. Jobling, M. 1994. Fish Bioenergetics. Chapman and Hall, London. 9. Lovell, R. T. 1998. Nutrition and Feeding of Fishes. Kluwer Academic Publishers. 10. Murray, R. K., Granner, D. K., Mayes, P. A. and Rodwell, V. W. 2000. Harper's Biochemistry. Appleton and Lange. 11. Nelson, D. L and Cox, M. M. 2005. Lehninger Principles of Biochemistry. W.H. Freeman and company. 12. Voet, D., Voet, J. G. and Pratt, C. W. 2006. Fundamentals of Biochemistry. John Wiley and sons, Inc.

FNT 505	**NUTRITIONAL REQUIREMENT AND FEEDING MANAGEMENT**	**2+1**
Objective	Nutritional requirements of commercially important fish and shellfish. Feeding methods and feed management.	
Theory		
Unit I	Methods for studying nutritional requirements in finfish and shellfish; body composition of fish and shellfish. Nutrient requirements of –fish and shellfish, Qualitative and Quantitative; larvae and broodstock of commercially important shellfish and finfish; Factors affecting nutritional requirements	
Unit II	Nutritive value of live food: algae, artemia, cladocerans, ostracods, rotifers and copepods. Bio enrichment of artemia and zooplankton.	
Unit III	Growth evaluation: FCR, absolute growth, relative growth. SGR, % weight gain. Thermal growth coefficient (TGC) and Digestible growth coefficient (DGC)	
Unit IV	body composition of fish and shellfish. Feed influence on body composition and quality; Effect of rations on fecundity and egg quality –	
Unit V	Feed dispensing devices, ration size/feeding rate, feeding frequency, check trays, restricted feeding, mixed feeding. Nutritional studies and the problem of applying research findings to farming systems.	
Unit VI	Record keeping and growth management	
Practical	Determination of food intake in fry and fingerlings, to ascertain the ration, Purified diet for a fish/prawn to determine protein and lipid requirements. Estimation of growth parameters for biological evaluation. Measures of protein quality. (FCR, PER, NPU, B.V). Mineral mixtures and vitamin premix and exercise on feeding.	

Suggested Readings	1. D' Abramo, L. R., Conklin, D. E. and Akiama, D. M. 1977. Crustacean Nutrition: Advances in Aquaculture Vol. 6. World Aquaculture Society, Baton Roughe, Los Angeles. 2. De Silva, S. S. and Anderson, T. A. 1995. Fish Nutrition in Aquaculture. Chapman and Hall Aquaculture Series, London. 3. Guillame, J., Kaushik, S., Berqot, P. and Metallier, R. 2001. Nutrition and Feeding of Fish and Crustaceans. Springer Praxis Publishing, Chichester, U. K. 4. Halver, J. E, and Tiews, K. T. 1979. Finfish Nutrition and Fishfeed Technology Vol. I and II, Heenemann, Berlin. 5. Halver, J. E. 1989. Fish Nutrition. Academic Press, San Diego, CA. 6. Halver, J. E. and Hardy, R. W. 2002. Fish Nutrition. Academic Press, London. 7. Hepher, B. 1988. Nutrition of Pond Fishes. Cambridge University Press, Cambridge. 8. Houlihan, D., Boujard, T. and Jobling, M. 2001. Food Intake in Fish. Blackwell Science Ltd., London. 9. Lovell, R. T. 1998. Nutrition and Feeding of Fishes. Kluwer Academic Publishers. 10. New, M. B. 1987. Feed and Feeding of Fish and Shrimp. A Manual on the Preparation and Preservation of Compound Feeds for Shrimp and Fish in Aquaculture. ADCP/REP/87/26 F.A.O., Rome. 10. NRC (National Research Council). 1993. Nutrient requirements of fish. National Academy Press, Washington.

FNT 506	**FEED INGREDIENTS AND ADDITIVES**	**1+1**
Objective	Requirement and availability of ingredients for aqua-feeds and different types of additives used.	
Theory		
Unit I	Introduction: National and international scenario; present production trend and future requirements of feed ingredients.	
Unit II	Ingredient classification: Conventional feed ingredients - protein sources, energy sources; Unconventional feed ingredients - by-products of agro-industry, slaughter house, fruit processing units, seafood industry and forest; Single cell proteins; leaf protein concentrates, gluten meal and grain by-products. Anti-nutritional factors: Classification and mode of action, methods of detection, detoxification.	
Unit III	Proximate composition; International coding of feed ingredients; Amino acid profile, Evaluation of ingredient quality	
Unit IV	Additives- Classification: Essential and auxiliary; Function. Gustatory stimulants and role of feed attractants. Nutraceuticals, non-nutrient feed components. Feed adulterants	

Practical	Estimation of Tannin, gossypol, phytate, Protease trypsin inhibitors, Cyanogen, Aflatoxin
Suggested Readings	1. ADCP (Aquaculture Development and Co-ordination Programme). 1980. Fish Feed Technology, ADCP/REP/80/11.F.A.O., Rome. 2. D' Abramo, L. R., Conklin, D. E. and Akiyama, D. M. 1977. Crustacean Nutrition: Advances in Aquaculture Vol. 6. World Aquaculture Society, Baton Roughe, L. A. 3. De Silva, S. S. and Anderson, T. A. 1995. Fish Nutrition in Aquaculture. Chapman and Hall Aquaculture Series, London. 4. Guillame, J., Kaushik, S., Berqot, P. and Metallier, R. 2001. Nutrition and Feeding of Fish and Crustaceans. Springer Praxis Publishing, Chichester, U. K. 5. Halver, J. E. and Hardy, R. W. 2002. Fish Nutrition. Academic Press, London. 6. Joachim, W. H. and Pascual, F. P. 2000. Handbook on Ingredients for Aquaculture Feeds. Kluwer Academic Publishers, London. 7. Lovell, R. T. 1998. Nutrition and Feeding of Fishes. Kluwer Academic Publishers. 8. Rechcigl, M. 1977. CRC Handbook Series in Nutrition and Food. CRC press. 9. Rechcigl, M. 1983. Handbook of Nutritional Supplements. CRC press.

FNT 507	**NUTRITION AND FEEDING OF CRUSTACEANS**	**2+1**
Objective	Crustacean nutritional requirements, feed formulation and feeding strategy.	
Theory		
Unit I	National prospects of crustacean feed availability and industrial perspectives	
Unit II	Nutritional and feeding of shrimps : Nutritional requirements, food and feeding habits, digestive system, feeds and feed management	
Unit III	Nutritional and feeding of prawn : Nutritional requirements, food and feeding habits, digestive system, feeds and feed management	
Unit IV	Nutritional and feeding of crab : Nutritional requirements, food and feeding habits, digestive system, feeds and feed management	
Unit V	Nutritional and feeding of lobster : Nutritional requirements, food and feeding habits, digestive system, feeds and feed management	
Unit VI	Role of feed additives in crustacean nutrition.	
Practical	Study of digestive system of Shrimps, prawns, lobster, crabs.	
Suggested Readings	1. D' Abramo, L. R., Conklin, D. E. and Akiyama. D. M. 1977. Crustacean Nutrition: Advances in Aquaculture Vol. 6. World Aquaculture Society, Baton Roughe, L. A.	

	2. De Silva, S. S. and Anderson, T. A. 1995. Fish Nutrition in Aquaculture. Chapman and Hall Aquaculture Series, London. 3. Guillame, J., Kaushik, S., Berqot, P. and Metallier, R. 2001. Nutrition and Feeding of Fish and Crustaceans. Springer Praxis Publishing, Chichester, U.K. 4. Halver, J. E. and Hardy, R. W. 2002. Fish Nutrition. Academic Press, London. 5. Lovell, R. T. 1998. Nutrition and Feeding of Fishes. Kluwer Academic Publishers. 6. New, M. B. 1987. Feed and Feeding of Fish and Shrimp. A Manual on the Preparation and Preservation of Compound Feeds for Shrimp and Fish in Aquaculture. ADCP/REP/87/26.F.A.O., Rome 7. NRC (National Research Council). 1993. Nutrient Requirements of Fish. National Academy Press, Washington.

FNT 508	**PROTEIN NUTRITION**	**1+1**
Objective	The importance of protein in aquafeed and relationship of protein with energy.	
Theory		
Unit I	Protein sources and requirement: Conventional and non-conventional; dietary non-protein nitrogen; Protein requirement for maintenance, growth and reproduction; Methods of requirement study.	
Unit II	Factors affecting protein requirement. Protein energy inter-relationship (P/E Ratio). Essential and non-essential amino acids, Amino acid antagonism	
Unit III	Digestion, Absorption and Metabolism: Digestion of protein, absorption of amino acids and their metabolism	
Unit IV	Evaluation of protein quality (PER, NPU, BV, ANPU, PPV), Protein and amino acid deficiency symptoms.	
Practical	Extraction and purification of protein. Microkjeldahl method; Estimation of protein by methods of – Biuret, Lowry et al. , Bradford, total free amino acid; *In-vitro* protein digestibility.	
Suggested Readings	1. De Silva, S. S. and Anderson, T. A. 1995. Fish Nutrition in Aquaculture. Chapman and Hall Aquaculture Series, London. 2. Halver, J. E. and Hardy, R. W. 2002. Fish Nutrition. Academic Press, London. 3. Lovell, R. T. 1998. Nutrition and Feeding of Fishes. Kluwer Academic Publishers. 4. Wilson. K. and Walker, J. 1995. Principles and Techniques of Practical Biochemistry. Cambridge University Press.	

FNT 509	**LIPID NUTRITION**	**1+1**
Objective	The importance of lipids in aqua feed, the relationship of dietary lipids and their role in protein sparing	

Theory	
Unit I	Lipid sources and requirement: Conventional and non-conventional; dietary non-protein nitrogen; Lipid requirement for maintenance, growth and reproduction; Methods of requirement study.
Unit II	Lipid digestibility, transport, storage, mobilization, protein sparing effect of lipids.
Unit III	Role of essential fatty acids, Qualitative and quantitative requirement of essential fatty acids, total lipids.
Unit IV	Auto oxidation of fats/lipids and evaluation of lipid quality, antioxidants, deficiency symptoms.
Practical	Estimation of total lipids phospholipids. And free fatty acid peroxide value, saponification number, iodine value, Estimation of individual fatty acid by GCMS.
Suggested Readings	1. Berg, J. M., Tymoczko, J. L. and Stryer, L. 2002. Biochemistry. W.H. Freeman and Company. 2. De Silva, S. S. and Anderson, T. A. 1995. Fish Nutrition in Aquaculture. Chapman and Hall Aquaculture Series, London. 3. Halver, J. and Hardy, R. W. 2002. Fish Nutrition. Academic Press, London. 4. Lovell, R. T. 1998. Nutrition and Feeding of Fishes. Kluwer Academic Publishers. 5. Murray, R. K., Granner, D. K., Mayes, P. A. and Rodwell, V. W. 2000. Harper's Biochemistry. Appleton and Lange. 6. NRC (National Research Council). 1993. Nutrient Requirements of Fish. National Academy Press, Washington. 7. Voet, D., Voet, J. G. and Pratt, C. W. 2006. Fundamentals of Biochemistry. John Wiley and Sons, Inc.

FNT 510	**CARBOHYDRATE NUTRITION**	**1+1**
Objective	The importance of carbohydrate in aquafeed and the relationship of dietary carbohydrate for protein sparing	
Theory		
Unit I	Carbohydrate sources and requirement: role of nutrient and non-nutrient carbohydrates; Carbohydrate requirement for carps and catfishes, Methods of requirement study.	
Unit II	Carbohydrate digestibility, Factors affecting starch utilization, carbohydrate and interaction with other nutrients and protein sparing effect.	
Unit III	Constraints of carbohydrate utilization in fish, Strategy to enhance carbohydrate utilization: gelatinization, exogenous amylases, glucose intolerance, carbohydrates and immunity.	
Unit IV	Uses of Carbohydrates for low cost feed.	
Practical	Estimation of starch gelatinization in different feed processing methods; Blood glucose estimation; *In vitro* starch digestibility; , Estimation of crude fibre, cellulose and lignin content of feed.	
Suggested Readings	1. D' Abramo, L. R., Conklin, D. E. and Akiyama. D. M. 1977. Crustacean Nutrition: Advances in Aquaculture Vol. 6. World Aquaculture Society, Baton	

	Roughe, L. A. 2. De Silva, S. S. and Anderson, T. A. 1995. Fish Nutrition in Aquaculture. Chapman and Hall Aquaculture Series, London. 3. Guillame, J., Kaushik, S., Berqot, P. and Metallier, R. 2001. Nutrition and Feeding of Fish and Crustaceans. Springer Praxis Publishing, Chichester, U. K. 4. Halver, J. E. and Hardy, R. W. 2002. Fish Nutrition. Academic Press, London. 5. Lovell, R. T. 1998. Nutrition and Feeding of Fishes. Kluwer Academic Publishers. 6. New, M. B. 1987. Feed and Feeding of Fish and Shrimp. A Manual on the Preparation and Preservation of Compound Feeds for Shrimp and Fish in Aquaculture. ADCP/REP/87/26 F.A.O., Rome. 7. NRC (National Research Council). 1993. Nutrient Requirements of Fish. National Academy Press, Washington.

FNT 511	**VITAMIN AND MINERAL NUTRITION**	**1+1**
Objective	Properties and functions of different vitamins and minerals.	
Theory		
Unit I	Vitamins: Properties and functions of water and fat soluble vitamins; Vitamin as coenzymes and prosthetic groups of enzymes.	
Unit II	Vitamin requirements for different species, Dietary sources of vitamins, Factors affecting vitamin requirements, Losses of vitamin during feed processing.	
Unit III	Metabolic changes associated with hypo- and hyper-vitaminosis. Manifestation of vitamin deficiency; Vitamin –mineral interactions.	
Unit IV	Minerals: Macro, micro minerals and heavy metals toxicity Minerals requirements for different aquaculture species, Dietary sources of minerals, Factors affecting mineral requirement, Nutrient-minerals interaction; Manifestation of mineral deficiency	
Practical	Estimation of zinc, phosphorus, magnesium, Iron, vitamin A, Preparation of vitamin and mineral premix, Estimation of vitamin and mineral losses due to leaching	

FNT 512	Nutraceuticals and Nutrigenomics	1+1
Objective	To understand the Nutraceuticals in immunomodulation and disease prevention To understand the nutrient gene interactions	
Theory		
Unit I	Nutraceuticals/Functional foods; definition, Classification and mode of action	
Unit II	Role of Nutraceuticals in immunomodulation and disease prevention	
Unit III	Introduction to nutrigenomics: terminologies in molecular nutrition, relevance of molecular studies in nutrition, Nutrgenomics approach to fish health. Expression	

	of genetic information, Bioinformatics tools.
Unit IV	Nutritionally important genes, gene regulation by lipids and carbohydrates, nutrient gene interaction and expression, reverse transcription and CDNA synthesis, genetic control of metabolic pathways
Practical	Estimation of phytase and phytate. Effect of acidifiers on pH in different parts of GI tract. Estimation of antioxidants vitamin E and vitamin C. RNA isolation, CDNA synthesis, PCR, Agarose gel electrophoresis, Semi quantitative PCR, Real time PCR , Use of Bioinformatics tools and nutrient-gene interaction studies etc.