

Fundamentals of fish nutrition,
growth in fish, Principal nutrients
(Proteins and Amino acids)

Fundamentals of fish nutrition

- In fish farming, nutrition of fish is critical because feed represents 40-50% of the production costs.
- Fish nutrition research has advanced in recent years with the development of commercial diets that promote fish growth and health.
- Growth is affected either due to less intake of feed or under utilization of feeds.
- An undernourished animal cannot maintain its health and be productive, regardless of the quality of its environment.
- The production of nutritionally balanced feed for fish requires efforts in research, quality control, and biological evaluation.

- Faulty nutrition obviously impairs fish productivity and result in a deterioration of health until recognizable diseases ensues.
- However, the problem of recognizing a deterioration of performance in its initial stages and taking corrective action will remain an essential part of the skill of the fish culturist.
- Fish feed technology is one of the least developed sectors of aquaculture
- Commercial formulations of feeds are generally proprietary secrets, and the ingredients used are often too expensive to be used in developing countries.
- The need for developing suitable feeds based on locally available inexpensive ingredients has therefore, been widely recognized.

Nutrient and growth

- The growth in fish follows s-shaped curve.
- Initially, the fish growth will be slow due to the small size of fish and thus the difficulty in consuming more food. This phase is termed as preparatory phase.
- With the advancement of time fish starts to consume more food, grow bigger and their capacity to feed and grow increases.
- Beyond certain point, the rate of increase in growth begins to slow down as the total weight of fish has now increased to a maximum point and thus the growth now occurs at a diminishing rate.

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- Although fish never stops growing but the growth is slower in older fish and proportional increase in size is greatest in younger fish.
- Like any other terrestrial animal, fish also needs the same nutrients for their growth. However, the amount of these nutrients varies due to variation of metabolic rate.
- Finfish require around 40 nutrients for optimal growth and well being. The proteins, lipids/fats and carbohydrates are considered as “macro nutrients”, while vitamins and minerals put together constitute “micronutrients” required for the healthy growth in fish.

Natural feed vs. ARTIFICIAL FEED

Natural feed

- Otherwise called as viable feed or live feed
- Serve as living capsule of nutrition. They are live feed or naturally occurring substances which can perform the growth prominently.
- Very cheap and occur very easily.
- Ex: Lab-lab, lumut, zooplankton

Artificial feed

- Otherwise called as compound feed
- This type of feed is produced by man using available raw materials and medicine.
- Cost is high
- Microencapsulated diet, micro coated diet, micro bound diet

Principal nutrients

- Proteins, lipids/fats and carbohydrates - macro nutrients”
- vitamins and minerals – micronutrients

Proteins and Amino acids

- Proteins are composed mostly of amino acids linked with peptide bonds and cross linked between chains with sulphhydryl and hydrogen bonds.
- Gross energy of protein is 5.60 kcal/g.
- Proteins are major nutrient in fish tissue constituting about 65-75% of the total on the dry weight basis
- Proteins are also required for synthesis of new tissues and hence growth.

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- Proteins are among the most important constituents of all living cells and represent the largest chemical group in the animal body, with the exception of water;
- The whole fish carcass contains on an average 75% water, 16% protein, 6% lipid and 3% ash.
- Proteins are essential components of both the cell nucleus and cell protoplasm, and accordingly account for the bulk of the muscle tissues, internal organs, brain, nerves and skin.

Structure and composition

- Proteins are very complex organic compounds of high molecular weight.
- Proteins are composed of carbon (50%), nitrogen (16%), oxygen (21.50%), and hydrogen (6.50%), sometimes phosphorus and sulphur.

Classification

- Proteins may be classified into three main groups according to their shape, solubility and chemical composition
- **Fibrous proteins:** (i) Insoluble animal proteins which are generally very resistant to digestive enzyme breakdown. Fibrous proteins exist as elongated filamentous chains.
(ii) Ex: collagens (main protein of connective tissue), elastin (present in elastic tissues such as arteries and tendons), and keratin (present in hair, nails, wool of mammals).

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- **Globular proteins:** (i) Include all enzymes, antigens and hormone proteins.
- Globular proteins can be further subdivided into **albumins** (water soluble, heat-coagulable proteins which occur in eggs, milk, blood and many plants); **globulins** (insoluble or sparingly soluble in water, and present in eggs, milk, and blood, and serve as the main protein reserve in plant seeds); and **histones** (basic proteins of low molecular weight, water soluble, occur in the cell nucleus associated with deoxyribonucleic acid - DNA).

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- **Conjugated proteins:** (i) these are proteins which yield non-protein groups as well as amino acids on hydrolysis.
(ii) Examples include the phosphoproteins (casein of milk, phosvitin of egg yolk), glycoproteins (mucous secretions), lipoproteins (cell membranes), chromoproteins (haemoglobin, haemocyanin, cytochrome, flavoproteins), and nucleoproteins (combination of proteins with nucleic acids present in the cell nucleus).
- **Derived proteins:** (i) These are proteins derived from simple or conjugated proteins by physical or chemical means.
(ii) Examples are: denatured proteins and peptides.

Protein digestion and metabolism

- Ingested proteins are first split into peptides by pepsin in the stomach or by trypsin and chymotrypsin from the pancreas.
- These peptides are then further reduced by the action of carboxypeptidase which hydrolyzes off one amino acid at a time beginning at the free carboxyl end of the molecule or by amino peptidase which splits off one amino acid at a time beginning at the free amino end of the polypeptide chain.
- The free amino acids released into the digestive system are then absorbed through the walls of the gastrointestinal tract into the blood stream where they are then re-synthesized into new tissue proteins or are catabolyzed for energy or for fragments for further tissue metabolism.

Amino acids

- Although over 100 different amino acids have been isolated from biological materials, only 25 of these are commonly found in proteins.
- Individual amino acids are characterised by having an acidic carboxy group (COOH) and a basic nitrogenous group (NH₂).
- In view of the presence of both acidic and basic groups, amino acids are amphoteric (i.e. Have both acidic and basic properties)

Classification

- For nutritional purposes, amino acids may be divided into two groups
- Essential amino acids (EAA): those amino acids that cannot be synthesized within the animal body or at a rate sufficient to meet the physiological needs of the growing animal, and must therefore be supplied in a ready made form in the diet.
- Ex: Methionine, arginine, threonine, tryptophan, histidine, isoleucine, lysine, leucine, valine and phenylalanine

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- Non-essential amino acids (NEAA): those amino acids that can be synthesized in the body from a suitable carbon source and amino groups from other amino acids or simple compounds such as diammonium citrate, and consequently do not have to be supplied in a ready made form in the diet.
- Ex: proline, glutamic acid, aspartic acid, hydroxylproline
- From a feed formulation viewpoint, it is important to know that the NEAA's cystine and tyrosine can be synthesized within the body from the EAA's methionine and phenylalanine respectively.

Classification based on chemical structure

- **Mono amino mono carboxylic acid:** glycine, valine, threonine, leucine, isoleucine
- **Mono amino dicarboxylic acid:** aspartic acid, glutamic acid
- **Diamino mono carboxylic amino acid:** arginine, lysine
- **Sulphur containing amino acid:** cystine, cysteine, methionine
- **Aromatic and heterocyclic amino acid:** Phenyl alanine, tyrosine, tryptophan, histidine, proline

Functions of Protein

- As a source of energy
- Required for formation of hormones, enzymes
- As a source of amino acid requirements for synthesis of diverse kind of proteins
- To prepare worn or wasted tissue and to rebuild new tissue.
- Serve as lubricants and protective agents
- Serve as substrates for CHO and FA synthesis

Amino acid composition and protein Quality

- The protein quality of a feed ingredient is dependent upon the amino acid composition of the protein and the biological availability of the amino acids present.
- In general, the closer the EAA pattern of the protein approximates to the dietary EAA requirement of the species, the higher its nutritional value and utilization.
- example, under certain conditions some of the amino acids may be unavailable because the proteins in the diet are incompletely digested.
- Thus, for carnivorous fish and shrimp species, the cellulose cell wall within plant protein sources may render the proteins present within the cell inaccessible to the digestive enzymes.
- In other cases, digestion may be hindered by the presence of enzyme inhibitors within the food protein like trypsin inhibitor within raw soybeans.

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- Although it is possible to inactivate these inhibitors by moderate heat processing, under conditions of excessive heat treatment proteins become more resistant to digestion due to peptide bond formation occurring between the side chains of lysine and dicarboxylic acid.
- The free epsilon amino groups of lysine are particularly susceptible to heat damage, forming addition compounds with non-protein compounds (i.e. reducing sugars such as glucose) present in the food stuff. This reaction is known as the Maillard reaction, and renders the lysine biologically unavailable.
- Substances other than reducing sugars which are known to react with the free epsilon amino group of lysine include gossypol; phenol based compound present in cottonseed meal. Thus an estimate of the biological availability of amino acids within feed proteins gives an indication of protein quality.