Practical Aquaculture 7

By

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Fish feeding

Nutrient and Other Components of Feedstuffs

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Energy

Energy can be defined as the capacity to do work. Energy is required to do mechanical work (for example, muscle activity for movement), chemical work (the chemical processes which take place in the body), electrical work (nerve activity) and osmotic work (maintaining the body fluids in an equilibrium with each other and with the medium, whether fresh, brackish or seawater in which the animal lives). Free energy is that which is left available for biological activity and growth after the energy requirements for maintaining body temperature (not necessary for fish) is satisfied. Excess energy is dissipated as heat

The gross energy (or gross calorific value) of a food, sometimes designated as GE, is the total energy contained in it. Not all of it is available to the animal. Different components of the diet have different energy availabilities.. The digestible energy (DE) of a food is the GE of the food less the energy of the faeces excreted. The energy available for the 'building blocks' of growth is what remains after the energy for metabolism 1/, reproduction, etc., has been supplied excess or insufficient dietary energy levels result in reduced growth rates. Energy needs for maintenance and movement will be fulfilled before energy is used for growth. Thus if the energy/protein ratio is too low, protein will be used to satisfy energy requirements first; what is left will be available for growth. Fish and shrimp eat primarily to satisfy energy requirements, so a diet with excess energy content will inhibit food intake and also reduce the protein available for growth. Excess dietary fat also leads to high body fat in cultured fish, low dress-out yield and poor shelf life in market size animals

DE is calculated on DM (dry matter) basis

Nutrient	Gross Energy (GE) 2/ kcal/g	Estimated Digestible Energy (DE (kcal/g)
Carbohydrate (non-legumes)		3.0
Carbohydrates (legumes)	4.1	2.0
Proteins (animal)	5.5	4.25
Proteins (plant)		3.8
Fats	9.1	8.0

GE = the amount of heat that is released when a substance is completely oxidized in a bomb calorimeter containing 25-30 atmospheres of oxygen

Example

of the method of calculation of DE. A cereal has the following analysis, on an as-fed basis: moisture 12.4%; lipid 1.5%; protein 12.2%; fibre 2.7%; ash 1.7%; NFE 69.5%. (NFE is the nitrogen free extract and is equivalent to the carbohydrate fraction of the diet). Only the lipid, protein and NFE values are relevant in this method of calculating estimated DE (digestible energy) values, but they must first be converted to a dry matter basis. The calculations are as follows :

<u>convert to a DM basis</u>

$$\text{lipid (on DM basis)} = 1.5 \times \frac{100}{(100-12.4)} = 1.71$$

$$\text{protein (on DM basis)} = 12.2 \times \frac{100}{(100-12.4)} = 13.93$$

$$\text{NFE (on DM basis)} = 69.5 \times \frac{100}{(100-12.4)} = 79.34$$

<u>calculate DE contributed by each component</u>

$$\text{DE of lipid} = \frac{1.71 \times 8.0}{100} = 0.1368\ \text{kcal/g}$$

$$\text{DE of protein 1/} = \frac{13.93 \times 3.8}{100} = 0.5293\ \text{kcal/g}$$

$$\text{DE of carbohydrate (NFE) 2/} = \frac{79.34 \times 3.0}{100} = 2.3802\ \text{kcal/g}$$

<u>sum to find total DE</u>

$$\text{Total estimated DE 3/ of cereal} = (0.1368 + 0.5293 + 2.3802) \times 1000 = 3046\ \text{kcal/kg}$$

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Proteins and Amino Acids

Animals cannot synthesise them from simple inorganic materials, unlike plants, and have to rely on ingesting them through their diet (either from plants or from other animals which already contain them) or on their synthesis by gut bacteria.

Proteins are composed mostly of amino acids linked with peptide bonds and cross linked between chains with sulphydral and hydrogen bonds. There are twenty major amino acids. The amino acid composition of proteins from different sources varies widely. Some proteins have none of certain amino acids

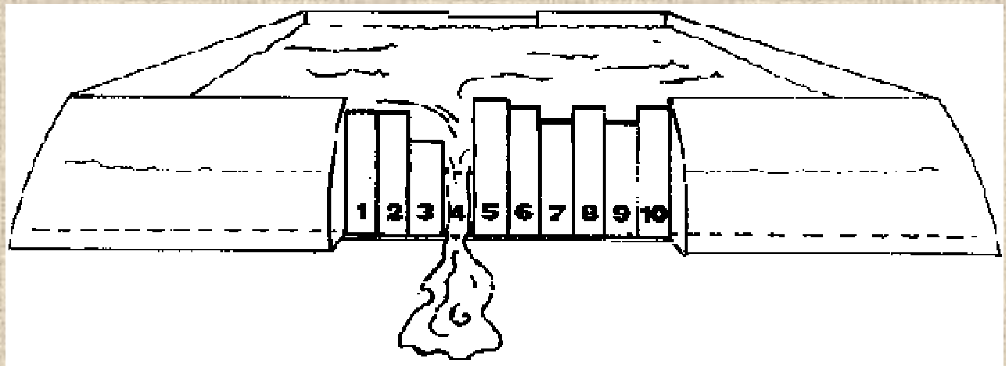
Amino acids contain different amounts of nitrogen; thus the figure given for protein level in feed compositional tables is never strictly accurate

The quantitative EAA requirements of different species varies . The EAA content of different feed ingredients varies even more widely . This is one of the principal reasons why a compound diet, made from several ingredients, is potentially more efficient than a single ingredient, which may be too high or too low in one or more essential amino acids. The amino acid profile of a feed must be balanced for the dietary protein to be used effectively.

What is the Quantitative Dietary Amino Acid Requirements for Various Fish?

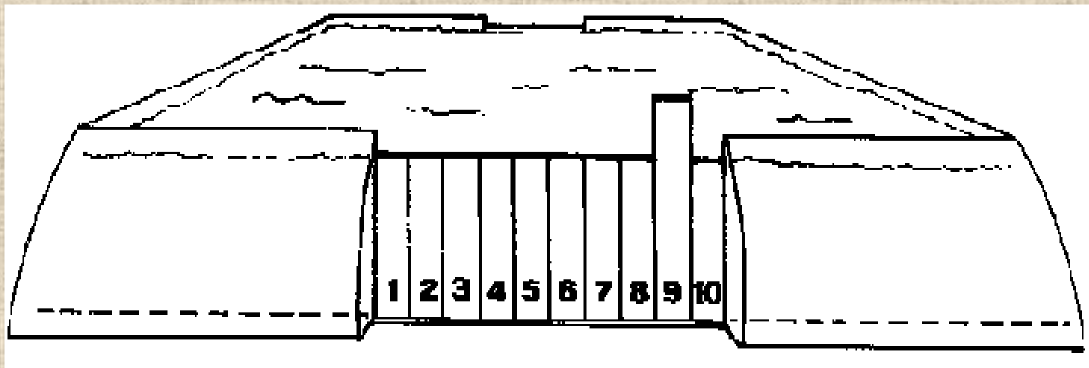
Limiting Amino Acids

the level of water in the pond will depend on the height of the shortest plank (plank 4). The shortest plank represents the 'first limiting amino acid'.



If this plank is lengthened (or this amino acid is increased in level by altering the proportion or the type of ingredients used, or by adding it in synthetic form) then plank 3 would control the water level (or be the next limiting amino acid). Ideally all the planks should be just as high as the level of water desired in the pond (the quantity of each amino acid in the diet at exactly the correct level for the species being cultured) to avoid wastage of materials.

what happens if one plank is unnecessarily long (or if one amino acid is present in excess in the diet) - it serves no useful purpose and is an unnecessary expense.



Limiting Amino Acids and Chemical Score of Essential Amino Acid Content of Selected Feed Proteins

Scores based on comparison with whole egg protein of the following amino acid composition (percentage of protein): arginine, 6.7; cystine, 2.2; histidine, 2.7; isoleucine, 7.0; leucine, 8.5; lysine, 6.8; methionine, 3.3; phenylalanine, 5.4; threonine, 5.5; tryptophan, 1.9; and valine, 8.2.

Feedstuff	Arg	His	Iso	Leu	Lys	Met + Cys	Phe	Thr	Try	Val
Fish meal	85	85	66	88	110	71	78	74	58	61
Meat meal	77	96	28*	100	86	36*	72	60	68	75
Milk, skimmed	53*	92	88	110	104	69	91	80	73	75
Milk, whole	60	100	100	136	106	83	92	83	84	78
Soybean meal	110	89	66	92	90	54*	102	69	68	63
Cottonseed cake	164	96	46*	69	60	51*	100	58	58	55
Sunflower oil cake	112	59	46*	62	32*	22*	61	47*	79	46*
Red bean	112	130	77	49*	128	27*	107	83	42*	72
Chlorella	77	55	64	90	44*	47*	92	100	68	72
Spirulina	97	66	86	94	67	33*	92	83	73	79
yeast	77	81	68	94	111	51*	81	91	63	66
Brewer's spent grains	68	66	77	97	48*	22*	87	58	68	66

Recommended dietary protein levels for various sizes of warm water fish.		
Fish weight		**Dietary requirement**
g/fish	**lb/1,000 fish**	**%**
0.02- 0.25	0.04- 0.55	52
0.25- 1.5	0.55- 3.3	48
1.5 - 5.0	3.3 -11.0	44
5.0 -20.0	11.0 -44.0	40
20.0 -27.0	44.0 -60.0	35
27 and up	60 and up	26-32

3 Lipids and Fatty Acids

In feedstuff chemistry the words **fat, lipid and oil** are sometimes used synonymously. Tables of feed composition often refer to the **crude fat level**, by which is meant the material which can be removed from the feed by ether extraction. The term **'oil content**' is also often used. The term **crude lipid** content can also be used. The word lipid is a general term which covers **sterols, waxes, fats, phospholipids and sphingomyelins**. Many of the **vitamins** are fat soluble and will be extracted by ether - thus the **term crude lipid content**. The words **oil, fat, and wax**, reflect the increasing **melting points** of these lipid components.

Fats are the fatty acid esters of glycerol and are the primary means by which animals **store energy**. Fish are able to metabolize lipids readily particularly when deprived of food, as during the migration of salmon, for example. Phospholipids are **components of cellular membranes**. Sphingomyelins are found in **brain and nerve tissue compounds**. Sterols are important components of, or precursors of, **sex and other hormones** in fish and shrimp. Waxes form important **energy storage compounds in plants and in some animal components**.

Dietary lipid has two main functions - as a **source of energy** and as a **source of its component fatty acids**, some of which are **essential** (i.e., cannot be synthesized by the animal itself) dietary components for the growth and survival of the recipient animal. Lipids are also important factors in the **palatability** of feeds.

The fatty acids which are components of lipids are categorized in the following way. They are given a **common name** but are also, besides their **straightforward chemical formula**, given a **specific numerical** designation, such as 14:0; 20:1; 18:3n-3; 18:2n-6; 20:4n-6; 22:5n-6; or 22:6n-3, for example. This nomenclature refers to **the length of the carbon chain in the molecule**, **the number of carbon-carbon double bonds present** and **the position of the first double bond**. This can be illustrated by the chemical formulae of some of the fatty acids mentioned above. This nomenclature may sound complex to those with little knowledge of biochemistry but it is necessary just to know what the terminology means so that it is possible to understand references to different types of fatty acids when fish and shrimp nutrition is being discussed. The methyl group is shown in the following formulae as CH3.