Practical Aquaculture 8

By

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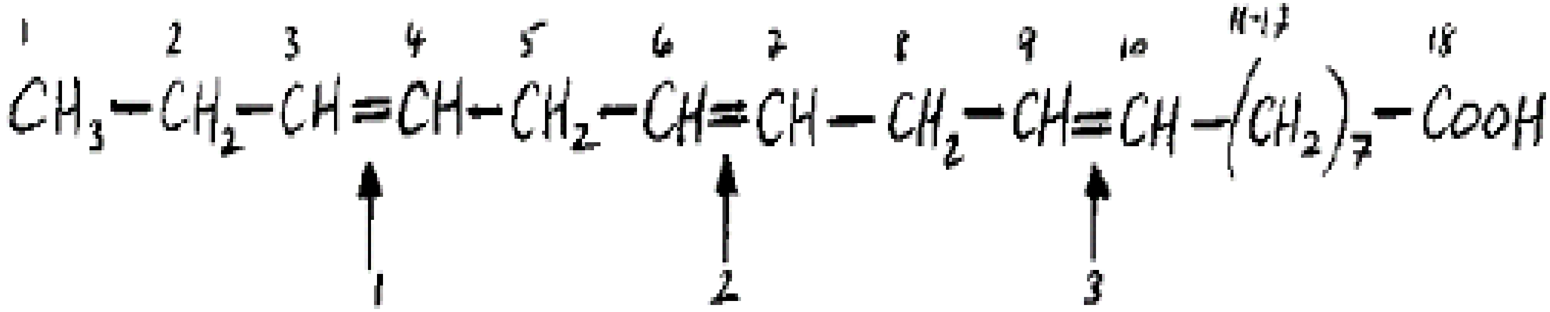
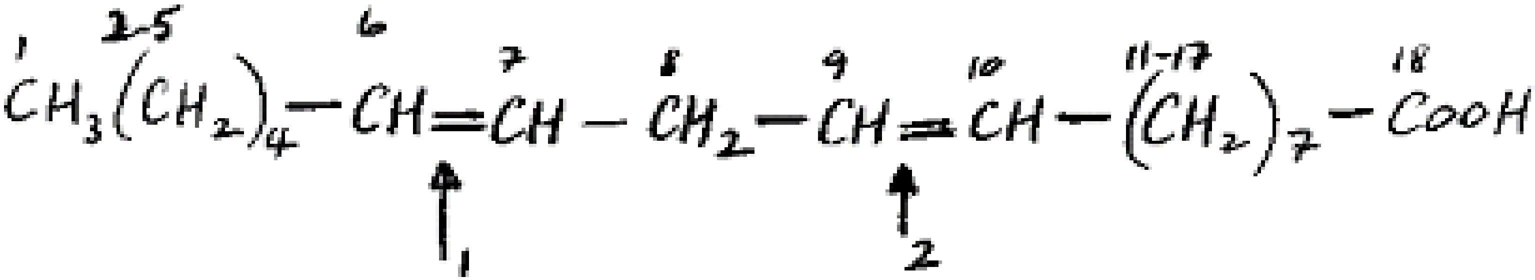
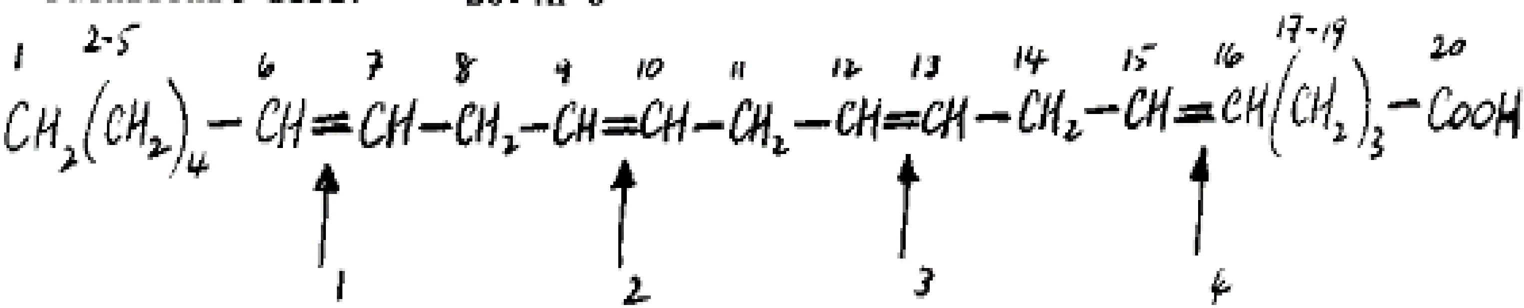
Linolenic acid: 18:3n-3



Linoleic acid: 18:2n-6



Arachidonic acid: 20:4n-6



Those fatty acids which have their first double bond on the third carbon atom are known as the 'n-3' series ,or the **'linolenic'** series after the name of the fatty acid in the series with 18 carbon atoms in its chain. Similarly, those which have their first double bond on the sixth carbon atom are known as the 'n-6' series, or the **'linoleic** series. It is essential to notice the difference (which is only the addition of the letter **n**) between the two words **linolenic** and **linoleic**. This similarity causes a great deal of confusion and printing errors

_Or **w -3' series**

_Or **w -6' series**

Saturated fatty acids are those **without** any **double bonds**. **Monounsaturated** fatty acids are those with only **one double bond**, while those with **more than one** double bond are known as **poly-unsaturated fatty acids**. Those with **fewer double bonds** are referred to as **'more saturated**' than those with a greater number. The **n-3** series and **n-6** series fatty acids, and the **n-7** and **n-9** fatty acids are all members of the group known as **polyunsaturated fatty acids**, because they have more than one double bond. Sometimes these are referred to as **PUFA's** for short. Members of this group which have many (**4 or more**) double bonds are sometimes referred to as **higher unsaturated fatty acids (HUFA'S**).

The essential fatty acid (EFA) requirements

a) **Aquatic animals** have a **higher** requirement for the **n-3 series** of fatty acids than **terrestrial animals**, for which the **n-6 series** is more **important**;
b) **EFA deficiencies** are more noticeable in **seawater** than in **freshwater** conditions (for trout). Thus **salinity affects EFA requirements**;
c) **Marine fish** appear to have a **greater** requirement for **HUFA's** than **freshwater** or **anadromous** species. It is **not yet known** whether they can utilize the **n-6** series as well as they can the **n-3** series;

d) **Coldwater** species appear to have a **greater** requirement for the **n-3 series** fatty acids than **warmwater** species;
e) **Shrimp** and prawns have a requirement for the **n-3 series** and the **n-3:n-6 ratio** is **important**;
f) The levels of either type of **PUFA's** can be detrimentally high in a feed. Knowledge of the specific requirements of a species is therefore constantly being sought to optimize formulation practice

g) Although many **vegetable** lipids (but not those of palm, olive or coconut) are **high** in **PUFA's**, the **best sources** (and the **most expensive**) sources of the **n-3 HUFA's** are **marine lipids**. **Vegetable** oils tend to have **high** levels of the **n-6 series** (**linoleic series**). **Beef** tallow have **low** total levels of **PUFA's**.

The necessity of high dietary levels of PUFA's in aquatic animal diets makes the possibility of fats becoming **rancid** very real. These may be **toxic** or **growth depressive**.

Carbohydrates. Carbohydrates are compounds of **carbon, hydrogen, and oxygen**, which include **sugars, starch, cellulose, gums**, and other closely related compounds. Carbohydrates are the major constituent of **plants**, comprising **50%** to **80%** of the **dry weight** of various plants. They form the structural framework of plants and are the primary form of energy stored in seeds, roots, and tubers. Plants synthesize carbohydrates from solar energy, carbon dioxide, and water through the process of photosynthesis.

Animal tissues contain **small** amounts of stored carbohydrate. **Glucose** in the **blood** of animals is relatively **constant** at about **0.05% to 0.1%.** Circulating glucose is utilized for **energy** and is replenished from stores of **glycogen** in the liver. Generally **glycogen** stores in the **liver** are **small**, representing only about **3% to 7%** of liver weight in most animals. **Excess** ingested carbohydrate is **converted** to and stored primarily as **lipid**.

Although carbohydrates are the **least expensive source of energy** for use in animal feeds, their role in **fish nutrition** remains somewhat **obscure**. **Enzymes** for the major pathways involved in carbohydrate metabolism have been detected in several fish specie s. However, it appears that **hormonal and metabolic control** of carbohydrate **metabolism** in **fish** may **differ** from that of **mammals**. The **utilization** of carbohydrate by **fish** appears to differ depending on the **complexity** of the carbohydrate. **Starch or dextrin** (partially hydrolyzed starch) is used more **efficiently** by fish than are sugars such as **glucose or sucrose**.

It has generally been thought that **fish** resemble **diabetic** animals by having **insufficient insulin** for maximum carbohydrate utilization. However, recent information has shown that **insulin** levels in fish are about the same as those found in mammals, which indicates that fish are **not diabetic**. **Glucose** is highly digestible by fish, but apparently a **large** portion of the absorbed **glucose** is **excreted**.

Although fish use carbohydrate effectively, there is **no dietary requirement** for carbohydrate. Carbohydrates are important dietary components as an inexpensive source of **energy**, as **precursors** for various metabolic intermediates, as an aid in **pelleting** practical fish feeds, and in **reducing** the amount of **protein** used for energy thereby **sparing** protein for growth.

A typical commercial fish feed contains 25% - 35% or more soluble (digestible) carbohydrate. An additional 3 to 6% carbohydrate is generally present as crude **fiber**. **Fiber** is considered to be **indigestible** by fish; thus, it is not desirable in fish feeds because indigestible materials may "pollute" the water. However, there is always some fiber inherent in practical feed ingredients.

Vitamins. Vitamins are highly diverse in chemical structure and physiological function. They are generally defined as **organic compounds** that are required in **small amounts** in the diet for **normal** growth, **health**, and **reproduction** by one or more animal species. Some vitamins may be **synthesized** in the body in quantities sufficient to meet metabolic needs, and thus are not required in the diet.
Characteristic vitamin deficiency signs can be induced in fish fed diets deficient in a particular vitamin, at least under experimental conditions . Vitamin deficiencies are rarely encountered in natural populations of fish. Vitamin C and pantothenic acid deficiencies have been documented in commercially cultured fish. The addition of sufficient levels of these vitamins to fish feeds eliminate deficiency problems.

Vitamin requirements for fish have generally been determined with **small rapidly** growing fish. These values are considered to be sufficient to meet the needs of **larger** fish; however, vitamin requirements are affected by fish **size**, **growth rate, stage of sexual maturity, diet formulation, disease, and environmental conditions**. The interrelationships among these factors and the vitamin needs of fish have not been adequately defined.
Fish feeds are generally supplemented with a **vitamin premix** that contains all essential vitamins in **sufficient** quantities to meet the **requirement** and to compensate for **losses** due to feed processing and storage (vitamin losses during storage are not a major factor where feed is generally not stored for more than 2 to 3 days).

Vitamin deficiency signs and minimum dietary levels required to prevent signs of deficiency in warm water fish.

Vitamin	Deficiency signs	Units (ppm or IU/lb)	Requirement
Fat soluble A	Exophthalmia, edema	IU	450-900
D	Low bone ash	IU	110-220
E	Skin depigmentation, muscle dystrophy,	IU	23
K	Skin hemorrhage, prolonged clotting time	ppm	R
Water soluble Thiamin	Dark skin color	ppm	1.0
Riboflavin	Short-body dwarfism	ppm	9.0
Pyridoxine	Greenish blue coloration , nervous disorders	ppm	3.0
Pantothenic acid	Clubbed gills, anemia, eroded skin, lower jaw, fins	ppm	15
Niacin	Anemia, lesions of skin and fins, exophthalmia	ppm	14
Biotin	Anemia, skin depigmentation, reduced liver activity	ppm	R
Folic acid	Reduced hematocrit	ppm	1.5
B_{12}	Reduced hematocrit	ppm	R
Choline	Hemorrhagic kidney and intestine, fatty liver	ppm	400
Inositol	None demonstrated	ppm	NR
Ascorbic acid	Reduced hematocrit, increased susceptibility to bacterial infections, reduced bone collagen formation	ppm	60

Vitamins present in feedstuffs are usually not considered during feed formulation because their bioavailability is not known, but they certainly contribute to the vitamin nutrition of fish. Natural food organisms may also be a source of vitamins for fish. Zooplankton collected from commercial fish ponds contain all vitamins, some in relatively high concentrations.

Several studies on the grow - out of fish in earthen ponds in which the fish were fed a diet with and without supplemental vitamins, and the results have consistently indicated no differences in any parameter measured. This is not to imply that supplemental vitamins are not needed in fish diets. However, it may be that the concentrations of certain vitamins can be reduced or that certain vitamins can be removed from the vitamin premix without affecting fish performance. Studies are currently underway to determine practical vitamin requirements for catfish.

The use of megadose levels of certain vitamins, particularly vitamin C, to enhance disease resistance in fish. Early evidence indicated that high levels of vitamin C (10 times or more than the level needed for normal growth) reduced mortality from certain bacterial diseases affecting fish. As a result some fish producers fed a high-C feed, which contained about 900 mg vitamin C/lb, during late winter or early spring, presumably to enhance the immune system of fish. More recent results from at least six studies do not show an advantage to using high levels of dietary vitamin C for disease resistance in fish.

Minerals. The same minerals required for metabolism and skeletal structure of other animals are apparently required by fish. Fish also require minerals for osmotic balance between body fluids and their environment, some of which can be absorbed from the water. Minerals may be classified as macro-minerals or micro-minerals, depending on the amount required in the diet. Macro-minerals are required in relatively large quantities; micro-minerals are required in trace quantities . Mineral nutrition studies with fish are complicated by dissolved minerals found in the water. For example, a dietary calcium requirement can only be demonstrated in fish reared in calcium-free water. In water containing sufficient calcium, fish can meet their calcium requirement by absorption of calcium from the water. Fourteen minerals are considered to be essential for catfish