Spirulina is probably one of the best fish food ingredients available. Any food for Koi is improved by the addition of Spirulina Algae. 

**WHAT IS SPIRULINA ALGAE (Spirulina Arthrospira)?**

Spirulina Arthrospira is a planktonic blue-green algae (Cyanobacteria) found in warm water alkaline volcanic lakes and is rich in raw protein and seven major vitamins: A1, B1, B2, B6, B12 (one of the best natural sources for B12, although the bioavailability its B12 is in dispute by many researchers), C and E. It naturally contains beta-carotene, color enhancing pigments, and whole range of minerals. In addition, Spirulina has a 62% amino acid content and contains all essential fatty acids and eight amino acids required for complete nutrition. Evidence as recent as 2007 shows even more proof as to the profound anti-oxidant properties of Spirulina.

The primary species of Spirulina are *Arthrospira platensis* and *Arthrospira maxima*. Another species is *Spirulina fusiformis*; it is a freshwater algae as opposed to Marine/Saltwater species of the commonly harvested/aquacultured species noted earlier. It used to be classified as *Spirulina platensis*. *Arthrospira fusiformis* is capable of a great deal of polymorphism, it changes its shape, color and other characteristics in adapting to its environment. This freshwater species thrives in waters that are loaded with various minerals such as sodium, magnesium, carbonates, sulfates and chlorides. It does not usually thrive in water which is suitable for watering crops, drinking or raising fish.

Most commercial Spirulina used for human and fish food consumption primarily is grown in the USA, Thailand, India and China.

Spirulina is different from other algae and is similar to bacteria in many ways, occupying a niche between plants and bacteria. Spirulina is similar to cyanobacteria in structure (spiral shape, unlike true plant plankton), which can be toxic. Spirulina Blue-Green algae are recognized by the body (fish in particular) as a bacterium, causing an increase in antibodies, which in turn increases disease resistance.

Spirulina is not Chlorella; Chlorella is a green micro-algae and does not have the same anti-viral, anti-cancer and immune stimulating properties of Spirulina. The Chlorella cell wall is made of indigestible cellulose, just like green grass, while the cell wall of Spirulina is made of complexed proteins and sugars.

Spirulina has a soft cell wall made of complex sugars and protein, and is different from most other algae in that it is more easily digested. Spirulina is also high in usable or digestible amino acids (the building blocks of proteins); proteins from cereal and soy are not as digestible by fish as the amino acids found in spirulina. Spirulina provides all the required amino acids, and in a form that is five times easier to digest than meat or soy protein.

An analogy used at a pet food seminar I attended was this: You can achieve the protein analysis on many pet foods with a used pair of leather shoes, but leather shoes contain little usable proteins.

*Aphanizomenon Flos-Aquae* is a related algae found in Klamath Lake Oregon (see References). Like Spirulina, this Klamath Lake blue green algae has been shown to be very nutritionally dense, diverse and absolutely non-toxic. It is a unique single cell organism that has characteristics of plants, animals and bacteria. Like plants, it has chlorophyll and through photosynthesis produces oxygen. Like bacteria, it has a fragile cell wall. Like animals, there are times when it uses oxygen and produces carbon dioxide.

**AQUATIC HEALTH BENEFITS:**

**Minerals:** Besides the above mentioned high protein content and digestibility, Spirulina come from waters with minerals deposited from ancient soils and mountains. No other plants can live in these areas due to the mineral content. Due to the fact that Spirulina thrives in such alkaline waters, it incorporates and synthesizes many minerals and derivative compounds into its cell structure. Transformed into natural organic forms by Spirulina (Arthrospira), minerals become chelated with amino acids and are therefore more easily assimilated by the body. Fish can ingest high amounts of added inorganic minerals (most fish foods are low in natural calcium and need added calcium to meet requirements) without benefit to health because the fish (or other aquatic organism such as shrimp) body does not know what to do with these incompatible forms. In fact, evidence is accumulating that the inorganic minerals can block absorption of the organic forms, leading ultimately to mineral deficiency diseases (see this human study: [Dietary calcium better](http://www.healthykoi.com))
Spirulina Algae’s most profound Benefit; It Improves Immune Function:

Spirulina provides phycocyanin, a source of biliverdin which is among the most potent of all intra-cellular antioxidants. Spirulina is a powerful tonic for the immune system. In scientific studies of mice, hamsters, chickens, turkeys, cats and fish, Spirulina consistently improves immune system function.

An animal (fish for our purposes) produces unconjugated biliverdin, a yellow colored breakdown product of normal heme catabolism, formed by failing red blood cells. Heme (also called Haem in the UK) is composed of iron plus amino acids from globin of hemoglobin. Erythrocytes which have a 120 day life span transport oxygen and carbon dioxide between the lungs and all the tissues of the body (a circulating erythrocyte is little more than a container for hemoglobin) are broken down utilizing these Heme via the tetrapyrrole; biliverdin, which is then converted to bilirubin and carried to the liver by the plasma protein.

Bilirubin is excreted in bile, and its levels are elevated in certain diseases and is then transported into the cytoplasm of every cell in the body of the animal (fish). As stated earlier, an enzyme called biliverdin reductase, converts the biliverdin to unconjugated bilirubin. The bilirubin quickly oxidizes back into biliverdin, and just as quickly biliverdin reductase recycles it back again into bilirubin.

This form of bilirubin, (similar to the bilin in hemoglobin or bile.), has been shown to be 10,000 times as powerful an antioxidant as is glutathione. The unconjugated bilirubin is also a powerful inhibitor of NADPH Oxidase (nicotinamide adenine dinucleotide phosphate-oxidase). This enzyme is a major source of Super Oxide in an animal’s body, and is involved in dozens of degenerative processes involved in disease resistance, aging and similar processes in fish and other animals (including humans).

There is now strong evidence that Spirulina supplements the amount of unconjugated biliverdin which the fish or other animals are born with, providing profound protection from oxidative stress. Scientists also find Spirulina not only stimulates the immune system through before described process, it actually enhances the animal’s body’s ability to generate new blood cells.

THIS REASON ALONE is why Spirulina should be part of EVERY fish’ aquatic diet, INCLUDING carnivores where it should be fed via gut loading of worms, feeder fish, or crickets (which I have done for my clients Arowanas diet).

As well, Spirulina fusiformis has been shown to provide Antioxidant/Hepatoprotective (Liver function)

In a study VIT University evaluated the hepatoprotective and antioxidant effects of Spirulina fusiformis against acetaminophen-induced hepatotoxicity in mice. For comparison purpose, results were compared with those for silymarin, a standard hepatoprotective drug. The study clearly demonstrated that Spirulina fusiformis shows hepatoprotective effect through its antioxidant activity on acetaminophen-induced hepatotoxicity.


Spirulina aids in building red blood cells and stem cells:

Spirulina is rich in a brilliant blue polypeptide called Phycocyanin. Studies show that Phycocyanin affects the stem cells found in bone marrow. Stem cells are “Grandmother” to both the white blood cells that make up the cellular immune system and red blood cells that oxygenate the body.

“Chinese scientists document Phycocyanin stimulating hematopoiesis, (the creation of blood), emulating the affect of the hormone erythropoietin, (EPO). EPO is produced by healthy kidneys and regulates bone marrow stem cell production of red blood cells. Chinese scientists claim Phycocyanin also regulates production of white blood cells, even when bone marrow stem cells are damaged by toxic chemicals or radiation”

The Effects of Polysaccharide and Phycocyanin from Spirulina platensis variety on Peripheral blood and Hematopoietic system of Bone Marrow in Mice.
Spirulina Anti-Viral and Anti-Cancer abilities:

Calcium-Spirulan is a polymerized sugar molecule unique to Spirulina containing both Sulfur and Calcium (another important element often missing from many aquariums). In studies hamsters treated with this water soluble extract had better recovery rates when infected with what would be a lethal Herpes virus. This works because Calcium-Spirulan does not allow the virus to penetrate the cell membrane to infect the cell. The virus is stuck, unable to replicate. It is eventually eliminated by the body's natural defenses.

Several studies show Spirulina or its extracts can prevent or inhibit cancers in humans, animals, and fish. Some forms of cancer are the result of damaged cell DNA "out of control", causing uncontrolled cell growth. Cellular biologists have defined a system of special enzymes called Endonuclease which repair damaged DNA to keep cells alive and healthy. When these enzymes are deactivated by oxidation, radiation or toxins, errors in DNA go un-repaired and, cancer may develop. In vitro studies suggest the unique polysaccharides of Spirulina enhance cell nucleus enzyme activity and DNA repair synthesis. This may be why several scientific studies, observing experimental cancers in animals, report high levels of suppression of several important types of cancer.

A study published by the US National Library of Medicine has also demonstrated that Spirulina fusiformis has substantial potential to reverse the pre-cancerous lesions or wounds of the mouth known as leukoplakia. See: [http://www.ncbi.nlm.nih.gov/pubmed/8584455](http://www.ncbi.nlm.nih.gov/pubmed/8584455)

SPIRULINA ANALYSIS

Here is the general analysis of pure Spirulina Algae:

- Protein: 55%- 70%
- Carbohydrates: 15% - 25% (an excellent low ratio for fish)
- Fats (lipids): 6% - 8%
- Minerals: 6 -13%
- Fiber: 8% - 10%

Natural Pigment Enhancers:

- Phycocyanin (Blue): 14%
- Chlorophyll (Green): 1%
- Carotenoids (Orange/ Red): 47%

Important Trace Minerals (many of these are essential for proper electrolyte balance and osmotic function):

- Calcium (1,315 mg/kg), Iron, Phosphorus (15,400 mg/kg), Iodine, Magnesium, Zinc, Selenium, Copper, Manganese, Chromium, Molybdenum, Sodium, Chloride, Potassium, Germanium, Boron.

Essential Amino Acids:

- Isoleucine (4.130/o): Required for optimal growth, nitrogen equilibrium in the body Used to synthesize other non-essential amino acids.
- Leucine (5.8001o): increases muscular energy levels.
- Lysine (4.000/o): Building block of blood antibodies, strengthens circulatory system and maintains normal growth of cells.
- Phenylalanine (3.950/o): Stimulates metabolic rate.
- Threonine (4.170/o): Improves intestinal competence and digestive assimilation.
- Tryptophane (1.1301o): Increases utilization of B vitamins, improves nerve health.
- Valine (6.0001o): Stimulates muscle coordination.

- The bottom line as to Spirulina, is that this is an area where I have seen noticeable differences in fish health with Spirulina Algae and very new scientific research especially into biliverdin and its antioxidant properties further make the point that Spirulina based fish foods are a MUST for aquatic diets