Astaxanthin in Aquaculture

Salmonid and crustacean coloring is perceived as a key quality attribute by consumers. The reddish-orange color characteristic of such organisms originate in the carotenoids obtained from their feeds which are deposited in their skin, muscle, exoskeleton, and gonads either in their original chemical form or in a modified state depending on the species. The predominant carotenoid inmost crustacea and salmonids is Astaxanthin. For instance, from the total carotenoids in crustacean exoskeleton, Astaxanthin comprises 84–99%, while in the internal organs it represents 70–96%. In the aquatic environment, the microalgae biosynthesize Astaxanthin which are consumed by zooplankton, insects, or crustacea, and later it is ingested by fish, thereby getting the natural coloration. Farmed fish and crustacea do not have access to natural sources of Astaxanthin, hence the total Astaxanthin intake must be derived from their feed. The use of Astaxanthin as pigmenting agent in aquaculture species has been well documented through many scientific publications for more than two decades. Astaxanthin is widely preferred due to the higher color intensity attained with similar concentrations. Additionally, Astaxanthin is deposited in muscles more efficiently probably due to a better absorption in the digestive tract. In spite of the fact that Astaxanthin is widely used with the sole purpose of attaining a given pigmentation, it has many other important functions in fish related mainly to reproduction: acceleration of sexual maturity, increasing fertilization and egg survival, and a better embryo development. It has also been demonstrated that Astaxanthin improves liver function, it increases the defense potential against oxidative stress and has a significant influence on biodefensemechanisms.

Similarly, several other physiological and nutritional studies have been performed in crustaceans, mainly on shrimp, which have suggested that Astaxanthin increases tolerance to stress, improves the immune response, acts as an intracellular protectant, and has a substantial effect on larvae growth and survival. Astaxanthin is also a “semi-essential” nutrient for tiger shrimp (Penaeus monodon) because the presence of this compound can be critical to the animal when it is physiologically stressed due to environmental changes.

According to the above information, the use of Astaxanthin in the aquaculture industry is important not only from the standpoint of pigmentation to increase consumer acceptance but also as a necessary nutrient for adequate growth and reproduction of commercially valuable species.

Astaxanthin Content of Different Salmonids:

Genus		Farmed	Wild	Astaxanthin mg kg^{-1} flesh
Oncorhynchus nerka	Sockeye salmon		X	26 - 38
Oncorhynchus kisutch	Coho salmon		X	10 – 21
Oncorhynchus keta	Chum salmon		X	3 – 5
Oncorhynchus tschawyzscha	Chinook salmon		X	5.4
Oncorhynchus gorbuscha	Pink salmon		X	4 – 7
Oncorhynchus Masou	Masu salmon		X	4.6
Salmo salar	Atlantic salmon		X	3 – 10
Salmo salar	Atlantic salmon	X		1 – 9
Oncorhynchus mykiss[a]	Rainbow trout	X		0 - 25
Salvelinus alpinus	Arctic charr	X		1-8
Salvelinus alpinus	Arctic charr		X	8.6

Free and esterified astaxanthin in crustaceans, yeast Phaffia rhodozyma and Haematococus pluvialis (%):

Astaxanthin	Free	Diester	Monoester
Euphausia superba (Antarctic krill)	5	64	31
Thysanoessa inermis (Antarctic krill)	4	61	35
Calanus finmarchicus (Marine copepode)	11	46	43
Acanthephyra purpurea (Deap sea shrimp)	20	43	37
Cancer pagurus shell (Edible crab shell)	58	22	13
Phaffia rhodozyma (Red yeast)	100		
Haematococcus pluvialis (Alga)	5	59	22

Astaxanthin in Ornamental Fishes

Astaxanthin is able to get into the skin of species such as sea bream and many others tropical fish species better, consequently bringing out more vibrant and natural-looking color in their skin. Astaxanthin is one of the primary sources of pigmentation in ornamental or tropical fish. Normally this carotenoid is obtained through Astaxanthin-containing organisms in the aquatic food chain, but commercial feed ingredients such as crustacean, yeast or algae meals (astaxanthin) are used as sources of Astaxanthin, which also enhance reproductive processes.

Astaxanthin Benefits in Mammals

Several studies have been done using Astaxanthin esters in mammals to prove its effectiveness in the treatment of muscle diseases, for example, exertional rhabdomyolysis or to increase the production of breeding and production mammals (equine, porcine, bovine, and ovine).

Horses

Equine exertional rhabdomyolysis is an acute disease that is potentially fatal. It manifests in the destruction of muscle which occurs because of a shortage of oxygen transporting to the muscles and a lack of protein storage in the muscles. This affliction can end the career or even kill a thoroughbred race horse in its prime. A very positive study was done on race horses with this horrible disease. They were supplemented with 30 mg of Astaxanthin per day, and after only two to three weeks the animals were symptom-free and able to continue training and racing.

Rodents and Dogs

An study demonstrated that Astaxanthin had “marked cardioprotective properties in both rodents and canines.” They concluded that, based on the excellent performance in dogs and rodents, Astaxanthin may be a means to prevent heart damage from myocardial injury.

Pigs, Cattle and Sheep

Astaxanthin improved three separate markers of fertility in livestock animals: The birth rate, the percentage of live births and the number of born animals. Astaxanthin also can help protect the lens of a pig’s eye against oxidative damage.

Rabbits

Astaxanthin was superior to Vitamin E in helping to stabilize plaque in the arteries, and concluded that it could be useful in the fight against atherosclerosis.

Minks

Astaxanthin showed a positive effect on live births of baby minks. It was documented that Astaxanthin given to the mothers significantly reduced the number of stillborn births.

Poultry

The administration of Astaxanthin to layer hen diet increases fertility, improves the overall health status of these animals, and decreases chicken mortality. Egg production and the yellow coloration of yolks is also increased,while salmonella infections reduced dramatically probably due to a stronger membrane formation. It also provides greater pigmentation to chicken meat, a desirable attribute to some consumers.

Potential benefits in animals

- Prevents cancer
- Reduces tumor size
- Promotes cardiovascular health
- Improves immunity
- Prevents diabetes
- Increases stress resistance
- Inhibits H. pylori bacteria
- Reduces gastric ulcerations
- Aids the liver in detoxification
- Prevents cataracts
- Protects the eyes and brain
- Decreases pain
- Increases endurance
- Improves fertility
- Reduces stillborn deaths
- Prevents DNA damage
- Prevents cell membrane damage
- Prevents enlargement of lymph nodes
- Improves growth rate in young animals
- Improves survival rate