

KHA Training Program

Nutrition Module

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7th April 2002

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A Word of Thanks and Acknowledgements

During the course of writing the Nutrition Module for the KHA program, I have attempted to cover all pertinent points related to nutrition. The more I researched and wrote, the more I worried that somewhere I had left something out.

Therefore, this section will be a dynamic one (together with the Filtration Section). As information becomes available and new discoveries are made so we will amend sections and improve on them.

The Nutrition Section was review by a group from the Curriculum Review Committee plus an outside expert enlisted by Chris Bushman.

I thank the following for their positive contributions to the finished document -

Richard Carlson

Chris Bushman

Duncan Griffiths

Spike Cover

Dr. Mark Griffin of Purina Mills

To each and every one - thank you all for your input.

I wish to thank Professor Dominique P. Bureau for his kind permission to use the excellent paper -

"An Introduction to Nutrition and Feeding of Fish" by Professor Dominique P. Bureau and Professor C. Young Cho of the Fish Nutrition Research Laboratory, Dept. of Animal and Poultry Science, University of Guelph, Guelph, Ontario, N1G 2W1, Canada"

as a frame work for this document. Several paragraphs are verbatim excerpts.

Candidates are encouraged to visit : <http://www.uoguelph.ca/fishnutrition>

Chris Neaves - April 2002

Introduction

For fish in captivity, nothing is more important than sound nutrition and adequate feeding. Fish in captivity have been cut off from natural sources of nutrition. Our ponds are literally miniature sections of natural streams. But there are not the massive volumes of water to ensure a continuous supply of food.

If the fish do not consume the feed or if the fish are unable to utilize the feed because of some nutrient deficiency, then there will be no growth. Further, an undernourished organism cannot maintain its health and be productive, regardless of the quality of its environment.

No matter the genetics of the koi or the sophistication of the filter system or the amount of oxygen in the water or the size of the pond – our koi cannot reach their potential with out correct nutrition over a sustained period of time.

Koi are literally coloured carp (*Cyprinus Carpio*). The earliest mention of the cultivation of carp in history appears to refer to China at least 2500 years ago. However, there are fossil remains of fish of the carp family dating back millions of years. Having successfully survived millions of years, the carp families feeding habits and nutritional requirements have been shaped accordingly.

In some unsympathetic quarters, carp are often referred to as the 'pigs' of the fish world. Their ability to consume and assimilate virtually anything has accorded them this indignity. Their ability to assimilate a large variety of food substances has great advantages for the hobbyist.

Koi are bottom feeders. In their natural environment a koi's intake of nutritional substances is extremely varied. As they browse around their environment using their barbels as sensors koi consume small amounts of food continually through out the day. If we can approach replication of these two basic facts, we will be along way towards successful koi nutrition.

Nutrition plays a vital role in the health of koi. **Therefore, you must remember that your koi are dependent on you to provide them with sound nutrition.**

As nutrition is directed at health and growth a basic discussion on these subjects is necessary.

CHAPTER 1: GLOSSARY - DEFINITIONS

As they relate to koi nutrition -

Amino acids

The molecules from which proteins are built, each protein being composed of a specific sequence of linked amino acids.

Amino acids are the 'construction material' from which protein is made. There are two groups - essential: the critically important amino acids which the body cannot manufacture (lysine, tryptophan, threonine, leucine, isoleucine, histidine, arginine, methionine, phenylalanine and valine) and non-essential: amino acids which can be synthesized by the body if enough building blocks are available (amino groups and carbon skeletons, usually from other amino acids-such as cysteine, tyrosine, arginine, glutamic acid, carnitine, histidine and glutamine).

Amino acid profile

The pattern and proportion of essential and nonessential amino acids in a protein.

Antigens

A substance, which is not normally found in the body, but which, if introduced to the body, will challenge the immune system so producing an immune response. Continued use of antigens may result in the body adapting and becoming immune to the stimulus.

Antioxidant

A substance which prevents the formation or mitigates the formation or action of oxidizing agents, free radicals, known to cause cancer and ageing of cells

A chemical or substance added to feedstuffs to stop fats breaking down. Vitamin E is a commonly used anti-oxidant in fish feeds.

Any substance that inhibits oxidative damage (oxidation of biological molecules creating 'free radicals').

Antioxidants work primarily by donating or "sacrificing" an electron to the free-radical thereby stabilizing the free-radical.

Ascorbic Acid

Vitamin C is a water soluble vitamin important for many essential processes of the body, including wound healing, the function of the immune system, and formation of many connective tissues (spine, skin,

blood vessels and others) A lack of Vitamin C can cause abnormalities of the spine and a reduction in the ability of the body to heal wounds.

Vitamin C in its pure form is easily oxidized and therefore has a short shelf life.

A stabilized (synthetic) form of Vitamin C is now available in better quality koi feeds.

Ash

Ash is the sum of all of the dietary minerals. It is determined by burning off all of the organic material. What is left over, the "ash", is the mineral component.

Astaxanthin

Astaxanthin are naturally occurring carotenoids. It is the principal pigment that gives the red colour on koi a boost.

Balanced Diet

A diet that has all the nutritional requirements, in the correct proportions.

Canthaxanthin

Canthaxanthin - a naturally occurring carotenoid used to enhance the red.

Carbohydrate

Carbohydrate is the general term for compounds such as sugars (animal energy storage), starches (plant energy storage) and cellulose (plant structural material) that contain carbon, oxygen and hydrogen. Many carbohydrates can be used as an energy source by animals, although some are difficult to digest and so release only small amounts of energy to the body. Bacteria in the gut of animals are responsible for the digestion of plant materials by herbivores. Healthy guts of healthy animals contain bacteria.

Carcinogen

Any substance that either produces or accelerates the development of cancer.

Carotenoids

A group of yellow, orange and red lipid soluble pigments with a similar chemical structure to Beta Carotene. Some carotenoids may be converted to vitamin A by animals. Beta carotene is simply two Vitamin

A molecules linked together. See also astaxanthin, canthaxanthin & spirulina.

Catabolism

Any destructive metabolism by which organisms convert substances into excreted compounds. Alternatively described as - the breaking down in the body of complex chemical compounds into simpler ones (e.g., glycogen to CO₂ and H₂O), often accompanied by the liberation of energy.

Color Enhancers

See : carotenoids - Astaxanthin - Canthaxanthin

Colorants

Colorants in koi food are used purely for commercial purposes. There is no nutritional value in colorants used to give the pellets an appealing look.

Diffusion

The ability for a dissolved substance to migrate across a membrane from a high to a lower concentration i.e. salt

Ectotherm

See poikilothermic

Essential Fatty Acids [EFA] (Omega-3 and Omega-6)

These are required in the diets of fish mainly to maintain the structure and integrity of the phospholipid cell membranes. Essential for cells (all cell membranes consist of fatty acids). EFA's need to be consumed via the diet.

The fatty acids in fish are more unsaturated, whereas those in land animals are more saturated.

Extruded

Food (usually moist and pre cooked) that is pushed through a die (under pressure) to give it a desired, consistent shape such as a pellet. Extrusion methods are used in the production of floating pellets.

Faeces

The solids excretion from fish. The faeces of most aquatic animals are enclosed in a membrane. The removal or settlement of the faeces, whilst this membrane is in tact, is relatively straight forward as it is a

large, dense particle. If the membrane is broken and the faeces decays, the removal of the waste from the water becomes much more difficult as the particles are much finer.

Fat

Fats or lipids are the most concentrated form of energy in the diet. In addition to providing energy they act as a carrier for the fat soluble vitamins A, D, E and K.

Feed formulation

The raw ingredients that make up a feed. This must be a balanced diet. See balanced diet.

Many manufacturers use the "least cost" method, where the ingredients of a feed may change regularly according to the availability and price of different feedstuffs, but the final formulation of the feed (in terms of percentage and overall quality of protein, fats etc.) will remain constant.

For example, it may be more economic to purchase a 50% mix of low quality protein and high quality protein one week, but due to availability and cost changes, the following week it may make more sense to purchase 80% medium quality, 10% low quality and 10% high quality protein.

Feeding Ring

A floating or supported ring on the water surface into which a floating diet is delivered. The ring prevents the feed from floating away.

Free Radicals

A chemical reactive molecule.

Consist of 'electrically charged compounds of oxygen' that exist within the body and which are damaging to normal physiological functioning. Free radicals are dramatically increased when there is stress, disease, trauma, and tissue damage. If not neutralized, free radicals work against the immune system, and play a major role in the development of some diseases.

Free radicals exist in unnatural, and unstable chemical states which causes them to trigger off self-perpetuating chain reactions in which the structures of millions of molecules are altered. These wreck havoc and damage the compounds of proteins, free amino acids, lipids, lipoproteins, carbohydrates, nucleic acids and connective tissue.

The method to counteract free radicals is to use antioxidants (also known as 'free radical scavengers') in the diet. Antioxidants neutralize free radicals and protect against the ongoing oxidative destruction.

Natural antioxidants found in koi food are Vitamin E, carotenoids and Vitamin C. Vitamin E and the carotenoids are fat soluble antioxidants, whereas Vitamin C is a water soluble antioxidant.

Lipids

A large group of compounds that contains fats and oils. See: saturated, polyunsaturated, EFA (essential fatty acids).

Live Feed

The term live feed can be used to describe naturally occurring animals which are produced (usually under artificial, controlled conditions) for feeding fish.

Omnivore

A living creature that eats both vegetable and animal matter as part of its diet. Koi are omnivores.

Osmoregulation

The process that controls the rate of osmosis. It normally refers to the transfer of water through cell structures based on the salinity of the "outside" water and the "inside" cell structure. Water with lower salinity levels will move to fluids with higher salinity levels.

The two major osmotic and electrolyte problems in freshwater fish are the elimination of excess water and maintaining the proper salt concentrations within their bodies. This process is sometimes termed "osmoregulation."

Osmosis

The passage of water through a semi permeable membrane into a solution. With respect to koi, the process of moving the pond's water through the gills and into the blood stream is the most prominent example of osmosis.

The process by which an animal maintains its correct balance of fluid/water in its body

Palatability

The attractiveness, in terms of taste, of a feed substance.

Pheromones

A chemical substance emitted by an organism as a specific signal to another organism, usually of the same species. Hormones or pheromones play an important part in the spawning as well as influencing other fish in

the pond. Various types of pheromones are excreted and can influence all the fish in the pond, especially if stocking densities are high. The pheromones are usually volatile organic acids or alcohols and are effective at minute concentrations.

Phospholipid cell membranes

A layer of unsaturated lipid that surrounds body cells in fish. Enables the transfer of nutrients across the cell wall. In coldwater species, more unsaturated fatty acids must be fed to ensure the lipid in the layer remains fluid. See EFA.

Protein

Protein is the principal constituents of the protoplasm of all cells and consists essentially of combinations of amino acids in peptide linkages.

Twenty different amino acids are commonly used to build proteins.

Protein substances in the body are essential to its structure and function for the building and repair of all kinds of body tissues. Structures such as cell walls, various membranes, connective tissue, and muscles are mainly protein. None of the cells of the body can survive without an adequate supply of protein, in fact, proteins constitute about 20 per cent of the cell mass.

Phosphorous

Non metallic element. Phosphorous is an essential element for living organisms, found in the tissues (especially bones and teeth) and cells. Excreted by fish as a result of more phosphorous being available in the feed than the fish requires. Excessive phosphorus or a high phosphorus/calcium ratio in the feed can lead to a loss of calcium, especially from bones.

Phosphorous is often the limiting nutrient in relation to algal blooms and plant growth. Excessive amounts of phosphorous released into the water can therefore, increase the plant growth in a pond.

Poikilothermic

Cold blooded – i.e. temperature of the animal mirrors that of the water environment. The animal's temperature remains approximately 0.2 - 0.5°C above that of the environment. Even though fish are cold blooded, they still produce some heat. In most fish species, this heat is lost into the environment around them.

Polyunsaturated Fatty Acids (PUFA)

A fatty acid with more than one double bond (see EFA). As fish have a high percentage of polyunsaturated fats, fish meal is generally used as a source for diets. Used for phospholipid cell membranes.

Probiotic

Probiotics are live microbial feed supplements which beneficially affect the host animal by improving its intestinal microbial balance. Antibiotics and other related compounds are not included in this definition.

Rancid

Having the disagreeable and repugnant odor or taste of decomposing oils or fats. Rancid fats are not healthy to feed to an animal.

Spirulina

Spirulina is a naturally occurring algae which is now grown commercially. It is used as a dietary component for both animals and humans. It contains many fatty acids, vitamins and minerals and has high levels of carotenoids and protein

Starch

A polymer of glucose synthesized by plants.

Vitamin

General term for micronutrients essential for normal regulation of metabolic processes but do not provide energy or serve as building units, and are present in natural foodstuffs. Some vitamins cannot be synthesized in sufficient amounts by some species; others cannot be synthesized at all and must be obtained in the food. They occur in the multiple and diverse source of foodstuffs found in nature.

CHAPTER 2: FACTORS AFFECTING KOI GROWTH

There are several critical factors affecting the growth of all koi - genetics, temperature, oxygen levels, the excretion of growth hormones and nutrition.

No matter what we do and irrespective of pond specifications, the vast majority of koi simply cannot grow much bigger than about 23 - 25 inches (60 - 65 cm). The number of jumbo koi in the world above 30 inches (75 -80cm) is limited - relative to the number of koi available on the commercial market. This is one of the reasons for large, high quality koi being very expensive.

At the 2002 All Japan Koi Show a Sanke of 1.01 meters (just on 40 inches) won Grand Champion. There were over 45 koi above 85 cm considered for Grand Champion.

Genetics

Genetics will determine the final size of the individual koi.

Individual genetically determined growth potential, which is influenced by bloodlines, is the great leveler of the playing fields when it comes to koi growth and the ultimate size the fish will attain. We tend to assume that all koi from a certain parentage will grow large. We assume that all koi have the potential to grow to a meter long. This is not true. Nature in her infinite variety and beauty has imbued each individual koi with certain characteristics through the genes that are passed on from parents to off-spring.

Each individual koi cannot reach a size greater than its individual maximum genetic potential, but the actual size that a koi will reach is ultimately determined by many environmental and nutritional factors.

Temperature

Temperature is one of the critical factors affecting koi growth rate. High water temperatures plus high protein diets (above 36% protein) will produce a faster growth rate. The lower the temperature, the lower the growth rate, in part because their metabolism is slower and their bodies cannot assimilate the nutrients in the food as fast as at higher temperatures. On the other hand, they will need to consume much lower levels of food (nutrients) at lower temperatures because their body metabolism slows down. Digestion enzymes and function changes at lower temperatures. Koi digest food poorly below 50° F, and do not digest some fats well, when the temperature is below 60° F.

Without warm water koi will not grow. Temperature is one of the critical factors affecting koi growth. High water temperatures plus high protein

diets (above 36% protein) will produce fast growth. At lower temperatures their bodies cannot assimilate the nutrients in the food they consume. Further, they will consume much lower levels of food (nutrients) at lower temperatures as their body metabolism slows down.

The optimal water temperature for koi keeping is 70 - 80°F (22 - 28°C). At this temperature there is maximum growth for a given amount of food ratio. However, above this temperature there is a fall in the conversion of food to energy and growth because of the relative fall in available oxygen levels.

Increasing oxygen levels and utilizing high temperatures along with a quality diet, can achieve excellent growth rates. At the high end of the koi temperature range, koi are stressed and will be more susceptible to breakdown and disease.

Koi Health Advisers should note that koi tolerate temperatures lower as well as higher temperatures than the "ideal" very well - provided the changes are not too large or too fast. However, when water temp goes above 85° F, the growth and food consumption is slowed down, no matter how much oxygen is added to the water.

Oxygen

The amount of dissolved oxygen in the pond water will be one of the limiting factors in achieving growth in a koi. Dissolved oxygen is critical for the growth and health of koi. For koi to remain healthy, adequate oxygen levels must be maintained (typically at least 5 - 6 ppm) The higher the oxygen levels in the water the healthier the koi will be and the more efficient the bioconverter will work. Koi are extremely efficient at extracting O₂ from water and can do so at very low levels. However, koi do well in water with dissolved oxygen levels above 6ppm.

The life functions of koi are similar to those of other animals in that they have muscles, skeletons, skins and internal organs which function in approximately similar ways. There is, however, one great difference between fish and land animals - fish live in water. More importantly to our circumstances, koi living in a pond, live in a *limited* volume of water. There is not endless fresh water with endless oxygen and fresh food, only the water in the pond surrounding the fish.

The whole pond system from the koi to the bacteria in the filter is completely dependant on oxygen for survival. All the various forms of life in the pond are competing with what is essentially a limited supply of oxygen. While the atmosphere has around 250 parts per million (milligrams per litre) water typically has less than of 8 - 10 parts per million.

It is an undisputed fact that koi have better growth, live longer and their colours are brighter and more intense in oxygen rich environments. It is also an undisputed fact that biological filtration is more efficient and flourishes in an oxygen rich environment.

Oxygen levels are dependent on various factors - these are discussed in detail in another sections of the KHA course.

Growth Hormones

Koi, like all living organisms, have a limit to their growth potential. The growth of koi begins immediately after the eggs hatch. For the first few years of their lives they produce growth hormones within the body. This is the period of maximum growth potential. Without correct nutrition during this initial period of the fishes life the fish will not grow to its full potential. The production of growth hormones gradually decreases after about 3 - 4 years. Around 5 - 7 years the growth is slowed. Many may still continue to grow until 10 to 12 years old but at a greatly reduced rate.

Koi are usually placed in mud dams or are encouraged to grow quickly during the first three or so years of their life spans. These are the years when the body has the maximum growth hormones available. After this time growth usually slows dramatically.

Nutrition

Good nutrition (in combination with temperature, oxygen, good water quality and genetic potential) from hatching, is possibly the most critical factor in achieving growth. For most koi, this will mean supplementing the natural environment with food, although koi in shallow ponds will have more natural food available than koi kept in deep ponds. However, deep ponds will protect the koi better than shallow ponds from temperature extremes and freezing. (Review the pond design section.)

Underfeeding of quality food, is one of the main reasons that maximum growth rate is not achieved in koi. This growth / nutrition link must be achieved early in the fish's life during the period when the fish can grow rapidly.

Nutrition and Health

The continuous intake of food sources that have the various substances needed by living organisms, is critical for the health of the organism. Koi need continuous quality food from a very young age.

Proper nutrition aids in the development of the immune system, strengthens the bones stimulates the blood etc. etc. Food deficient in vitamin C for example, has been associated with poor growth, spine and blood disorders. Food with increased levels of vitamin C has been

demonstrated to improve the general health as well as the healing time of sick koi.

Mention is made of vitamin C as an example because natural vitamin C degenerates very rapidly in fish food. In fact, only 90 days after manufacture, natural vitamin C may have degenerated to only 30% of its original strength. In extruded diets, more than 75% of what was mixed into the diet can be denatured in the extrusion process itself. Therefore, it is essential that a stable form of vitamin C be used.

Some koi foods may be old before we receive them. Some koi foods are not date coded, therefore there is no way to determine how old it is - it may be 1 week old, or it might be 5 years old.

My Koi Are Not Growing?

If all the factors related to koi growth are in place and your koi are not growing then there are several possibilities:

1. The **genetics** is a limiting factor. That individual fish cannot and will not get any larger. Just as with humans so with the koi. Each individual grows to a different size.
2. The koi you have purchased is **old**. It may look young because it is small, but the fish is past the age when it has the capability to grow significantly.
3. There are **excessive pheromones** in the water. Pheromones can suppress the growth of other koi in the pond or even suppress the immune systems. Usually found in over crowded pond situations or in pond situations where fresh water changes (out) are minimal or not done at all. Try removing the koi that does not grow into a different pond situation. If it still does not grow then genetics is in all probability the answer.
4. Water **temperatures are low** or **oxygen levels are low**.
5. **Physical crowding**. Try removing some of the fish to give the others more space.

Summary – Chapter 2

Genetics will determine the maximum size of the individual koi at any stage of its growth up to and including its final size.

Temperature is one of the critical factors affecting koi growth rate.

In general, warmer water promotes better growth up to about 80 F.

In general, more oxygen in the water is better for growth up to the point of saturation.

The amount of dissolved oxygen in the pond water is one of the limiting factors in achieving growth in a koi. Dissolved oxygen is critical for the growth and health of koi.

For the first few years of their lives koi produce growth hormones within the body. This is the period of maximum relative growth potential.

Good nutrition, from hatching, is possibly the most critical factor in achieving optimum growth.

Reasons for koi Not Growing

The *genetics* is a limiting factor.

The koi is *old*.

There are *excessive pheromones* in the water.

Water *temperatures are low* and/or *oxygen levels are low*.

Physical crowding.

CHAPTER 3: DIETARY REQUIREMENTS OF KOI

Koi, like all living creatures, require certain amounts of nutrients in the diet on a regular basis. Nutrients are necessary for cell growth, energy, food utilization, and organ function. The five important nutrients are amino acids (protein), lipids (fat), carbohydrate, vitamins and minerals.

Amino Acids

Protein is not required in the diet per se. Protein provides the amino acids that are necessary. Protein in body tissues incorporate about 23 amino acids and among these, 10 amino acids must be supplied (essential amino acids) in the diet since fish cannot synthesize them. Amino acids are needed for maintenance, growth, reproduction and replication of tissues.

A large proportion of the amino acid consumed by a fish is catabolized for energy. Fish are well adapted to using an excess protein this way. Catabolism of protein leads to the release of ammonia, which up to 70% is excreted across the gills.

Protein is the most important component of the diet of fish because protein intake generally determines growth. Koi diets generally contain 32-38% protein.

Natural diets are generally plankton, invertebrates, worms etc. These are generally rich in protein and have a good amino acid balance. All dietary proteins are not identical in their nutritive value. The nutritional value of a protein source is a function of its digestibility and amino acid makeup. A deficiency of indispensable amino acid creates poor utilization of dietary protein and hence growth retardation, poor weight gain, and feed efficiency.

In severe cases, deficiency reduces the ability to resist diseases and lowers the effectiveness of the immune response mechanism.

Why do koi have such high requirements for protein? The main factors explaining this phenomenon:

- 1) The protein requirement in terms of dietary concentration (% of diet) is high but the absolute requirement isn't (g/kg body weight gain). This is due to the fact that fish have a lower absolute energy requirement than mammals.
- 2) Protein (amino acids) is used as a major energy source. Some economy can be made here if other dietary fuels are present in adequate amounts, e.g. increasing the lipid (fat) content of diet can help reduce dietary protein (amino acid) catabolism and requirement. This is referred to as the protein-sparing effect of lipids. Protein-to-useful-energy ratio is the factor that should be

considered, not % protein of the diet per se.

Indispensable (essential) amino Acids

Indispensable amino acids are - Phenylalanine (Phe) : Histidine (His) : Isoleucine (Iso) : Leucine (Leu) : Lysine (Lys) : Methionine (Met) : Tryptophan (Trp) : Valine (Val) : Arginine (Arg) : Threonine (Thr)

Lipids (Fats)

Lipids (fats) encompass a large variety of compounds. Lipids have many roles: energy supply, structure, precursors to many reactive substances, etc. In the diet or body of fish, lipids are most commonly found as triglycerides, phospholipids and, sometimes, wax esters.

Deficiency in essential fatty acid result in general, in reduction of growth and a number of deficiency signs, including depigmentation, fin erosion, cardiac myopathy, fatty infiltration of liver, and possibly a loss of consciousness for a few seconds following an acute stress.

Carbohydrates

The carbohydrate most commonly found in fish feed is starch, a polymer of glucose. Many fish have a poor ability to utilize carbohydrates. Raw starch in grain and other plant products are generally poorly digested by fish. Koi do not process carbohydrates well and as such, carbohydrates constitute only about 30% of the koi's nutritional requirements.

Cooking of the starch during pelletizing or extrusion, however, greatly improves its digestibility for fish. However, even if the starch is digestible, fish only appear to be able to utilize a small amount effectively. Carbohydrates only represent a minor source of energy for fish. A certain amount of starch or other carbohydrates (e.g. lactose, hemicellulose) is, nevertheless, required to achieve proper physical characteristic of the feed.

Carbohydrate - another Perspective

Once you have the protein, energy, vitamin and mineral levels necessary in a feed formulation you have to deliver this food to the fish's gut. The traditional and successful method has been to suspend these nutrition ingredients in a digestible binder - carbohydrate. This mixture is then processed into a pellet or paste food. Flour, wheat, starch are some such carbohydrates used to bind the food into pellets or paste foods.

The starch (carbohydrate) is largely the medium to carry the ingredients in a stable form.

Vitamins

Vitamins can be equated to the spark plugs in an engine. It is the spark that ignites a reaction. Vitamins regulate the metabolism through enzymes. Vitamins are components of the enzyme systems that, acting like spark plugs, energize and regulate the metabolism.

The vitamins are generally defined as dietary essential organic compounds, required only in minute amounts, and which play a catalytic role, but no major structural role.

For KHA candidates the best indicator of low vitamins is old food and food of low quality.

Minerals

Vitamins alone are not enough. As important as vitamins are, they cannot function without minerals. Although the body can synthesize some vitamins it cannot manufacture a single mineral.

Inorganic elements (minerals) are required by fish for various functions in metabolism and osmoregulation. Fish obtain minerals from their diet but also from their environment. Many minerals are required in trace amounts and are present in sufficient quantity in the surrounding water for the fish to absorb through their gills. In freshwater, there is generally sufficient concentration of calcium, sodium, potassium and chloride for the fish to absorb from the surrounding water and cover its requirements.

A good case for regular water changes is the fact that the minerals will be replenished.

Koi require certain minimum levels of nutrients in the diet on a regular basis.

Nutrients are necessary for cell growth, energy, food utilization, and organ function.

The five important nutrients are:

1. Protein provides the necessary amino acids. Good Koi diets generally contain 32-38% protein.
2. Lipids have many roles: energy supply, structure, and precursors to many reactive substances.
3. Carbohydrate is most commonly found in fish feed as starch, a polymer of glucose. Heating (cooking) greatly improves its digestibility for fish. Starch is the glue that holds koi pellets together.
4. Vitamins are generally defined as dietary essential organic compounds, required only in minute amounts, and which play a catalytic role, but no major structural role.
5. Minerals are obtained from the diet and also from the environment.

CHAPTER: 4 FEEDING KOI

Why Fresh Food is So Important

The freshness of the food you feed the fish is very important for their health, growth and well-being. Age will degenerate even the most heavily preserved food. Old food will have lost much of its nutritional value.

Unless manufactured dates or sell by dates are printed on packets it is very difficult to know exactly how fresh or when the food was manufactured.

Some large fish food companies would manufacture large amounts of food to reduce costs. This is then stored and exported.

Koi food that is old loses its effectiveness. Vitamins degenerate rapidly in koi foods (within months). Vitamins that have degenerated are no longer present in the required quantities. Without sufficient vitamins proteins do not function to their full potential. Oils will become rancid with contact with the oxygen in the atmosphere. Without oil levels energy is not provided and the balance in the formulation will be lost.

The formulation or balance of the ingredients of the food is calculated so that the protein, vitamins, minerals etc. will be at the required level *after* cooking and extrusion.

However, the cooking process increases the digestibility but destroys a portion of the vitamins and minerals present in the actual food ingredients. Adding a vitamin and mineral pre-mix to increase their levels before extrusion, compensates for this.

The vitamins are extremely vulnerable to degeneration, one of the first being Vitamin C. A few years ago vitamin C would start degenerating within weeks of manufacture. Now heat stable, long lasting vitamin C is added to koi food.

Oil, so necessary for energy and proper utilization of the protein content, will go rancid after time. Many anti-oxidants are used in koi food to delay these processes. But it can never be stopped.

Any additional moisture will activate any of the ingredients in the food with the disastrous production of toxic substances.

Therefore, food that is more than 9 months old should be viewed with great suspicion - no matter the claims of the selling agents. *When in doubt - throw out.* Food older than 9 months should be thrown away.

Temperature and Feeding

Growth in koi occurs above about 59°F (15°C). Below about 59°F food intake is greatly reduced as the fish's metabolism is greatly slowed.

Below 50°F the amount of food given should be strictly limited and even stopped. A few weeks without food at very low water temperatures is healthier for koi, in the long run, than food sitting in the gut that cannot be digested. It can even lead the food fermenting and producing toxins.

At low temperatures Koi will simply not eat more than the body needs. As the metabolism slows down the intake of food is gradually reduced. Throwing in more food than the fish consume is poor water quality management. Uneaten food will heavily pollute the pond and bio-converter system even to the point of the fish being poisoned by the degeneration in water quality.

There are claims that in winter the type of food given to the fish should change from an animal based protein to a vegetable based protein food. The protein content of many of the plant based koi foods - e.g. wheat germ type feeds, are as high as animal based protein koi foods. Some wheat germ koi foods have a 24% protein level whilst others have around 32 - 34% protein.

It is claimed that vegetable protein is more easily digestible than animal protein. In reality protein from plant sources is more difficult to digest. However the extrusion process uses heat to cook the food. This increases the digestibility of the ingredient.

In winter the protein and energy requirements are greatly reduced because of the lower metabolism.

Digestion Time

Koi usually take 4 - 5 hours to digest (pass through the gut) their food at 68°F (20°C). It will be faster at higher temperatures and slower at lower temperatures.

Feeding Methods

In their natural environment koi are bottom-feeders by nature. However, they are capable of ingesting food in any manner. Some fish suck their food, so do koi. Some fish chew at their food, so do koi. Some fish feed on the surface, so do koi. Others feed off the bottom, so do koi.

Koi consume food in small quantities throughout the day in mud dams where they are grown rapidly. When temperatures are higher feeding several times a day will produce better results in terms of growth than if the collection is fed once a day.

Most koi keepers prefer to feed floating pellets for several reasons. Firstly, floating pellets encourage the collection to the surface to the delight of the keeper. Secondly floating pellets keep out of the bottom

drains and filters and can be easily skimmed off the top if not eaten. Thirdly, it affords the koi keep the opportunity to regularly inspect the koi to determine their health. Feeding time is often the very best time to determine if there is a problem (i.e. disease or water quality).

Fourthly, floating diets are extruded, which have the best carbohydrate digestibility.

Storage of Food

Koi food should be stored in cool, dark and dry places. Sunlight, moisture and oxygen will speed up the process of degeneration of the ingredients.

The longer a packet of koi food is exposed to the atmosphere the less the nutritional value. Many vitamins, the lipids as well as the protein become unstable when exposed to oxygen.

After opening a large packet of koi food it is suggested that you re-pack the bulk of it into smaller bags and seal them to keep the food fresh. If necessary store food in a fridge. Having a plastic bin or container that can seal is a good idea and will help to keep the food fresh. Food stored cold must be brought up to room temperature before the container is opened. If it is not, water will condense on the food creating a potential spoilage problem.

Koi food should never be stored where it may become damp. This includes the concrete floor of the garage. Moisture in sufficient quantities will seep through the concrete floor to dampen the koi food. Therefore, ensure the food has been stored an inch or two off the floor.

Any food that has become damp for a period of time should be discarded. Rancid food can have a long-term effect on the health of koi. Disease problems may only occur many months or years after feeding rancid food.

Food that appears to have mildew or fungus on it has become damp at some stage or the other and should be discarded. When storing feed avoid humidity and dampness. Always close / seal the packets / containers after feeding.

When in doubt - throw out! It is cheaper to discard a few kilograms of food than replace a fish collection.

Packing

Much effort has been used by brand name koi food manufacturers in packaging their products in high-class packaging which keeps koi food fresher for longer. It is a fact that most of the high quality brand name koi foods have excellent packaging – not only for marketing but also for

shelf life. In recent years many advances in packaging have resulted in fresher products being available to the consumer for longer periods of time.

Type of Feed

Green pellets or red pellets? Large or small pellets? Paste food or pellets?

The color of the pellet is purely for commercial reasons – food manufacturers are selling pellets to you and not the fish. The color of the pellet has absolutely no nutritional value what so ever.

Large pellets can be fed to larger koi and smaller pellets to smaller koi. However, by dampening large pellets these can be fed to koi of all sizes. There is no difference between paste food formulations and pellet formulations. Paste foods should go through the same process as pellets and then be ground up to the powder form. This is necessary to gelatinize the carbohydrates.

Feeding Young Koi

When koi are young they require a higher protein content in the food. Above 35% of high quality protein will ensure fast growth.

Koi do very well on feeds containing 35 – 38% protein. This is high quality animal or plant protein.

Feeding Older Koi

Koi older than 5 or 6 years can be fed koi food with 32% protein. However, many hobbyists have excellent results by continuing to feed the koi on the 35 – 38% protein diet.

Pellet Size

Different sized pellets are available for koi. Feeding small pellets is a good technique for making sure different sized fish get a portion of the food. Small pellets fit through certain types of auto-feeders easier but the big fish have to work a bit harder for a meal.

However, one sized pellet can be fed to large and small koi. Soften large pellets in a cup of warm water for a few seconds. Throw the water away and leave the pellets to stand for a few minutes. The pellets become soft but still maintain their shape. These can then be fed to small as well as large koi.

Only dampen the amount of feed to be given to the collection for that day. Do not keep damp pellets for longer than a day as the moisture will activate the ingredients.

Paste feeds can be given to all sizes of koi. These are easy to handle and easy for the koi to ingest. Paste food has to be moistened.

Feeding Times and Rates

As koi do not have a stomach to store food, the best results for growth and health will be obtained by equating nature. A measured amount of food for the day should be fed during the course of the day and not at one single time. Feeding small amounts several times a day will be more beneficial to the koi and will produce the desired results.

It is always a good idea to indicate in some way to your koi that they are about to be fed. Clapping your hands as you approach the pond just before feeding will attract them to the edge every time you approach the edge, much to the delight of the onlooker.

Try to work out a varied and balanced regime to your feeding program. If you are feeding different types of food, alternate these over the course of a week. However, one single feed of a particular type of food will not affect the koi in any significant way. Correct nutrition over a period of time is the key.

Feeding three or four times a day will produce good results in terms of growth. It was found that growth rates increased by 60% when koi were fed three times a day as opposed to once a day.

Catching Up

It is vital that koi, as all creatures, receive quality nutrition from an early age. Younger koi will require more protein in their feed.

If the first few years have passed with poor nutrition it is very rare that koi can "make up" this loss of critical growth period. They will remain smaller than other koi that have received good quality nutrition from the beginning.

This is one of the reasons why every effort is made to grow koi as quickly as possible in the first few years of its life.

Koi Color

We cannot deny that the color of our koi is of importance to us. There is possibly nothing more heart breaking to a koi keeper than having his prize fish loose color. Unfortunately there are many more myths than facts about koi coloring. It is a subject that has not been researched to the same degree as the other aspects of koi nutrition. It is extremely difficult to predict what the final quality of young koi will be as many of them improve with age because of the genetics.

Colour and Genetics

A koi's colour is genetically determined. We do not have any definite answers as to why some koi lose their colour and others improve. The reason why colours fade and blemishes appear on others has not been satisfactorily determined either.

How does one recognize koi with the basic colour pigmentation that one desires when this pigmentation can be dormant? A simple answer, at this point in time, is not available. However if you purchase a koi from a known bloodline and you are experienced in selection, there is every chance that you will have brilliant fish in your collection.

In other words - purchase a poor quality koi and the chances of it improving are slim indeed. Purchase a good quality koi and the chances of the koi improving are very much greater.

The operative word is 'chance'.

Explanations offered suggest that pH, water quality, shock, quality of food etc. all have some bearing on the color intensity. Shiro Utsuri (a black koi with white markings) is renowned for the black areas turning grey when under stress. It is also known that different foods have different results in different ponds.

Synthesising Colour in the Body

There are colours that koi can and cannot synthesize in the body. The typical red pigment can't be synthesized in the body. Consequently this has to be supplemented from the outside as a food supplement.

Living organisms (such as daphnia) with carotenoid pigment are widely distributed in the natural world. Therefore, koi consume these organisms from birth. The pigment is then accumulated in the cells through various processes of metabolism.

It is also known that some koi will inherently redden without special colour enhancers. Usually, the color of such koi won't fade even when they are kept in wild ponds.

The sumi or black can be synthesized in the body. This color is often deep in the skin when the koi are young. It is seen as a gray area or shade pattern beneath the skin. Over time the black pigment strengthens and comes to the surface.

Animal Sources and Plant Sources

Krill (i.e. animal source) and Spirulina (i.e. plant source) are the most popular source of colour enhancers.

If the proportion of krill in the feed is too high, damage to the white background is caused. Also, too much shrimp/krill has a laxative effect on fish, which is not desirable in large quantities.

Over Feeding Colour Enhancers

Over-feeding (over 5%) of color enhancers should be avoided, as this will affect the purity of the white areas causing yellowing. Regular, consecutive feeding of small quantities for a long term is necessary to produce good results.

Feed containing color enhancers should be given in water of more than 68°F (20°C). At lower temperatures the rate at which koi can metabolise the carotenoid decreases. This will produce rough skin and congestion in the koi.

Koi colour can be enhanced and developed with the addition of certain compounds in the feed. In natural environments, fish are constantly ingesting a variety of food substances. Many of these substances have elements that are stored in the skin and enhance certain pigment cells. One commonly used is spirulina.

Spirulina

Spirulina is an algae that contains more than 60% usable protein and has high levels of carotenoids. For comparison purposes soybean has 34% protein and meat has 22%. Spirulina is a useful ingredient for your homemade food.

Carotenoids

Carotenoids are dear to the heart of every Koi keeper because they help provide that all important color they strive for in their fish.

Carotenoids are a family of pigments with similar chemical structures. Many are useful to animals for coloration as well as for their antioxidant qualities when obtained from the diet.

Since your fish cannot produce carotenoids of their own, they must obtain them from their diet through natural sources such as plants, algae, worms or small organisms or through the feed you buy for them. Usually, an artificial environment, such as your pond, does not provide enough natural carotenoid-rich foods, so if you want your Koi to display vibrant reds and oranges you have to give it to them. Goldfish will turn a deeper reddish gold if fed carotenoid-rich food, and yellow fish may show an orangey tint. Different fish process carotenoids differently, it has a lot to do with their genetics. Koi are able to take these pigments and transform them into their color patterns.

The all-popular *Spirulina platensis*, a blue-green stringy algae, is a fine example of a natural carotene containing food. Therefore, a good Koi food will often contain this plant in dehydrated form, which does not alter its ability to provide, strengthen and fix their color. Not only is spirulina good for your fish in other ways as it contains vitamins, minerals and fatty acids, but it is also highly digestible and can be fed

at quite low temperatures. Incidentally, health food stores have packaged Spirulina for humans. Wonder why??

Many other ingredients besides Spirulina add carotenoids to your fish's nutrients. Some are synthetic, like the Xanthins seen on food labels (Asta-xanthin, Canthaxanthin, Zeaxanthin). Animal sources of carotenoids include shrimp and krill, but they usually contain a lot of ash due to their shells, so take care in not overfeeding your fish with these foods.

The absorption of dietary carotenoids works very effectively when water temperatures are high. Therefore colour enhancers are given at high temperatures above about 68°F or 22°C.

Immune-Stimulants

Koi foods, which contain additives to stimulate the immune system, are available. These additives are called immuno-stimulants or immunopotentiators.

The koi's immune system is temperature dependent. At low temperatures around 52°F (12°C) the immune system in koi is virtually not working. The metabolism is so slow at these temperatures there is effectively no immune system.

A disadvantage of feeding immune stimulants continuously is that the body will adapt to certain of the stimulants being fed. If the course of these immuno-stimulants is continued, the body adapts and the immuno-stimulants become ineffective and a waste of money.

Immuno-stimulants should only be fed in very controlled circumstances and for a limited time.

Immune system

The immune system is the body's **and it must be emphasized its best** defense mechanism against disease. The ancestors of koi developed in a relatively stable environment over millions of years. In this relatively stable environment, there was never any need to develop a highly effective system against environmental changes that cause stress in fish. Because of this, the immune system is, unfortunately, very sensitive to environmental changes.

The best method to ensure a healthy immune system is to provide a stress free environment and quality nutrition.

Fish, like humans have evolved to successfully cope with everyday living on this planet. It is **abnormal** for a koi to become sick and diseased. Many people in the hobby place great emphasis on "sick" koi and diseases. It is no wonder that a normal slight variation in behavior is seen as an open invitation to spend hundreds of dollars treating the

whole pond system - "just in case". The emphasis should be on the fact that *normally* koi are not sick and *normally* the environment is healthy and *normally* koi will live a long time

The environment and koi are intimately interwoven. Koi are literally sacks of water separated from the surrounding pond water by a semi-permeable membrane (the skin). Their bodies are composed of approximately 80% water. Any changes to the environment have a direct and immediate effect on our koi. Changes greater or more sudden than what the fish has evolved to cope with - will result in stress. It is the response of the immune system to these changes that ultimately determines whether our fish will survive an encounter with stress and the after effects thereof.

- The candidates on the KHA course will not have laboratory facilities available to him or her in the field. But you will be called upon to give an opinion in certain circumstances and may have to decide if food is fresh or is rancid. *When in doubt - throw out.*

Summary – Chapter 4

Freshness is essential in koi food as old food will have lost much of its nutritional value. Food older than 9 months should be thrown away.

The formulation or balance of the ingredients of the food is calculated so that the protein, vitamins, minerals etc. will be at the required level *after* cooking and extrusion.

The vitamins are extremely vulnerable to degeneration. Vitamin C being one of the first. Heat stable, long lasting vitamin C is now added to koi food.

Growth in koi occurs above about 59°F (15°C).

Below 50°F feeding should be stopped.

Koi usually take 4 - 5 hours to digest (pass through the gut) their food at 68°F (20°C).

Feeding floating pellets -

1. Encourages the collection to the surface
2. Makes it less likely to be kept out of the bottom drains and filters

3. It affords the koi keeper the opportunity to regularly inspect the koi to determine their health
4. Affords a high level of carbohydrate digestibility as floating diets are heated during extrusion.

Koi food should be stored in cool, dark and dry places. If necessary, store food in a fridge but do not continually open and close the container - rather, take enough out for a few weeks at a time.

Any food that has become damp for longer than one day should be discarded and never fed to the fish.

Rancid food can have a long-term effect on the health of koi.

In recent years many advances in packaging have resulted in fresher products being available to the consumer for longer periods of time.

The color of the pellet has absolutely no nutritional value what so ever.

Koi do very well on feeds containing 35 - 38% protein. This is high quality animal or plant protein.

Feeding small amounts several times a day will be more beneficial to the koi and will produce better growth than a single daily feeding.

If the first few years have passed with poor nutrition it is very rare that koi can "make up" this loss of critical growth period. They will remain smaller than other koi that have received good quality nutrition from the beginning.

A koi's color potential is genetically determined. We do not have any definite answers as to why some koi lose their color and others improve. The reason why colors fade and blemishes appear on others has not been satisfactorily determined either.

Over-feeding (over 5%) of color enhancers should be avoided, as this will affect the purity of the white areas.

Feed containing color enhancers should be given in water of more than 68°F (20°C).

Spirulina is an alga that contains more than 60% usable protein and has high levels of carotenoids.

Immuno-stimulants should only be fed in very controlled circumstances and for a limited time and are not recommended for use by hobbyists.

The best method to ensure a healthy immune system is to provide a stress free environment and quality nutrition.

It is abnormal for a koi to become sick and diseased.

CHAPTER 5: COMMERCIAL KOI FOODS

The vast majority of the major brand name koi foods on the market utilize computer technology and spend much on research. They also have excellent machinery available to produce the koi food we use. Many leading companies have spent vast amounts on packaging to increase the shelf life of their products.

The leading brand names have the ingredients and the proportions thereof stated clearly on the packet. In the US the proportions listed on koi food only apply to nutrition groups only, i.e. crude protein, crude fat, crude fiber, phosphorus, and added minerals. The ingredients are listed in order of prevalence but the ingredient proportions are rarely stated.

Manufacturing Koi Foods

All pellet koi foods are manufactured in more or less the same way – with heat, moisture and pressure. The heat cooks the food; hence the digestibility is better, especially with the carbohydrates. The moisture is removed by drying after the manufacturing process to below 10% moisture. This ensures the food remains fresher for longer. Damp food will go rancid rapidly. The pressure forms the pellet in the extruder. By juggling the pressure/moisture/heat ratio the density will change and the pellet will float or sink. The pellets will float if the specific density of the pellet is less than water.

The production of nutritionally balanced diets for koi requires efforts in research, quality control, and biological evaluation. Faulty nutrition obviously impairs fish productivity and results in a deterioration of health until recognizable diseases ensue.

The borderlines between reduced growth and diminished health, on the one hand, and overt disease, on the other, are very difficult to define. There is no doubt that as our knowledge advances, the nature of the departures from normality will be more easily explained and corrected. 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.

Summary - Chapter 5

All pellet koi foods are manufactured in more or less the same way - extruded with heat, moisture and pressure.

The vast majority of the major brand name koi foods on the market use computer technology, spend, much on research and have excellent machinery available to produce the koi food we use.

The nutritional value of these foods is usually very good.

The limiting factor to these foods being of good nutritional value is the age of the food.

CHAPTER 6: INGREDIENT DISCUSSION

Diet Formulation

Diet formulation and preparation are the process of combining feed ingredients to form a mixture that will meet the specific goals of production. In our chosen hobby, koi keeping, the goals of diet formulation are growth, health, appearance, low pollution and good digestibility.

The food has to be nutritionally balanced (to support maintenance, growth, reproduction, health) as well as being economical, it must also be palatable and water stable. Koi food needs to minimize waste output & its negative effect on water quality. The final product must be commercially desirable - attractive & safe.

Ingredient Quality

The first consideration for formulation and production of successful diets is the quality of the feed ingredients. Diets produced with poor quality raw materials and/or under adverse processing conditions have inferior nutritive value and adverse effects on fish health.

Quality criteria for the ingredients must be respected to insure that the final product is of consistent quality and that deleterious effects are avoided. The chemical composition (nutrient, energy, anti-nutrients, contaminants) of the ingredient obviously plays a determinant role in the quality. However, biological aspects, such as digestibility and utilization of nutrients are important.

Measurement of digestibility provides, in general, a good indication of the availability of energy and nutrients, thus providing a rational basis upon which diets can be formulated to meet specific standards of available nutrient levels. Several factors can affect the digestibility of proteins or specific amino acids. The type of drying techniques used during processing and the composition of the protein fraction are the factors which have a determinant effect on the digestibility of protein or other feed ingredients.

Fishery by-products

The protein source in koi food is more often than not sourced from fish meal. There are various qualities of fish meals on the market, relating to the original raw fish quality, level of ash in the meals, and the type of processing techniques used. The most important factor is the freshness of the product.

Although we have virtually no control of this aspect of koi nutrition, fish used in feed must be processed as soon as possible after capture.

Ageing and spoilage decrease the nutritive value and also lead to the contamination with potential toxic compounds, such as histamine, cadaverine, and agmatine. Also, fish contain large amounts of thiaminase, an enzyme that destroys thiamine, an important B vitamin. Frozen fish, therefore, have very little if any thiamin left, and B vitamin deficiency becomes very important. This can be prevented by supplementing B vitamins during processing which is more often than not done by manufacturers, or even by the owner, when needed.

The second most important factor is the type of raw material used (whole fish or by-products). By-products, such as those generated by the filleting industry (sometime referred to as white fish meal) have higher level of ash and lower level of protein than whole fish meals. High level of ash generally affects digestibility of dry matter and results in high waste outputs, and can also produce mineral imbalances (e.g. Zn deficiency).

The type of fish used is not necessarily a determinant factor in the quality of the products. At equal freshness and if the same processing technique is used, whole capelin, anchovy, herring, menhaden and sardine meals will support similar growth.

Animal by-products

Animal protein by-products can be very useful complementary protein sources in fish diets. It is important to use highly digestible products with limited ash content. High ash content ingredients are generally more polluting and the ash dilutes useful nutrients. It is especially important when buying these products to deal with suppliers who consistently provide high quality products. Apparent digestibility of animal by-product is relatively high and they have been used at significant levels in practical diet with success.

Plant protein by-products

There are several plant proteins and grain by-products that are used on a regular basis in fish diet formula. Certain plant protein products have a good nutritional value (high in digestible protein, good amino acid profile) and are economical at the same time. Other products improve the physical characteristics of the pellets.

The incorporation of certain products must be limited for various reasons, such as their content in starch and fibre, the presence of antinutritional or undesirable factors and their acceptability (palatability).

Many plant products contain antinutritional factors. Most plant protein ingredients are heat treated during processing, which greatly reduce the level of several antinutritional factors, such as soybean trypsin

inhibitors. Excess heat, however, generally decreases the nutritional quality of plant protein products.

Fish diets formulated with high levels of certain plant protein ingredients appear to be nutritionally adequate but not very acceptable to certain fish species.

For example, diets containing high levels of soybean meal are poorly accepted by chinook salmon and other salmonids but well accepted by carp (koi).

Corn gluten meal is a plant protein ingredient known to be highly palatable. Corn gluten meal or combination of corn gluten meal and soybean meal can replace most of the fishmeal without any effect on performance of the fish. Nonetheless, the incorporation of corn gluten meal must be limited in food fish production feeds due to its high concentration in xanthophylls that can produce undesirable pigmentation of the skin and flesh.

Fats and Oils

Fish oil is the main source of lipid in koi diets. Marine fish oils are, in general, excellent sources of long chain n-3 PUFA (EPA & DHA), fatty acids required by koi. Other types of oils and fats can be used in koi diets. Vegetable (canola, soyabean, safflower, etc.) oils and animal fats (tallow, lard, poultry fat) can also be used at certain levels in feeds without effect on growth performance and health of the fish.

Rancidity problems

Fish oils used in the manufacture of koi food are rich in polyunsaturated fatty acids and are susceptible to rancidity.

Rancid fat has deleterious effect on some of the nutrients present in fish feed and health of the fish. Fatty liver disease is usually seen in fish fed rancid fat.

The easiest way to determine if a feed is rancid may be its smell. Feed with a rancid smell must not be fed. It is preferable to discard such feeds instead of jeopardizing the health of the fish by feeding them.

Summary – Chapter 6

The goals of diet formulation are growth, health, appearance, low pollution and good digestibility.

Diets produced with poor quality raw materials and/or under adverse processing conditions have inferior nutritive value and adverse effects on fish health.

The protein source in koi food is more often than not sourced from fish meal.

Animal protein by-products can be very useful complementary protein sources in fish diets.

Certain plant protein products have a good nutritional value (high in digestible protein, good amino acid profile) and are economical at the same time.

Fish oil is the main source of lipid in koi diets.

Fish oils used in the manufacture of koi food are rich in polyunsaturated fatty acids and are susceptible to rancidity.

CHAPTER 7: POTENTIAL PROBLEMS ASSOCIATED WITH KOI NUTRITION

Long Term Effects of Nutritional Deficiencies

Long term deficiencies are very difficult to prove or determine as the degeneration of the body from nutritional imbalances or shortages are never immediately apparent. For example, if the koi are fed continuously on rancid food they MAY develop liver cancer. The question is - how is this proven as a problem with the nutrition as the liver cancer may only occur after several years? And how is it proven that the rancid food was the cause of the liver cancer?

A lack of a specific vitamin COULD result in malformed bodies. Again this occurs over a period of time and is extremely difficult to prove as a direct result of deficiencies. The symptoms of vitamin deficiency are similar to some diseases for example.

In the following chart we have attempted to place a practical, pond side analysis of nutrition problems in front of the KHA. We therefore take what we are observing and then relate it to possible deficiencies.

The role of nutrition in the diagnostic studies is actually one of exclusion as all other potential causes should be ruled out before nutrition-related diagnostics are applied.

The role of nutrition can be narrowed to two primary and a number of secondary areas of interest: 1) the nutritional elements of proteins, fats and carbohydrates provide the growth and energy needed by the koi to thrive and prosper while 2) minerals and vitamins form the basis for proper function of the koi's physiological systems.

Nutrient Deficiencies and their Symptoms

Protein

See page 19

Lipid

See Page 19

Vitamins

Nutrient	Best Natural Sources	Deficiency Symptoms
<p>Vitamin A Requires fats as well as minerals to be properly absorbed. Occurs in two forms - performed vitamin A called retinol found in foods of animal origin and provitamin A known as carotene. Related to vision and mucus secretion. Essential for growth and reproduction.</p>	<p>fish liver oils, liver, carrots, green and yellow vegetables.</p>	<p>anorexia, fading body colour, haemorrhages of skin, fin erosion, pop-eye, deformed gill covers (opercula).</p>
<p>Vitamin B₁ (thiamine) Essential for normal metabolism, promotes growth, aids digestion, especially of carbohydrates. Necessary for enzymic reactions.</p>	<p>meats, dried yeasts, whole wheat, oatmeal, most vegetables and bran.</p>	<p>poor growth, fading body colour, lightening of body colour, congesting skin and fins, equilibrium loss.</p>
<p>Vitamin B₂ (riboflavin) Aids growth, promotes healthy skin. Needed for carbohydrate metabolism. Breaks down carbohydrates, fats and proteins and is not stored to any great degree in the body and must be regularly supplied in the diet.</p>	<p>liver, kidney, yeast, leafy green vegetables.</p>	<p>poor appetite, poor growth, haemorrhages in epidermis.</p>
<p>Vitamin B₃ (niacin) Biochemical carrier. Necessary for breakdown and use of all major nutrients; healthy skin, maintenance of nervous system.</p>	<p>liver, lean meat, whole wheat, brewers yeast, kidney, wheat germ.</p>	<p>poor growth, loss of appetite, haemorrhages, erratic swimming, high mortality.</p>
<p>Pantothenic Acid (vitamin B₅) Builds antibodies. Biochemical carrier.</p>	<p>meat, whole grains, bran, liver, heart, green vegetables, brewers yeast.</p>	<p>poor appetite, poor growth, nervousness, haemorrhage of body surface.</p>
<p>Vitamin B₆ (pyridoxine) Properly assimilates protein and fat. Aids in the conversion of tryptophan (an essential amino</p>	<p>brewers yeast, wheat bran, wheat germ, liver, kidney, heart, cabbage, beef, green</p>	<p>Abnormal swimming, balance problems, poor appetite, abdominal dropsy.</p>

acid) to niacin. Blood formation.	vegetables	
Vitamin B₁₂ Promotes growth, increases energy. Forms and regenerates red blood cells. Properly utilizes fats, carbohydrate and proteins.	liver, kidney, beef, yeast	Nervousness, damage to nerve tissue and brain anaemia
Vitamin E Active anti oxidant, prevents desiccating of fat compounds as well as that of vitamin A. Enhances the activity of vitamin A.	wheat germ, soybeans, vegetable oils, leafy greens, whole grain cereals.	Declining reproduction, exophthalmia (protrusion of the eyeballs) / also early rancidity in food.
Biotin (Vitamin h) necessary for fatty acids metabolism.	brewers yeast, beef. liver, rice	poor growth, changes in tissues and blood cells.
Folic Acid A member of the vitamin B complex. Essential to the formation of red blood cells. Aids in protein metabolism. Essential for the division of body cells. Needed for the utilization of sugar and amino acids.	deep - green leafy vegetables, carrots, yeast, liver, beans, whole wheat, rye flour.	Poor growth, anemia
Inositol Combines with choline to form lecithin. Another member of the vitamin B complex. Cell membrane formation.	liver, brewers yeast, beef brains, heart, wheat germ, cabbage.	poor appetite, loss of mucus, poor growth, skin lesions.
Vitamin C (ascorbic acid) Metabolism of amino acids and synthesis of hormones, immunity booster, resistance to disease, formation of bone, skin and other connective tissue, wound healing, fights bacterial infection, strengthens walls of capillaries (tiny blood vessels) Aids in preventing many types of viral and bacterial to hold together.	green leafy vegetables. potatoes.	lack of resistance to infection, slow healing, malformation of bone and body.
Vitamin D	fish liver oils, sardines, herring	bone deformities.

Properly utilize calcium and phosphorus. Normal formation of bones. Aids in assimilating vitamin A (carotene).	salmon, sun light.	
Vitamin K Essential for the formation of prothrombin, a blood clotting chemical.	alfalfa, fish meal, soya bean oil, fish liver oil, kelp, leafy green vegetables, peas	Poor blood clotting, haemorrhage of skin and eyes.
Choline Works with inositol to utilise fats and cholesterol. Bonus: Further serves to provide rich color in fish	brain heart, green leafy vegetables, yeast, liver, wheat germ.	poor growth, accumulation of neutral fats on various organs.

Minerals

See Page 19

Summary - Chapter 7

Long term deficiencies are very difficult to prove or determine as the degeneration of the body from nutritional imbalances or shortages are never immediately apparent.

The role of nutrition in the diagnostic studies is actually one of exclusion as all other possible causes should be ruled out before nutrition-related diagnostics are applied.

The nutritional elements of proteins, fats and carbohydrates provide the growth and energy needed by the koi to thrive and prosper while minerals and vitamins form the basis for proper function of the koi's physiological systems.

CHAPTER 8: The KISS Chapter (Keep it Simple Stupid)

Analyzing Problems with Koi Foods

The average person does not have access to laboratory facilities. Therefore, a completely scientific approach is nearly impossible when analyzing problems associated with Koi nutrition.

However, we can arrive at some fairly accurate conclusions with a little detective work.

Fresh or Old?

The Smell Test

By smelling the food you can establish with some degree of certainty whether the food is fresh or not. If the koi food has a warm fish meal smell it is fresh. However, if the food does not have any smell at all - the food is old. Old food should be viewed as suspect. Thirdly, if you smell the food and it has a smell something like paint thinners then the food is becoming rancid and should be discarded immediately.

Good or Poor Nutrition?

Poor nutrition can be the exclusive use of home made foods without the necessary nutrition properties needed for growth, using feeds with little or no nutritional values (white bread for example), feeding very old food, feeding foods with protein contents below 30%, continuous feeding the wrong types of food (e.g. high carbohydrates - low protein diets)

Most nutrition deficiencies would manifest themselves over a period of time. Therefore the occasional feeding a "wrong" diet should not harm the fish.

Supplementing the daily diet with extra nutritious things is a must for good koi keeping (various feeds - see chart above with the "best natural sources" for ideas).

The Food or the System?

A very difficult one to establish. Keep in mind that finding fault with the food is usually the last resort. Problems with the pond will become apparent much sooner than problems with the food.

A pond that is too small, ponds with out adequate filtration or circulation or ponds with continuous low oxygen levels will all have a detrimental effect on the koi before the lack of a specific vitamin or low protein diet.

The Food or the Feeding?

Establishing a brief history of the koi keeper's food storage facilities are necessary.

Questions to ask Koi Keepers when trying to analyze possible nutrition problems at the pond side.

1. What brand of food do you use?
2. When did you purchase it? Has the koi keeper bought large stocks of food for the whole season?
3. Where do you store the food?
4. How much do you feed?
5. Do you use an automatic feeder?
6. Do you leave the uneaten pellets floating on the surface?
7. Has the food ever become damp?
8. What quantities of koi food do you purchase in 4 - 6 weeks.

Visual Appraisal.

1. Examine the food for signs of mould, insects, webs and the area for mice or rat dropping etc
2. Where is the food kept - if the need arises to 'see for yourself.'
3. Is it stored in direct sunlight?

Koi food must be kept dry. Storage on concrete floors is dangerous as there is moisture seepage through the concrete. Koi food that has become damp could become toxic within a few days. Food that has become damp for some time will have a mould or fur on it. This must be discarded.

Food that is stored in transparent plastic bags can sweat during temperature changes. The pellets could absorb extra moisture and become moldy.

Weevils can be introduced on your own property if a moth happens to land on the food and lay her eggs.

The Food or a Disease?

Long-term nutrition deficiencies are extremely difficult to detect.

Koi can develop liver cancers from rancid and mould food. This would develop over time and be very difficult to prove let alone have analysed.

The Food or Genetics?

My koi are not growing! -----

A lack of protein from an early age will stunt the growth of koi.

Poor nutrition from the early part of the fish's life will result in poor growth and health. Feeding white bread or oats may sustain a koi but will not produce growth. Once a fish has lost out on growth in the early part of its life this cannot be made up. The damage has been done.

Old food will have degenerated. The vitamins are the first to degrade. Food with the incorrect level of vitamins will not produce the growth and health needed.

Older koi cannot grow much.

Some koi will not grow beyond a certain size.

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