

**FACT AND FICTION, REGARDING THE USE OF FISH MEAL IN *GROW OUT*  
*DIETS DESIGNED FOR Litopenaeus vannamei.***

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**Abstract**

The commercial culture of shrimp has been one of the most successful components of the aquaculture industry, representing around 20% of the world value of aquaculture products. Although this industry only represents 4% of the world aquaculture production by volume, we are using around 23% of the fish meal used in aquaculture feeds. This use is not only unwarranted but it is no longer economically or politically sustainable. Our reliance on fish meal has evolved out of numerous economic and nutritional constraints as well as farmer related demands. However, as agriculture reshapes itself into a world market driven by the final consumer and commodity pricing of everything we must modify our thoughts and remove old assumptions. We must recognize there are numerous assumptions associated with feeds that have little to do with nutritional quality of the feed or the economic returns we obtain using them. The first idea we must embrace is that there are no nutritional requirements for fish meal or marine ingredients. There are nutritional requirements for specific compounds that are often met using fish meal. Using proper replacement strategies, a number of studies have demonstrated that fish meal and marine oil levels can be reduced or eliminated from growout diets of the Pacific white shrimp *Litopenaeus vannamei*. Currently, a mixture of cheaper high quality plant proteins (e.g. solvent extracted soybean meal, corn gluten meal, distillers grain solubles, pea meal, canola meal) or terrestrial animal protein sources (e.g. poultry by-product meal, meat and bone meal) can be used to successfully replace fish meal in shrimp feeds without compromising growth or survival. However, this can only be done if shifts in nutrient requirements such as essential amino acids in particular methionine, energy content of the diet, essential fatty acids as well as minerals such a phosphorus are accounted for. Based on a number of trials under research and commercial conditions in several countries, the

reduction or replacement of fish meal levels in production diets can result in reductions in feed costs and improved economic returns. To maintain economic viability, farmers and feed mill manufacturers must embrace the use of feed formulations based on alternative ingredients and reduce the use of fish meal in shrimp feeds.

Irrespective of your ecological views of the long term status of world fisheries, fish are an over exploited resource for which wild harvests have remained relatively stable at around 80-90 million metric tons per year. Properly managed capture fisheries are a renewable resource, but harvest can not be expanded beyond current levels and may actually need to be reduced. The majority of wild seafood harvests goes toward human consumption as this is the most valuable market for any product and a critical source of essential nutrients. Of the world total, around 20-30 million tons are not acceptable for human consumption and have traditionally been used for industrial products, primarily fish meal and oil for the animal feed industry. The production of industrial products has been fairly stable; over the last 20 years, 5-7 million tons of fish meal, and close to 1 million tons of fish oil per year have been produced. Although this value is not expected to dramatically increase, there will be small increases as waste products from the processing of seafood products are increasingly converted towards products for the animal feed industry. Unfortunately, this is not going to be adequate to supply the worlds ever increasing demand for fish meal and oil. Hence, marine ingredients are considered high value commodities for which demand far exceeds supply.

At a recent meeting, J. Shepherd of the International Fish meal and Fish Oil Organization, noted that “aquaculture currently utilizes over 50% of the fish meal and 80% of the fish oil”. Given the growth rate of aquaculture (> 8% per year) and the limited supply of fish meal and fish oil this luxurious use by the aquaculture industry must stop. Aquaculture feeds represent only 4% of the total feed industry production, so we should reduce our excessive use of these limited ingredients. Reduction of fish meal in feeds is a lesson learned by other animal industries a long time ago and one that the aquaculture

industry has talked about for a long time. Despite warnings, it took a 40% increase in fish meal prices in less than a year to finally wake the industry to the fact that our excessive and casual use of fish meal and oil must stop. In addition to economic concerns caused by limited supplies and increasing demand, the use of marine ingredients has received considerable attention by the public in terms of perceived sustainability issues. Hence, the overall reduction in the use of fish meal and other marine ingredients are of considerable concern to the industry.

Based on FAO figures for 2004 (FAO 2006), around 2.4 million tons of shrimp were produced through aquaculture. This represents only about 4% of total aquaculture output but the second most important in terms of values (~ 20% of world value of aquaculture products). Because of historically high profit margins in shrimp culture combined with a poor understanding of nutrient requirements the use of “luxury” ingredients has been common in shrimp feeds. Consequently, the shrimp feed industry is also one of the primary users of fish meal and other marine ingredients. Based on reports by Tacon et al (2006) marine shrimp feed uses 22.8% of the fish meal used in aquaculture feeds. The production of marine shrimp has continued to expand at a healthy pace yet, the increased production has also been accompanied by a decrease in shrimp value and reduced profitability for the farmers. Facing the economic reality of lower income, there has been considerable interest to evaluate alternatives to reduce shrimp production costs.

Shrimp farming developed in a market environment in which shrimp were a luxury item demanding a high price and often produce high profit margin for producer. This has resulted in a number of inefficient practices, which include the use of very expensive feeds containing high levels of marine ingredients. As shrimp prices have fallen, the

profit margins have also decreased making it more difficult to run a profitable commercial shrimp farm. Considering that feed represents one of the largest variable costs associated with fed culture systems, reducing feed costs can produce considerable savings. The use of feeds with reduced levels of fish meal is one potential method to reduce feed costs if production efficiencies can be maintained. Commercial shrimp formulations historically contain between 25% to 50% fish meal, representing the primary and most expensive protein ingredient (Dersjant-Li, 2002; Tacon and Barg, 1998). Clearly the high inclusion levels of fish meal make it the preferred protein sources. After all it is an excellent source of essential nutrients such as protein and indispensable amino acids, energy, essential fatty acids, cholesterol, vitamins, minerals, attractants and unidentified growth factors (Swick et al., 1995; Samocha et al., 2004). Because of fish meals nutritional value, it has a high demand resulting and corresponding high market value. Due to limited supply and increasing prices, we must shift our emphasis and only use this ingredient when nutrient requirements of the animal demand its use. In cases where we can substitute fish meal with a combination of other ingredients we must embrace these technologies. We have not identified how to remove fish meal from diets for a number of species and life stages but for the vast majority of species we can either remove fish meal or reduce it to reasonable levels. Given the nutritional requirement of shrimp the obvious question is why is fish meal used extensively in shrimp feeds? The nutrient requirements of larval and early post-larval stages demand a highly nutritious diet that warrants the use of fish meal and other high quality marine ingredients that are cost effective. However, production diets must be economically viable and use the most economical nutrients. To use a protein source that costs almost twice as much as that of

other ingredients is not acceptable. As an example fish meal FOB Peru is currently listed at \$830/ton for a 65% protein meal or \$12.76 per unit of protein yet FOB price for soybean meal is \$319/ton for a 48% protein meal or \$6.64 per unit of protein with similar cost savings for other protein sources. Based on numerous research studies with *L. vannamei* reared under a variety of culture conditions and densities there is clearly no need for fish meal in production diets (Amaya et al 2007a,b; Browdy et al 2006; Patnaik et al. 2006, Samocha et al 2004).

So we must pose the question: Why are feed mills still using high levels of fish meal? There are numerous economic, nutritional and social reasons, thus there are no easy answers. First of all, most countries have some agricultural production but not enough to meet animal feed demands so a significant quantity must be imported. To protect local agriculture, agricultural imports are often taxed whereas imported fish meal is taxed at a lower level. When fish meal prices were low, there was a minimal differences in price per unit nutrient making fish meal a cost effective ingredient. However, in today's market where fish meal prices have increased, other sources of protein such as soybean meal are clearly cheaper. Unfortunately, as feed mills and farmers have become accustomed to using high levels of fish meal in the feed they assume it is required by the animal. To further complicate the issue, some countries regulate the quantity of some ingredients entering the country hence, due to government regulations a given feed ingredient may not be available on the local market as a result of import restrictions.

The impression of aquaculturists that fish meal or animal protein is required in shrimp feeds has also contributed to the excessive use of fish meal and the high cost of

feeds. There are no nutritional requirements for fish meal and there are no differences between protein originating from animals or plants. However, these ingredients do bring differing levels of essential nutrients and some ingredients do not contain adequate levels of some essential nutrients. Hence, as one removes fish meal, fish oil or other marine ingredients, one has to equalize nutrient shifts. Quite often even when alternative protein sources are available and cheaper, fish meal often enters formulations because of inadequate information on nutrient requirements, especially the required level of methionine or total sulfur amino acids. If this is the case, the formulation will be over specified in terms of nutrient requirements (contain more nutrients than the animal needs) and will contain fish meal. For example, until recently we assumed that the total sulfur amino acid requirement (methionine + cystine) of *L. vannamei* was > 3.1% of the protein which heavily favors the use of fish meal as this is one of the richest sources of these essential amino acids. However, more recent data indicates that the requirement is less than 2.8% of the protein which favors the use of alternative ingredients. Hence, one can use a combination of alternative proteins, e.g. soybean meal in combination with corn gluten meal, to meet the protein requirement. One potential problem with some alternative protein sources (e.g. 48% protein soybean meal) is that it takes more to deliver the same amount of protein consequently, reducing room in the formulations. This is a real problem especially with high protein diets. As fish meal prices continue to rise, the cost for protein concentrates has been stable and/or decreased. This means that in the future you will see more protein concentrates being made from oil seeds (e.g. soybean or canola) being used as replacements for the protein originating from fish meal.

Our use of fish oil follows a similar trend. In the past fish oil was cheap so fish oil was the best way to provide energy and meet the essential fatty acid requirements. As fish oil prices have risen it is now more cost effective to mix various oil sources. Hence, the feed formulator now must take into account essential fatty acid requirements of the animal if they are to reduce oil costs. There are also a number of properties that fish meal indirectly provide that farmers look for. These include the darker color of the feed as well as imparting a “fishy” smell to the feed. As shifts in color and smell are things a farmer can evaluate on their own, these are often observations the farmer relies on to evaluate the feed quality. I am sure that the smell of feed relates to ingredients, but I have never see any correlation between what we smell and or see in the feed and what a shrimp prefers. Although, I know of no study that has evaluated the color of the feed we have utilized diets from snow white to dark brown, light to dark green as well as fluorescent pink, yet I have never seen any indication of a preference for one or more colors.

In addition to local cost differences and inadequacies of nutrient requirement data there are also what could be considered social issues that are the result of farmer feed mill interactions. Remember, the feed mill must provide the farmer with a feed that will perform well but as well meet the demands of the farmer. Most consumers buying feed do not have the equipment to run sophisticated tests but they can make observations of the feed. Hence, uniformity of pellet size, color, proper size, presence of fines, water stability, and smell are easily evaluated by the farmer. Unfortunately, most of these factors probably have little influence on predicting nutritional quality or the economic value of the feed in producing good growth and survival. Clearly very low water stability and the presence of fines will influence performance. However, we put a lot of emphasis

on color and smell of the feed. Fish meal adds a distinct smell and facilitates a darker color so we indirectly put an emphasis on the use of fish meal when we demand these characteristics.

Once we have accepted the fact that fish meal is not required in most feeds, and that we can replace it using a combination of ingredients, to produce a better and more cost effective feed, we will be able to continue to expand aquaculture production. To do this we must remember that fish meal is: a rich source of highly digestible protein that has an exceptionally good profile of essential amino acids particularly methionine; a rich source digestible energy; a moderate source of lipids; and an excellent source of vitamin and minerals. Fish oil, whether it enters the diet through the fish meal or via direct oil supplements, is a highly digestible energy source, rich source of essential fatty acids and enhances the palatability of the feed for most species. Hence, from a nutritional standpoint we need a replacement strategy that blends a number of cost effective ingredients to maintain a nutritionally balanced diet that meets the requirements of the animal but is not excessive in nutrients.

Using proper replacement strategies, a number of studies have demonstrated that fish meal and marine oil levels can be reduced or eliminated from growout diets. A mixture of cheaper high quality plant proteins (e.g. solvent extracted soybean meal, corn gluten meal, distillers grain solubles, pea meal, canola meal) or terrestrial animal protein sources (e.g. poultry by-product meal, meat and bone meal) can be used to successfully replace fish meal in shrimp feeds without compromising shrimp growth. However, this can only be done if shifts in nutrient requirements such as essential amino acids in particular methionine, energy content of the diet, essential fatty acids as well as minerals

such a phosphorus are accounted for. Based on a number of trials under research and commercial conditions, the reduction or replacement of fish meal levels in production diets has result in reductions in feed costs and improved economic returns on the investment in feeds. Marine fish oils can also be reduced simply by blending oil sources to meet a minimal essential fatty acid requirement. There are also examples of the complete removal of marine oils from the feed by using a suitable combination of plant oils and alternative sources of highly unsaturated fatty acids (e.g. fermented products). Such a technique has been demonstrated but due to current prices of the alternative sources of essential fatty acids, may not reduce over all costs. Such a technique would allow the advertisement of more environmentally friendly production systems, possibly resulting in an increased sale price to the consumer. Such alternative oil sources are likely to be economical in the near future as prices for fish oil continue to rise.

In summary, marine shrimp have no dietary requirements for fish meal or fish oil. However, these are two excellent sources of a number of nutrients that are difficult to obtain using other ingredients. As marine ingredients are of limited supply they should only be used in diets for which price and nutrient profiles demand their use. Most production diets do not require the use of marine ingredients in feed formulations. In fact, the use of alternative protein sources such as solvent extracted de-hulled soybean meal, in combination with corn gluten meal, reduces product variability and is often cost effective and a nutritionally balanced source of protein for many of our cultured species. Such modifications to the feed can only be done if the replacement strategy takes into account nutrient requirements of the species for essential amino acids, fatty acids and minerals as well as potential palatability shifts in the diets. Approaches to reduce or

eliminate marine ingredients from production diets have been successful, yet, there is still a need to identify limiting nutrients and further develop cost effective solutions that will ensure the long term success of the shrimp industry.

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