

Comparison between FAQ fish meal and ProFloc™ December 2010

Introduction

Fish meal (FM) is a premium protein ingredient used in a variety of animal feeds including those for aquaculture. Although numerous grades of FM are generally available, the most common is known as fair average quality (FAQ). FM is an international commodity that is increasingly found in only the feeds destined for the highest-value markets; that is, young animals growing at their most rapid rate and carnivorous, high-value aquaculture species such as shrimp, prawns, salmon, trout, and others. As opposed to FM's wide application across all animal feed types just a few decades ago, today it is overwhelmingly being used within aquaculture feeds (also known as "aquafeeds"). For example, in 2010 approximately 70% of available global FM is used in aquafeeds. This trend towards increasing allocation of FM is expected to continue with an increasing percentage of this finite resource being allocated to aquaculture. Oberon's single cell protein product, ProFloc™, offers a unique opportunity to the feed industry in that it possesses many of the attributes of FM while promising future advantages in the form of custom products. Additionally, ProFloc™ is the only near-market and commercially scalable FMR (fish meal replacement) that can be offered at a competitive price and in a sustainable manner.

Production

FM is the result of "reducing" small school fish or industrial fish by-product into a useable feed ingredient. In other words, FM material inputs include fish considered too small for human consumption or fish material rendered from processing operations. Over recent decades, FM production has dropped from a high point of more than 6.5 million metric tons (MMT) per year to approximately 5 MMT or less. Over 40% of the world's FM supply is caught and processed in only two countries: Peru and Chile. As a result, average transport of FM from point-of-production to point-of-use is 5,000 km. Recognizing the value of this resource, these two important FM-producing countries (i.e., Peru and Chile) have recently implemented strict fishing and production limits in order to ensure sustainability for the FM industry. The result has been lower levels of global FM production.

ProFloc™ is produced in a manner entirely different from that of FM. Through the leveraging of water treatment facilities dedicated to large human-food manufacturers (i.e., those producing products from plant inputs only), Oberon supplies a proprietary mixture of ubiquitous, harmless bacteria with the nutrients necessary for growth. Through the implementation of operational controls and the addition of growth factors, Oberon's process produces clean water (shown to be cleaner than when conventional treatment methods were used during a full-scale demonstration at a MillerCoors brewery in Trenton, OH) while simultaneously producing a bacterial protein meal containing approximately 65% protein ($\pm 5\%$). The process uses only nutrients, food processing residuals, air, and water as inputs to the process. The cells are then mechanically dewatered, thermally dried and inactivated, and delivered as an ingredient for animal feeds. The process is completely sustainable and

scalable. Additionally, ProFloc™ can be produced locally, results in a net decrease in the carbon footprint of a facility, and does not deplete marine resources.

Ingredient Benefits

FM is used in animal feeds because it offers significant nutritional benefits. FM possesses between 60% and 64% crude protein and an amino acid profile that is close to optimal for many animals. FM protein is slightly greater than 90% digestible in many animals, it contains approximately 11% lipids, and it is a valuable source of phospholipids and essential fatty acids – from both the omega-3 and omega-6 families. It is highly palatable (scientific literature indicates that this may be a result of the glutamic acid content of the protein), promotes absorption of nutrients in the feed, and stimulates growth in young animals and those with fastidious nutritional demands.

ProFloc™ possesses many of the attributes of FAQ fish meal. ProFloc™ is highly palatable (also possibly a result of its high glutamic acid content) as demonstrated during Oberon’s trials with white shrimp, salmon, tilapia, poultry, and pigs, and results in animal growth and performance that is equal (or possibly superior) to FM (see case study below). ProFloc™ is a source of a wide range of B vitamins and the antioxidant Vitamin E. ProFloc™ contains approximately 6.5% total lipid and 4%-5% fatty acids. Unsaturated fatty acids are approximately 2% in the ingredient (future efforts are planned to characterize these fatty acids more fully). Similarly, phospholipids are an essential component of bacterial cell walls and are a constituent of ProFloc™. ProFloc™ also contains beneficial immune system stimulants not found in FM including coenzyme Q10, free nucleic acids, beta glucans, and mannans (i.e., cell wall polysaccharides).

Amino acids fall into two categories: the essential (not able to be synthesized by the recipient animal and; therefore, required in the feed) and non-essential (able to be synthesized by the animal). As shown in the table below, ProFloc™ possesses an amino acid profile that is similar to FM. However, ProFloc™ generally has higher levels of the essential amino acids for fish and shrimp (i.e., threonine, valine, leucine, isoleucine, methionine, tryptophan, lysine, histidine, arginine, and phenylalanine highlighted in gray in Table 1):

Table 1: Amino Acid Composition of ProFloc™ Compared to Fish Meal (FM)

	ProFloc™	FM
Alanine	3.8%	5.4%
Arginine	3.6%	4.0%
Aspartic Acid	6.4%	6.3%
Glutamic Acid	8.0%	5.7%
Glycine	2.8%	4.4%
Histidine	1.5%	1.3%
Isoleucine	3.4%	2.7%
Leucine	5.1%	4.4%
Lysine	4.3%	4.5%

Methionine	1.4%	1.7%
Cystine	0.6%	0.8%
Phenylalanine	3.3%	2.3%
Proline	2.8%	2.8%
Serine	2.8%	3.1%
Threonine	3.1%	2.6%
Tryptophan	1.0%	0.7%
Tyrosine	2.8%	1.8%
Valine	3.5%	3.0%
Total Amino Acids	60.2%	54.4% - 60.5%
Crude Protein	66.0%	60.0% - 64.0%

ProFloc™ Case Study

Even though complete understanding of ProFloc™ continues to develop, animal performance is the real indication of the value of a product. From this perspective, Oberon can already draw some important conclusions for ProFloc™ efficacy through numerous successful trials with salmon, tilapia, shrimp, pigs, and poultry. Due to its \$10B market size and the fact that shrimp consume 1/6 of the world's supply of FM, that market has been identified as an initial target for Oberon. Opportunities with other high-value aquaculture species and weanling pigs are also being developed.

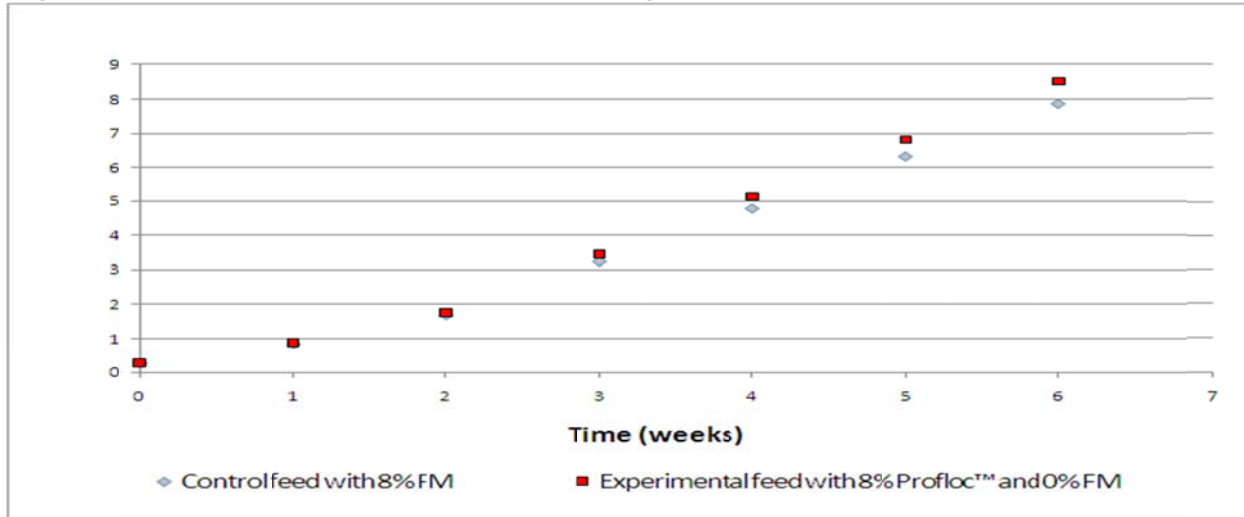
In 2009, Oberon commissioned a white shrimp trial with Texas A&M University in Port Aransas, TX through Dr. Addison Lawrence (note: this was Oberon's second trial with white shrimp and was initiated due to the preliminary success of the first trial). This 2009 study was designed to put the maximum pressure possible on the ProFloc™ ingredient. Thus, a state-of-the-art FM-based diet was formulated in which FM comprised 8% of the final diet by weight. Using this formulation, an experimental diet was then produced in which FM was removed and ProFloc™ was added in an amount sufficient to result in 8% ProFloc™ by weight. Feed formulations for the experiment are shown in Table 2:

Table 2: Formulations Used in 2009 Texas A&M Shrimp Feeding Trial

Ingredient	FM Diet	Oberon Diet
Fish meal, Menhaden	8.00%	0.00%
ProFloc™	0.00%	8.00%
Wheat Starch	29.50%	28.80%
Plant/Animal Ingredients	35.7%	35.5%
Mineral Premix	14.70%	15.10%
Lipid Premix	5.40%	6.00%
Vitamin Premix	0.50%	0.50%
Alginate	2.00%	2.00%
NaHexaMeta PO4	1.00%	1.00%
Cellulose	3.20%	3.10%

The results of the experiment are illustrated in Figure 1. Though the results are equivalent on a statistical basis, it is noted that the trend for the ProFloc™ diet indicates that a significant difference may have resulted by trial's end were the trial to have been carried out for a longer period. As a result, Oberon is currently investigating ProFloc™ performance in white shrimp on a South American shrimp farm over a 12-week period (completion mid-January, 2011).

Figure 1: Results of Texas A&M Shrimp Feeding Trial



Results of other trials have shown that ProFloc™ is highly digestible (i.e., in rainbow trout) and results in equal or superior growth versus FM-based diets (i.e., in swine, poultry, and tilapia).

ProFloc™ Value

For simplicity, the pricing of protein commodities can be viewed as falling into approximately four brackets. These brackets are capped by readily available commodities with known performance characteristics. For example, at the low end of the protein market are products with poorer performance, anti-nutritional factors, and amino acid imbalances. A ceiling for this lower bracket could be considered to be the price of 48% soy meal (\$440 USD per metric ton; Dec 2010) or feather meal (80% protein, \$430/tonne; Dec 2010). These products are readily available, well understood, and although relatively high in protein, these ingredients are limited with respect to their utility in many types of animal feeds.

The next bracket is occupied by higher quality proteins as measured by amino acid profile and performance in animals. This bracket could be considered to be capped by 60% protein, low-ash poultry by-product meal (low-ash PMB, \$1050/ton; Dec 2010). As opposed to standard PBM \$400/ton; Dec 2010), low-ash PMB consists of the meaty fractions of processed poultry. The bones are largely removed. Low-ash PMB contains approximately 60% protein and possesses a beneficial amino acid profile. It is a proven performer in feeds

but it is in very short supply (because it is significantly easier to include the bones and render all of a processor's waste into PBM versus separating wastes and having bones that need disposal after the low-ash PBM has been produced). Most low-ash PBM is used in high-value pet feeds.

The next bracket consists of the premium proteins and is capped (and largely occupied without competition) by fish meals. This category contains FAQ FM (\$1290/ton; Dec 2010) as well as the steam-dried FMs – also known as the “prime fish meals” (\$1440/ton; Dec 2010). These proteins are proven performers and have nearly optimal amino acid profiles; but they are also supply-constrained. Proteins that fall into the final price bracket above the FMs generally consist of additives, palatability enhancers, and other ingredients that are added at very low levels to produce a desired effect on the feed or on the animals. This bracket is occupied by krill, yeast products, and other proteins that are not typically used as protein sources in animal feed; instead, they are used because of a particular constituent within the product (such as the minerals and mannans in the yeast cell wall).

Upon successful completion of Oberon's first trial with tilapia in 2005, ProFloc™ showed performance characteristics superior to those of soy meal and feather meal. The tilapia in this trial received up to 43% ProFloc™ by weight in the diet and they surpassed the growth of tilapia receiving only conventional vegetable proteins (all diets contained FM at this early stage in Oberon's development). At that point (2005), indications were that ProFloc™ belonged at the top of the bracket capped by soy and feather meals. In 2008, the Director of Nutrition of a medium-sized (250,000 tons of feed per year) aquafeed company in South America said that he wanted to purchase the product in the \$700/ton range. Subsequent investigations with rainbow trout digestibility (>90%) and Oberon's first shrimp trial with white shrimp that showed the performance of ProFloc™ to be 85% of Special Select Menhaden FM (a prime FM) then bumped the price of ProFloc™ up against low-ash PBM – then at approximately \$900/ton. More recently, the Texas A&M white shrimp trial has indicated that the product may exceed FM in performance. However, until this assertion can be verified through further study, Oberon has considered pricing ProFloc™ at slight discount to low-ash PBM. Feed manufacturers currently are very interested in purchasing the ProFloc™ at this level of pricing with the understanding that other components, including cell fractions as well as use of ProFloc™ as a liquid additive, could also prescribe greater value to Oberon's product.

Additional Opportunities and Conclusion

Even though it is a premium ingredient for animal feeds, FM does have drawbacks:

1. Because fish meal must be produced close to the location of the fish used to make it (i.e., primarily in Chile and Peru), FM must be transported long distances
2. Limited supplies and concerns regarding sustainability of the supply of fish used to make fish meal have reduced production to approximately 5 MMT per year. There is no reasonable expectation for FM supplies to increase in the future
3. FM production is seasonal and is often purchased in bulk well in advance of use

ProFloc™ does not share these difficulties as it can be produced year-round at the local level, it is perfectly sustainable (because it derives from plant carbohydrates which themselves are a by-product of human food production), and its supply can be increased over time as increasing number of production facilities come online. ProFloc™ performs extremely well in many types of animal feeds and it should be able to command a high-quality price point as this performance becomes better known and the ingredient is adopted in the marketplace.