

FeedKind Protein Applications in Salmonid Species

Developed in Norway, FeedKind *Aqua* protein was originally developed for the Atlantic salmon industry. The extensive data and body of work developed by Norway's leading academics support the use of FeedKind protein at all life stages. With a nutrient density and amino acid profile comparable to fishmeal, FeedKind *Aqua* protein can easily be incorporated into smolt diets.¹ A proximate analysis of FeedKind *Aqua* protein can be seen in Table 1.

FeedKind *Aqua* protein is a non-GMO single cell protein produced via natural fermentation. It is listed on the EU Catalogue of Feed Materials and is available year round from a state of the art production facility reducing feed company supply chain risks.

Table 1.

| Typical Analysis | |
|------------------|-----|
| Crude Protein | 70% |
| Crude Fat | 8% |
| Crude Fiber | <1% |
| Moisture | 4% |
| Ash | 10% |
| NFE | 8% |

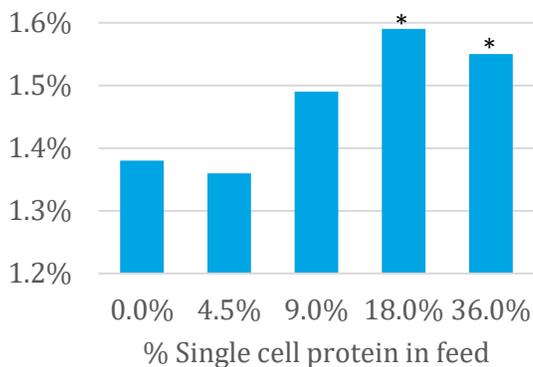
Nutritional Value of Single Cell Protein in Salmonids

In a study done by the Institute of Aquaculture Research in Sunndalsøra, triplicate groups of 18 Atlantic salmon were fed varying levels of single cell protein as compared to a control diet for 48 days.² The single cell protein replaced fishmeal and wheat; all diets were designed to be isoenergetic and isonitrogenous. The fish were stocked at an initial body weight of 170 grams and grown to 327 grams (4.5% single cell protein) to 364 grams (18% single cell protein). The diets fed 18% and 36% single cell protein had significantly higher growth rates and feed efficiency ratios.

Typical Amino Acid Content of FeedKind *Aqua* protein

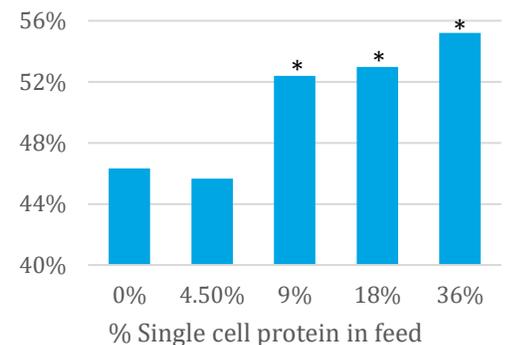
| | |
|------------|---------|
| Lysine | 44 g/kg |
| Methionine | 19 g/kg |
| Threonine | 32 g/kg |
| Histidine | 17 g/kg |
| Tryptophan | 15 g/kg |

Specific Growth Rates



Following the growth study, a digestibility trial was done with salmon from the 0%, 18%, and 36% single cell protein diet.² Triplicate groups of fish with a mean initial weight of 494 grams were fed for 15 days before being stripped for faeces. Apparent digestibility for nitrogen and amino acids were significantly different across all three diets, while the fish fed the 18% and 36% single cell protein diets retained significantly more nitrogen and energy

% Nitrogen Retained



than the control diet. Digestibility coefficients for key amino acids are on the following page in Table 2.³

¹ All measurements are on an as-is basis.

² Aas, Turid, et al. "Improved Growth and Nutrient Utilisation in Atlantic Salmon (*Salmo Salar*) Fed Diets Containing a Bacterial Protein Meal." *Aquaculture* 259.1-4 (2006): 365-76.

³ Skrede, A., et al. "Digestibility of Bacterial Protein Grown on Natural Gas in Mink, Pigs, Chicken and Atlantic Salmon." *Animal Feed Science and Technology* 76.1-2 (1998): 103-16.

Single Cell Protein and Gut Health in Salmonids

In addition to its value as a nutrient, FeedKind *Aqua* protein can help maintain a healthy gut in salmonid species. When single cell protein was part of the diet, studies have reported that soya induced enteritis in Atlantic salmon is not seen, and inflammation markers in gut epithelial cells are reduced.^{4,5}

Soybeans as well as many other plant based sources of protein cause digestive problems such as enteritis in Atlantic salmon and carnivorous fish generally. Anti-nutritional factors present in soybeans and other crops are easily managed by terrestrial digestive tracts, but cause significant issues for fish that have never seen these compounds before.

In a study done with Nofima, solvent extracted soymeal was included in diets for Atlantic salmon and combined with single cell protein to assess impacts on gut health. Four diets were formulated, a control with high quality fishmeal as the primary source of protein, a diet with 200g/kg soybean meal, a diet with 300 g/kg single cell protein, and a diet with 200g/kg soybean meal and 300g/kg single cell protein.⁵

An 80-day experiment was carried out with three replicate tanks with 75 fish per tank. Tanks were stocked at an average weight of 133 grams and fed the control diet for a four week acclimation period. The fish fed the soybean meal diet had lower final weights and higher feed conversion ratios. Fish fed the single cell protein diet saw improved feed conversion ratios. 15 fish per diet were randomly selected and tissue samples were taken from the distal intestine for histology and immunochemistry. All fish fed the soybean meal based diet showed distal intestines typical of soybean induced enteritis, while all fish fed the control diet, the single cell protein diet, and the combined single cell protein and soybean meal diet presented normal intestines.⁴

In addition to the ability of single cell proteins to help maintain a healthy gut, it is also believed that many microorganisms can be beneficial to a healthy immune system as well. Calysta intends to further explore this effect in Atlantic salmon and other carnivorous fish.

Please contact Calysta at feedkind@calysta.com or +1(650)492-6880 to request samples or get more information.

Additional Reading

Overland, Margareth. "Evaluation of Methane-utilising Bacteria Products as Feed Ingredients for Monogastric Animals." Archives of Animal Nutrition 64.3 (2010): 171-89.

⁴ Romarheim, O., and M. Overland et al. "Bacteria Grown on Natural Gas Prevent Soybean Meal-Induced Enteritis in Atlantic Salmon." Journal of Nutrition 141.1 (2010): 124-30.

⁵ Romarheim, Odd H. et al. "Prevention of Soya-induced Enteritis in Atlantic Salmon (*Salmo Salar*) by Bacteria Grown on Natural Gas Is Dose Dependent and Related to Epithelial MHC II Reactivity and CD+ Intraepithelial Lymphocytes." British Journal of Nutrition 109.06 (2012): 1062-070.

Table 2.

| Apparent Digestibility Coefficients for Essential Amino Acids | |
|---|-------|
| Arginine | 91.8% |
| Histidine | 80.8% |
| Isoleucine | 83.1% |
| Leucine | 83.5% |
| Lysine | 91.7% |
| Methionine | 83.4% |
| Phenylalanine | 77.1% |
| Threonine | 82.2% |
| Valine | 84.7% |