



Matching today's expectations.
Natural ingredients for sustainable aquafeed.

Matching today's expectations.

With aquaculture becoming crucial for the production of animal protein on a global scale, there is a rising interest in optimising the nutritional and technological quality of aquafeed. The BENEIO ingredients fit perfectly with the global demand for sustainable aquafeed production. With our vegetal proteins, prebiotic fibres and functional starches we offer you a number of innovative solutions for high-quality aquafeed, in line with economic and ecological challenges.

Natural ingredients for sustainable aquafeed.

As the major protein source in fish feed, fish meal is an important area where BENEIO ingredients can make a qualitative difference. Due to the limited amount of available fish meal in the market, its lack of sustainability and its increasing price, the inclusion of fish meal in diets has been progressively reduced. In order to replace the fish meal in the feed without impairing growth performance, research was conducted on vegetal proteins such as vital wheat gluten.

In addition, BENEIO offers an alternative to the traditional use of antibiotics in aquaculture, which has been criticised due to the potential development of antibiotic-resistant bacteria, the risk of antibiotic residue in seafood, the possible negative impact on the aquacultural environment and the danger of a suppressed immune system in aquatic animals. As an alternative strategy to antibiotics, our prebiotics can be used to improve intestinal health and development.

Finally, there are technical challenges related to the ingredient characteristics in the aquafeed. The ingredients used in the feed influence the behaviour of the feed in an aquatic environment. Important parameters include the oil absorbing capacity, the water stability and the sinking rate.



Open the doors to healthier aqua-nutrition.

Where nutritional ingredients are not only important for growth performance, but also for protection against contamination or infection, opting for high quality can make a significant difference. Based on numerous aqua species studies BNEO developed high-quality vegetable proteins and prebiotics to improve the overall nutrition of aquatic animals and help strengthen their immune system.

High-quality vegetable protein source.

With a protein content of more than 80 %, vital wheat gluten is one of the most concentrated vegetable protein sources available. It is a valuable alternative to fish meal in aquafeed formulations and has proven beneficial in the nutrition of a wide range of aqua species. Studies in various fish show that fish meal can be exchanged with vital wheat gluten by up to 100 % with comparable or even better zootechnical results as a consequence.

Fig. 1: Effect of fish meal replacement by vital wheat gluten.

Author	Species	Fish meal substitution level (%)	Lysine supplementation	Growth performance vs. reference
Storebakken <i>et al.</i> (2000)	Atlantic salmon	35	–	Comparable
Tibbetts <i>et al.</i> (2006)	Sea bream	30	–	Comparable
Schneider <i>et al.</i> (2004)	Nile tilapia	32.8	–	Comparable
Tibaldi <i>et al.</i> (2003)	European sea bass	50 70	0.20 0.80	Slightly lower in fish fed with 70% VWG
Helland <i>et al.</i> (2006)	Atlantic halibut	30	–	Comparable
Kissil & Lupatsch (2004)	Sea bream	100	2.10	Improved





Supporting optimal feed uptake with high-digestible protein.

Mink digestibility trials, that function as a reference for salmon digestibility, have shown that true protein digestibility can reach 99 %. This makes vital wheat gluten one of the most digestible vegetable protein sources and the preferred vegetable protein concentrate for aquafeed.

The first limiting amino acid is lysine; if high inclusion rates are used, a supplementation is necessary. On the other hand vital wheat gluten contains high levels of glutamine, which supports the immune response in fish. Glutamine is also one of the most important energy substrates of enterocytes in the gut system and has a positive influence on villus height.

Fig. 2: Amino acid profile of vital wheat gluten, compared to fish meal.

Amino acid	% of protein		
	Wheat Gluten (WG)	WG/FM (%)	Fish Meal (FM)
Alanine	2.5	40.3	6.2
Arginine	3.3	53.2	6.2
Asparagine/ Aspartic acid	3.0	32.0	9.5
Cysteine	2.2	217.2	1.0
Glutamine/ Glutamic acid	36.1	261.0	13.8
Glycine	3.0	45.5	6.6
Histidine	1.8	74.7	2.4
Isoleucine	3.4	70.5	4.8
Leucine	6.6	87.0	7.6
Lysine	1.6	19.4	8.1
Methionine	1.9	65.3	3.0
Phenylalanine	5.8	138.1	4.2
Proline	11.8	259.8	4.6
Serine	5.3	118.0	4.5
Threonine	2.6	59.2	4.3
Tryptophane	0.8	71.3	1.1
Tyrosine	3.4	89.2	3.8
Valine	3.8	67.0	5.6



Chicory-derived prebiotics for optimal gut health.

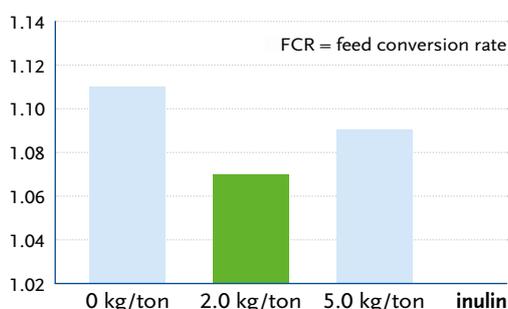
Aquaculture is steadily growing worldwide and its production capacity is dependent on optimal zootechnical performance. Rational aquaculture involves strategies to improve the function and efficacy of the digestive apparatus of the animal, to reduce stress and to prevent diseases. The latter can be achieved by strict environmental management and prophylactic strategies such as vaccination. However, vaccines cannot cover every important disease in aquaculture. Therefore, other preventive measures must preferably also be taken. In this respect, nutrition can play an important role to help optimise performance and disease resistance in fish.

Prebiotics have proven beneficial for gut health both in humans and in animals. Inulin and oligofructose are fibres which are resistant to enzymatic digestion and are selectively fermented by Lactobacilli and Bifidobacteria in the gut. This selective fermentation leads to a shift in bacterial flora, with a reduced likelihood of harmful bacteria as a consequence.

Since lactic acid bacteria are part of the normal flora of healthy fish and may even antagonise fish pathogens (Gatesoupe, 2008), prebiotics may also be beneficial in fish nutrition. Despite the fact that fish feed traditionally contains as little fibre as possible, research with shrimp, turbot, salmon and trout suggest a positive effect through inclusion of low levels of inulin/oligofructose. Both the zootechnical performance as well as the resistance against infectious diseases are improved.

The results of a trial with 900 salmon are summarised in Figures 3 and 4. In this research, growth performance was monitored during the first two months, before the fish were challenged with a *Piscirickettsia salmonis* infection. The results show a positive effect from inulin on mortality reduction and feed conversion and confirm that prebiotic inulin and oligofructose are natural and sustainable alternatives for the use of in-feed antibiotics.

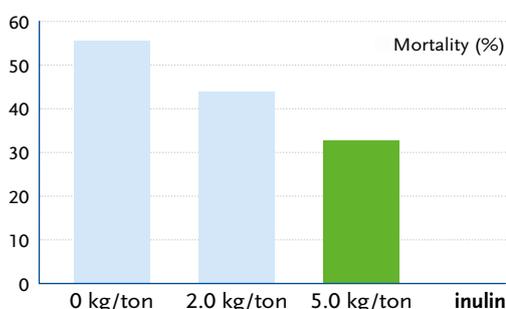
Fig. 3: Improved feeding.



SGS Aquatic Health, 2007

Effect of various dosages (/ton feed) of inulin on feed conversion rate (FCR) in Atlantic salmon (d31-60).

Fig. 4: Lower mortality rate.



SGS Aquatic Health, 2007

Effect of various dosages of inulin on mortality in salmon after bacterial challenge with *Piscirickettsia salmonis* (d1-31).

Optimising the technological quality of the aquafeed pellet.

When formulating diets for aqua species, it is not only the nutritional content of the feed that should be considered; the physical characteristics of the final product are also of great importance. For instance, the texture, water stability or buoyancy of a diet can be modified not only by feed processing techniques, but also by the physical nature of the ingredients.

Vital wheat gluten: an optimal binder for aquafeed.

Vital wheat gluten is an interesting technological ingredient for aquafeed diets due to its visco-elastic properties. It serves as a strong cohesive matrix and prevents gas expulsion during extrusion. The table illustrates the effect of vital wheat gluten addition on the technological parameters of aquafeed. It can be concluded that vital wheat gluten improves water stability of the extrudate and enables the feed producer to include higher dosages of oil in the feed.

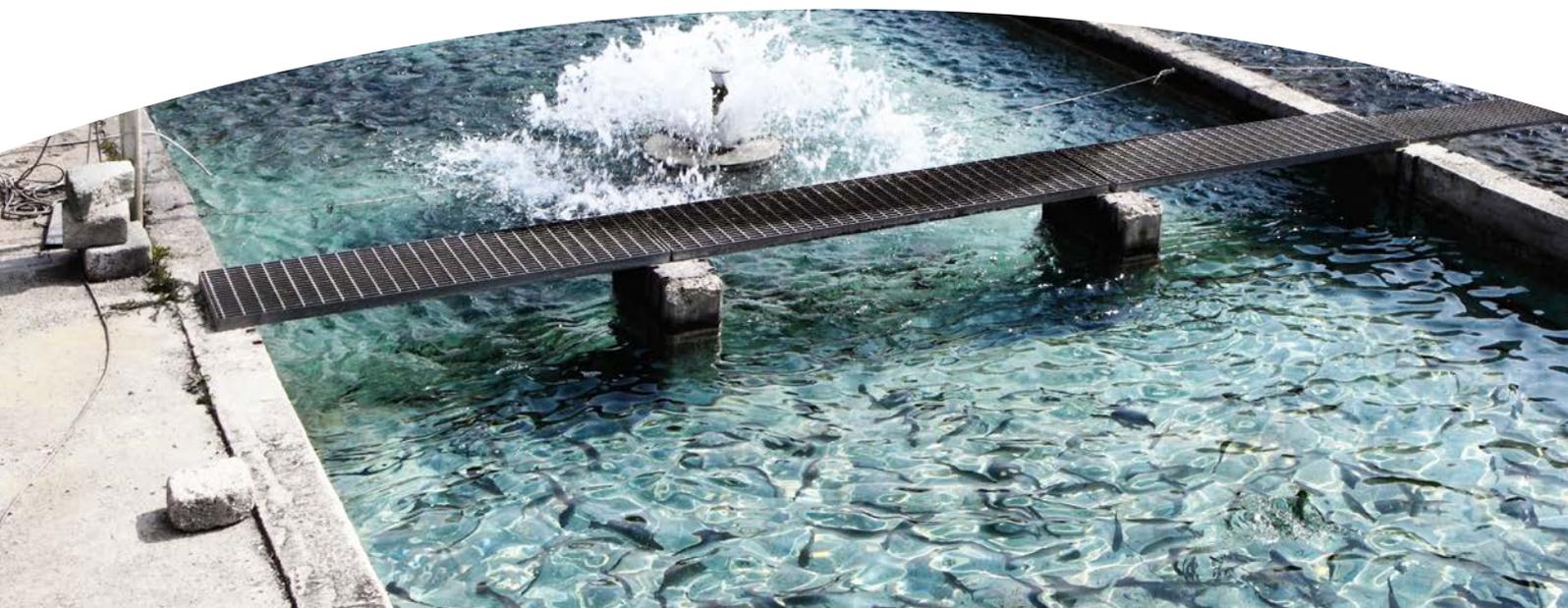
Fig. 5: Gluten improves the physical parameters.

Food mixture	Control diet ¹⁾	Test diet ²⁾
Mass volume (g/l)	580	504
Sinking rate (cm/sec)	6.2	4
Water stability (% residues at 10 min and 1 hr)	0/4	11/92
Oil absorbing capacity (%)	18	31

Effect of vital wheat gluten addition to aquafeed on the technological parameters of pellets and extrudates.

¹⁾ Basal diet containing fish meal, fish oil, gelatinised starch, vitamin and mineral mixtures

²⁾ Test diet = 80% control diet + 20% vital wheat gluten

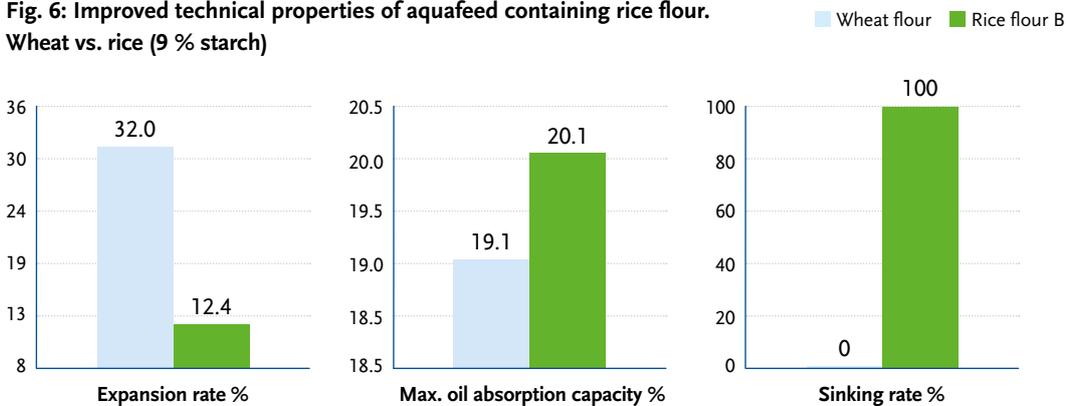


Rice starch: an extrusion enhancer.

Though starch is difficult for fish to digest and therefore limited as a nutritional value, its specific binding and expansion characteristics make it a very important component for the physicochemical properties of aquafeed. When it expands, starch reaches a certain degree of pellet porosity, allowing it to absorb oil or other liquids, to meet the fish's nutritional requirements and to achieve the optimum pellet buoyancy.

Compared with wheat flour, the rice flour expansion rate is considerably lower at the same starch level in the formula. And yet, the oil absorption is higher for rice starch (see Figure 6). As a result of this lower expansion rate, a better sinking product can be produced with rice flour. A lower expansion rate of starches with the same binding properties also enables more efficient production of mini-pellets. Smaller pellets can be produced with the same die-hole diameter or, alternatively, a bigger die-hole diameter may be utilised to produce the same size mini-pellet. In both cases the production capacity of the extruder is increased and risk of blockage from the extruder die is reduced.

Fig. 6: Improved technical properties of aquafeed containing rice flour.
Wheat vs. rice (9 % starch)



Expansion rate, oil absorption capacity and sinking rate of wheat and rice flour formulas, produced at identical processing conditions.





How do these technical properties work?

In the extrusion process, one of the most important characteristics is the hot-set of the starch, meaning the increase of viscosity during the cooling of dough. Rice starch is characterised by a very high hot-set temperature and viscosity increase rate during expansion of the dough after the extruder's die, certainly compared to other cereal flours. As the viscosity increases earlier and faster with rice derivatives, the expanded dough will offer more resistance to the formation of steam pockets. Once the extrudates are cooled, the product structure is more homogeneous and the surface is smoother. The surface of the extrudate is important when it comes to pellet behaviour in the water. Thanks to the use of rice starch, water penetration in the pellet can be limited, increasing its durability in the water.

Our rice flour offers a way for aquafeed producers to decrease formulation cost whilst maintaining or even improving physical properties such as binding, expansion rate and oil absorption.

BENEO rice flour increases flexibility to optimise feed nutrient composition.

Convincing across all parameters.

Two groups of characteristics are important in the formulation of aquafeed: nutritional properties and technological or physical features. Nutritional features range from prebiotic fibres and sustainable, natural protein sources, to the digestibility of these ingredients and the energy content they contribute to the fish feed, and ultimately to the aqua species.

The technological quality of aquafeed is determined by the processing techniques as well as by the physical nature of the involved ingredients. Parameters for the technological quality of aquafeed include the sinking rate, texture and water stability.

Fig. 7: BENEEO's ingredients matrix.

Product	Fish meal replacement	Technological ingredient	Optimising gut health
Vital Wheat Gluten	***	***	***
BENEEO Prebiotics		*	**
Rice starch		***	



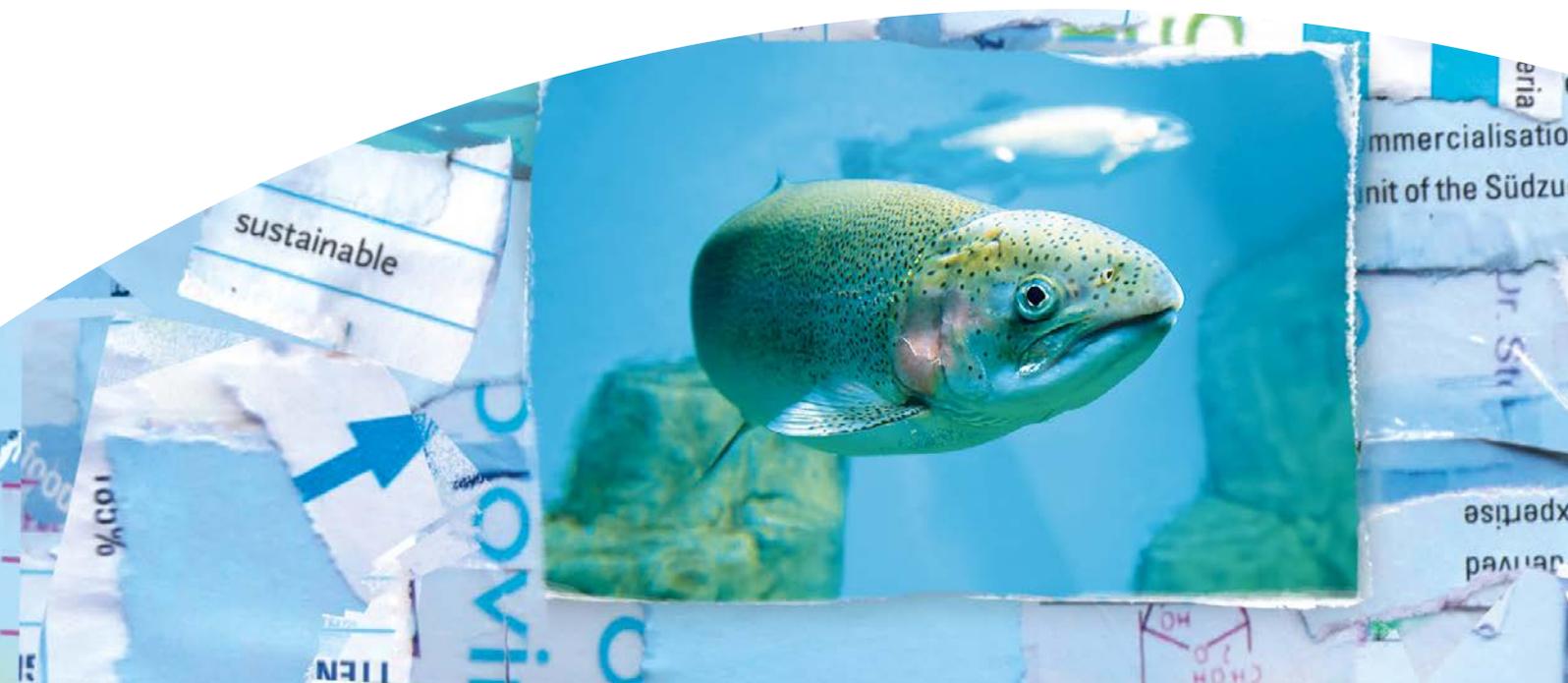
Always at your side: Profit from our interdisciplinary expertise.

Our experience entails valuable insights in various areas. No matter if your question concerns process technology, if it is marketing related or if it is about legislation and regulations. With nutritionists, marketers, regulatory professionals, technical food engineers and a competent sales force throughout the world, there is always a BENEEO expert who can help you. It's the combination of advanced ingredients and specialist knowledge together with access to a global network of experts that makes BENEEO a unique business partner.

Also interested in other ingredients? Discover our complete range now.

BENEEO-Animal Nutrition offer a broad range of natural ingredients with nutritional benefits. The product range comprises vegetable proteins, digestible carbohydrates and prebiotic chicory-derived fibres. BENEEO-Animal Nutrition extends BENEEO's unique expertise in human food to the world of pet food, animal feed and aquafeed.

BENEEO specialises in the production and commercialisation of functional feed ingredients and is a business unit of the Südzucker Group. Learn more about BENEEO ingredients online: www.beneo.com



Gatesoupe, F.J. 2008. Updating the Importance of Lactic Acid Bacteria in Fish Farming: Natural Occurrence and Probiotic Treatments. *Journal of Molecular Microbiology and Biotechnology* 14(1-3), 107-114.

Boon, H. and BENEIO Technical Staff. 2015. Functional aspects of rice starch in aquafeed formulation and production. *Aquafeed* 7(3), 4-7.

Helland, S.J. and Grisdale-Helland, B. 2006. Replacement of fish meal with wheat gluten in diets for Atlantic halibut (*Hippoglossus hippoglossus*): effect on whole-body amino acid concentrations. *Aquaculture* 261(4), 1363-1370.

Kaushik, S. J. 2000. Feed formulation, diet development and feed technology. *Cahiers Options Méditerranéennes* 47, 43-51.

Kissil, G.W. and Lupatsch, I. 2004. Successful replacement of fishmeal by plant proteins in diets for the Gilthead seabream, *Sparus aurata* L. *The Israeli Journal of Aquaculture - Bamidgah* 56(3), 188-199.

Schneider, O., Amirkolaie, A.K., Vera-Cartas, J., Eding, E.H., Schrama, J.W. and Verreth, J.A.J. 2004. Digestibility, faeces recovery, and related carbon, nitrogen and phosphorus balances of five feed ingredients evaluated as fishmeal alternatives in Nile tilapia, *Oreochromis niloticus* L. *Aquaculture Research* 35(14), 1370-1379.

Storebakken, T., Shearer, K. D., Baeverfjord, G., Nielsen, B. G., Åsgård, T., Scott, T., and De Laporte, A. 2000. Digestibility of macronutrients, energy and amino acids, absorption of elements and absence of intestinal enteritis in Atlantic salmon, *Salmo salar*, fed diets with wheat gluten. *Aquaculture* 184(1), 115-132.

Tibbetts, S. M., Milley, J. E., and Lall, S. P. 2006. Apparent protein and energy digestibility of common and alternative feed ingredients by Atlantic cod, *Gadus morhua* (Linnaeus, 1758). *Aquaculture* 261(4), 1314-1327.

Tibaldi, E., Tulli, F., Piccolo, G., and Guala, S. 2011. Wheat gluten as a partial substitute for fish meal protein in sea bass (*D. labrax*) diets. *Italian Journal of Animal Science* 2(1S), 613-615.

The information in this brochure is presented in good faith and believed to be correct, nevertheless no responsibilities/warranties as to the completeness of this information can be taken. This information is supplied upon the condition that the persons receiving the same will make their own determination as to its suitability for their purposes prior to use. It is strongly recommended to consult and apply all national food legislation (e. g. legislation on claims, communication towards the consumer etc.) prior to any communication to consumers. This information does not contain any warranty that the supply or the use of the products in any territory is not an infringement of the rights of third parties in industrial or intellectual property. It can also not be regarded as an encouragement to use our products in violation of existing patents or legal provisions in the matter of food stuffs.



What can we do for you?

If you have any questions about our BENEEO ingredients, please don't hesitate to contact us.
We will be happy to help you.

BENEEO-Animal Nutrition

Aandorenstraat 1

B-3300 Tienen (Belgium)

Phone +32 (0) 16 801 582

Fax +32 (0) 16 801 592

contact@beneeo.com

www.beneeo.com

Follow us on:   