INTERNATIONAL

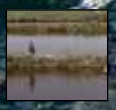
# AQUA FEED

INCORPORATING
FISH FARMING TECHNOLOGY

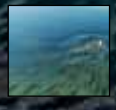











## Transforming aquaculture production using oxygenation systems

## Nutritional benefits of processed animal proteins

*– in European aquafeeds*

## Bioenergetics

*– application in aquaculture nutrition*

## Towards aquafeeds with increased food security

VOLUME 16 ISSUE 2 2013 - MARCH | APRIL

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MUYANG

INTERNATIONAL AQUA FEED

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AN INTERNATIONAL MAGAZINE FOR THE AQUACULTURE FEED INDUSTRY - INCORPORATING FISH FARMING TECHNOLOGY

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## Aqua News



## Features



## Regular items



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# CROESO - Welcome

2013 has started with several meetings and workshops and a busy schedule for me as both editor and academic. I have just returned for Brussels where I spoke at the Nutra-ingredients meeting that largely focused on human gastro-intestinal health but attracted a large gathering of scientists from major European companies and government agencies concerned with probiotics, prebiotics and legislation of feed additives and supplements. My contribution on fish and the role of probiotics was well received by the medical fraternity as we were able to learn so much from each other in terms of research directions and the functionality of novel dietary ingredients in humans and animal systems.

*Professor Simon Davies*

My following visit to Scotland enabled me to visit BioMar's impressive feed plant facilities in Grangemouth where my latest PhD student, Daniel Leeming is now starting in a new position in R&D. The drinks were on him of course!

In this issue that I dedicate to Dr John E Halver who passed away last year, I include an article in tribute to this great scientist who was so distinguished in the subject of fish nutrition for over 50 years.

In this issue we feature cobia as our guest fish species. An amazing fish with unique attributes and a capacity for production that should in theory revolutionise marine fish farming. Its potential has not been fully realised to date, but active research towards producing healthy hatchery raised juveniles for on-growing will allow its expansion. Its versatility should see this fish being successfully farmed in many regions in the near future. I first encountered cobia directly on a British trade visit to Salvador, Brazil in 2008 and was fascinated by its rapid growth characteristics and excellent taste qualities.

We report on the use of oxygen and its vital role in intensive fish production using the latest technology and delivery and control systems by the Linde Gases.

We are always interested in the scope for raw material inclusion in feeds and we have been heavily involved in Plymouth with strategic research to optimize the use of animal by-products from category 3 sources for use in aquafeeds. On this theme, Eric De Muylder examines the potential of processed animal proteins (PAPs) from a European perspective prior to their re-introduction in aquafeeds in Europe in July.

Fish bioenergetics is fundamental to efficient feed formulations since energy is a core requirement in maintenance and growth of fish and its mode of intake, losses drive the need for protein, amino acids and other nutrients. The 'plane' of nutrition and feed intake all relate to energy density in feeds. Ingrid Lupatsch describes the application of bioenergetics with examples taken from her elaborate research work on marine fish such as sea bream.

We also look at the multifunctional dietary properties of spirulina, the role of bioremediation in water quality management by Goncalo A Santos of Biomin and the health benefits of olive oil and olive pomace in fish feeds.

Together with all our main news and regular features, we have quite a spectrum of topics covered. Enjoy!

## New team member joins IAF

International Aquafeed is pleased to announce a new addition to the team. Dr Yu Yu joins us as an associate editor and will work on our Chinese editions.

Dr Yu Yu began his academic career at the National Chung-Hsing University, Taichung, Taiwan where he gained his undergraduate degree in Animal Husbandry in 1968. He moved to Michigan, USA for his post graduate studies, completing a PhD in Dairy Science in 1974.

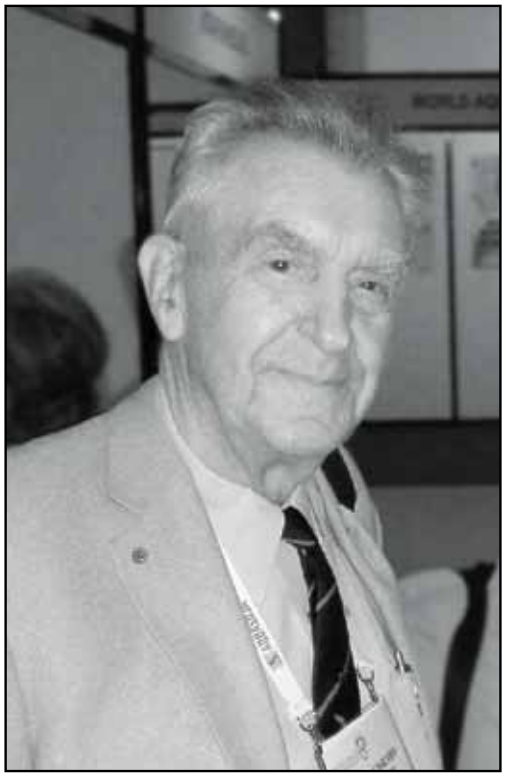
After graduation, he worked at the University of Guelph, Canada as a research associate and then as director of research and development at the United Co-operatives of Ontario.

In 1992, Dr Yu Yu moved to Kong Kong to take up the role of Asia regional director, technical services, at Ralston Purina International before moving to the National Renderers Association in 1996.

At present he is the director of East Bright Consulting in Hong Kong and the USA. We are looing forward to Dr Yu Yu lending his expertise in animal nutrition and feed formulation to the magazine.

# A tribute to the 'father of fish nutrition'

## Professor John E Halver



It was with much sadness that I learned of the passing before Christmas 2012 of Dr John Halver, the recognised 'father of fish nutrition' at the great age of 90 years. He was a wonderful friend and colleague who had given me invaluable advice and support over many years as I embarked on my career at Plymouth. He was a truly remarkable person and highly acclaimed world-class scientist.

I first met him in 1985 at a fish nutrition workshop in Brighton, England. He walked over to me onto the famous Brighton pier and asked me if I had understood the morning talks, giving me his characteristic mischievous glint of the eye as he quizzed my biochemistry knowledge. I seemed to pass his test and my second PhD examination was thankfully approved on the spot! This was Halver, the true professor and mentor who I was privileged to meet and have frequent exchanges with over the next 30 years.

It was in 1989 at the Toba, Japan fish Nutrition Symposium that he called me into his hotel room where I had supper with John and his wife Jane that I saw his kindness and love for science at first hand. I really got to know him well after that visit. He was a man of supreme intellect and endless wit and had a capacity for knowledge across so many disciplines but especially nutritional biochemistry and his specialist area of fish nutrition.

Indeed having served with distinction in the Second World War (receiving two bronze medals and a purple heart) he was asked by the US government to embark on developing feeds and setting nutritional standards for farmed fish leading to research on mycotoxins and the famous Halver test diet to determine vitamin and amino acid requirements of fish. John Halver spent much of the 1980s and 90s working on vitamin C and antioxidants such as vitamin E and selenium and was instrumental in providing a platform for future scientists to investigate the many areas of fish nutrition. His first and second editions of Halvers' Fish Nutrition is a classic text for all time and an excellent reference work in this subject found in so many university libraries and institutions involved in aquaculture science. My personal signed copy will never leave my study where the great man wrote 'Best wishes, John Halver- have fun!!' This was typically Halver, science must be fun as well as hard work.

John was never amiss at all the major prestigious conferences and symposia worldwide. He was famous for his questioning of presenters and the detailed cross-examination of their talks to help stimulate their further understanding of the complexities of fish metabolism. It was always done with finesse and politeness. I would meet him all over Europe, Asia, USA and his pace and sharpness of mind was incredible to witness.

In Brazil, it was Halver who found that perfect little restaurant serving the local fish and his chemistry skills were most applicable in serving the wine at its best. Indeed one of his hobbies was to make his own Merlot at his ranch home in Washington State. He enjoyed life to the full and loved the company of younger scientists and students who shared his passion.

It was on September 10, 2001 that I hosted John and Jane Halver at my home in Plymouth and we dined that evening at a local restaurant. That day we had taken a tour by boat of the Royal Navy base and some guest US Navy warships were in port. I will never forget the pride in him seeing his nation's military representation and we discussed in depth our alliances and long history of US-UK friendship. We walked on the sea front, the iconic hoe and I acted as the tour guide showing the famous landmarks of Plymouth, and the rich history of this maritime city and the legacy of Sir Francis Drake. He was fascinated by it all, absorbing every detail.

Tragically the next day on September 11 news of the World Trade Center and other attacks were announced as the Halvers' arrived in Ireland as a stopover for their journey back to the United States. The world changed forever, and travelling the corners of the globe became even more of a challenge after those fateful events.

In early 2009, at the Aquaculture America venue in Seattle, John Halver was in his element as he greeted me and my PhD students to his own city by the ocean. He met us at the airport full of energy and drove us all to our hotels. My colleague Dr Daniel Merrifield and I were dinner guests at the Halvers' home in Seattle and we enjoyed his endless stories and reminisce of his long distinguished academic career as we tucked into the wild salmon he had caught with his home made wine. As Emeritus Professor at the School of Fisheries in the University of Washington, we toured his laboratories and modest office. He was still a man of books and papers.

Knowing my interest in aircraft, he drove us to Puget Sound and the Boeing plant where we had a marvellous day together seeing the wonders of technology. It was during this venue that Halver was as busy as usual participating in the National Research Council meetings to update the nutritional requirements of fish for the final NRC; 2011 document.

I last met John in Porto, Portugal at the 2010 Aquaculture Europe meeting where we enjoyed the sunshine and hospitality of this fine city and its gathering of experts in aquaculture. John Halver had many new ideas and was particularly interested in the nutritional biochemistry of ageing in humans. When I asked him why he said charmingly, "Simon, when you reach my age it's natural to want to know how and why we age and what we can do about it?"

His attention was focused on lipid membrane function and the role of long chain fatty acids and the implication of fish oil. He was actively engaged in several patents for cancer treatment and working closely with institutions in Hungary where he was also a member of the Hungarian National Academy of Sciences.

John died peacefully at home in Seattle on October 24, 2012 and he had been working to the end on manuscripts and scientific reports. I am so thankful to have known him as a friend and speak for hundreds who have benefitted from his company and guidance in all walks of life.

We will serve him well to remember his place in the history of the science of fish nutrition and feeding and continue in our quest for knowledge based on rigorous research underpinned by good sense and humour.

*As the one and only, John Halver would say, "work hard, but have fun!"*

# Alltech feed survey finds significant growth in aquaculture

The world is producing 959 million tons of feed and has increased its production by at least 4 percent in the last year, according to the 2013 Global Feed Tonnage Survey released by Alltech. The company assessed the compound feed production of 134 countries in December. 2012 through information obtained in partnership with local feed associations and Alltech's sales team, who visit more than 26,000 feed mills annually.

"The 2013 publication of the annual year-end assessment by Alltech is being released as an industry outlook resource for the new calendar year and will hopefully allow governments, non-governmental organisations and the greater public to appreciate the value that the feed industry is generating globally," said Aidan Connolly, vice president of Alltech and director of Alltech's annual Global Feed Tonnage Survey.

Among the 134 countries assessed in Alltech's survey, China was reaffirmed as the chief producer of feed at 191 million tons and an estimated 10,000 feed mills. Consistent with late 2011 assessments, the United States and Brazil followed with 179 million tons produced by 5,251 feed mills and 66 million tons produced by 1,237 feed mills respectively. Overall, a 26 million ton increase was observed in BRIC countries (Brazil, Russia, India and China) year to date.

Asia continues to be the world's number one producing region at 350 million tons. However, Africa exceeded Asia in percent growth over 2011 results, increasing its tonnage nearly 15 percent from 47 million in 2011 to 54 million in 2012.

Globally, the survey identified 26,240 feed mills, with North America and Europe serving as home to more than half of them. The Middle East was estimated to have the largest feed mills, with an average of more than 63,000 tons produced per mill. Sixty percent of feed produced globally is pelleted, with percentages particularly high in Europe.

When analysed by species:

- Poultry continues to dominate with a 43 percent share of the feed market at 411 million tons, likely due to religious and taste preferences as well as cost. It grew by approximately 8 percent over 2011 estimates. Sixty percent of all poultry feed tonnage is dedicated to broilers, with the rest fed to egg layers, turkeys, duck and other fowl.
- The pig feed sector matched poultry's 8 percent growth, moving to 218 million tons globally.
- The ruminant feed market, comprising dairy, beef and small ruminants, grew more than 13 percent between late 2011 and December 2012, and now requires 254 million tons.
- Equine feed tonnage increased almost 17 percent to 10.8 million tons.
- Aquaculture is the fastest growing species sector by tonnage with growth greater than 55 percent since 2011.
- Pet food represents 20.5 million tons, 40 percent of which are produced in the United States, but Brazil continues to make considerable advances in this sector.

"As we look to the demands of the future, chiefly the feeding of 9 billion people by 2050, these survey results should stir optimism and resolve within our feed and food industries," said Dr Pearse Lyons, president of Alltech. "Our global feed industry is rising to the challenge, and we're seeing growth across the board. Moreover, we're seeing it in some particularly key areas– BRIC, Africa and aquaculture."

Global feed production has traditionally been difficult to quantify because many countries lack a national feed association. For this reason, Alltech began in late 2011 to leverage its global presence to obtain a finer estimate of the world's feed tonnage. The results of the annual year-end assessment are announced in January as an industry outlook resource for the new calendar year.

Connolly presented the 2012 Alltech Global Feed Tonnage Survey findings at a joint meeting of the International Feed Industry Federation and the Food and Agriculture Organization (FAO) in October 2012.

# **Research:** Sea lice do not affect salmon mortality

A study by Marine Institute and NUIG Galway, Ireland has concluded that sea lice do not play a significant role in salmon mortality. The research, which has been published in the *Journal of Fish Diseases,* involved more than 350,000 fish, released into eight different rivers in 28 separate experiments over a nine year period.

In this long-term study, one group of salmon smolts were treated with a commercial agent which protects them against sea lice infestation for eight weeks after going to sea. The return rates of control or unprotected mirror groups of fish were compared with the 'protected' fish to see if they suffered any additional sea lice induced mortality following release into the sea.

The research has been welcomed by the Irish Farmers' Association Aquaculture Executive, Richie Flynn. Flynn said, "The fact that the paper confirms that sea lice "is a minor and irregular component of marine mortality in the stocks studied and is unlikely to be a significant factor influencing conservation status of salmon stocks" is hugely important in focusing attention on the real threats to wild fish."

Flynn argues that more research should be done into juvenile wild salmon deaths. "Energy and time must be spent on trying to understand and, if possible, do something about lessening the factors which cause 95-96 percent of wild juvenile salmon to die when they travel to sea to feed. Revisiting all the impacts of wild salmon deaths (including angling) on the 4-5 percent of those lucky enough to return to our rivers each year should be a factor in this," he said.

# New global partnership to promote aquaculture in fighting hunger

A major international initiative has been launched to better understand the role of aquaculture in food security in poor countries.

Bringing together a global alliance of development agencies, governments and universities, the initiative will help low-income food-deficit countries in Africa, Asia and Latin America to develop sustainable policies for improving the livelihoods of millions of poor people.

The European Union (EU) is funding the three-year project with one million euros, which is managed by FAO in partnership with a global alliance of 20 development agencies, governments and universities.

## Pivotal role

Fish is the primary source of protein for 17 percent of the world's population - nearly 25 percent in low-income food-deficit countries. Fish is also a good source of omega-3 fatty acids. Omega-3 fatty acids benefit the heart and brain development of healthy people, and those at high risk of - or who have - cardiovascular disease. Nearly 50 percent of the fish that we eat now comes from aquaculture.

Although aquaculture is widely regarded to play a pivotal role in fighting hunger, little is known about its exact impact on food and nutrition security and poverty alleviation in developing countries.

Given population growth projections, increasing demands for fish products with stable production of capture fisheries, aquaculture will need to expand to meet the future demand for fish.

## Impact on food security

The new partnership represents the world's regions where aquaculture plays a major role and supports the livelihoods of millions of small-scale fish farmers. It also includes key institutions with a strong expertise in research, development project implementation and dissemination.

The project, Aquaculture for Food Security, Poverty Alleviation and Nutrition (AFSPAN) will develop new ways to quantify the contribution of aquaculture with better tools and more systematic and quantitative assessments. Moreover, it will elaborate strategies for improving the impact of aquaculture on food and nutrition security and poverty alleviation.

"The project will work closely with fish farming communities and will focus on field research in many major aquaculture countries in the developing world. It will develop tools and methodologies to help key partners to develop policies geared to improving aquaculture's contribution to food and nutrition security," said Rohana Subasinghe, senior FAO expert on aquaculture and coordinator of the project.

# AQUACULTURE VIEW

*by Dominique P Bureau, member of the IAF Editorial Panel*

## On the usefulness of bioenergetics and the need for more rational approaches

Bioenergetics, the study of energy transactions in biological systems, has found wide application in animal nutrition, including that of aquaculture species. A century ago, Ege and Krogh (1914) first applied the principles of bioenergetics to fishes. Today, we formulate feeds to a certain digestible energy (DE) basis and ensure that the feeds have a proper digestible protein (DP) to DE ratio (DP:DE). It is also increasingly common for feed manufacturers to alter the essential nutrient concentrations of the diet, and aquaculturists to adjust the ration to be delivered to the fish, on the basis of the DE of the feed used. Bioenergetics-driven models, such as those proposed by my mentor, Dr C Young Cho, have proven very useful and practical for estimation of feed requirement and waste outputs of fish populations held in captivity. The suitability of comparing feeds on the basis of their DE content has been demonstrated on a number of occasions in the scientific literature.

Despite its increasing acceptance and popularity in aquaculture nutrition, it must never be forgotten that bioenergetics is a 'system' aimed at simplifying interpretation of highly complex of biochemical processes. Hundreds of widely different compounds contain energy (Gibb's free energy). Animals do not simply metabolize this energy per se, instead, they metabolize specific nutrients, each with their specific roles and metabolic fates. Consequently, the widely held belief that 'animals eat to meet their energy requirement' is overly simplistic.

While it is true that animals need to consume nutrients that will be catabolized to harness their chemical energy, which will then be used in life sustaining processes, it must be recognised that a very large proportion (well over 50% under most conditions) of the feed intake of an animal is to acquire nutrients that are precursors for the biosynthesis of molecules that are structural or catalytic components (structural proteins, enzymes, phospholipids), storage forms (triglycerides, glycogen) or biologically active molecules (hormones, cytokines, lipid mediators, etc.). The amount of 'energy' that needs to be consumed is, thus, largely driven by 1) what the animal seeks to achieve (its growth potential, desired body composition, etc.), 2) the nutritional composition of the feed, and 3) the specific metabolic rules that govern the utilization of the individual nutrients consumed. In this context, to boil down such complex processes to a single term or factor, i.e. the 'energy' content of the diet or requirement of the animal, is not sensible.

Evidence suggests that significant differences exist between different aquaculture species in terms of the efficiency of different energy-yielding nutrients (amino acids, lipids, digestible starch) to support protein deposition and growth. Arguably the most significant limitation of bioenergetics models is that they are based on 'hierarchy of energy allocation', a concept according to which 'growth is the surplus of energy after all other components of the energy budget have been covered or satisfied' (Kitchell et al., 1977). This concept has proven to be a relatively flawed since young fish fed a maintenance ration (ration supporting zero body energy deposition) can still deposit protein and grow.

To quantitatively look at the requirement and utilization of all dietary components in a detailed and integrative fashion is highly desirable but it is also extremely complex. Consequently, bioenergetics offers today a relatively simple and practical way of looking at the global nutrient needs of the animal and the partitioning of these nutrients between catabolism as fuels and anabolism as storage in tissues. However, we should be unsatisfied with this situation and should strive to develop more rational approaches and models based on more or less explicit representation of biochemical reactions and metabolic roles and fates of nutrients.

A number of this type of models has been developed by various research groups for various fish species. Given the complexity of the task, all these 'mechanistic' models have been developed with some degree of simplification of metabolic pathways, included numerous assumptions, and been generally driven by more or less transparent and rational partitioning rules. These highly detailed models can work well within the narrow range of conditions for which they are developed. However, they generally fail to accurately describe nutrient utilization by fish under a wide range of conditions (differences in feed composition, environmental conditions, husbandry practices, life stages, genetic background of animals, etc.) encountered in fish culture.

A major bottleneck has been the lack of critical mass in terms of R&D effort invested on this topic. Efforts in the past have largely been idiosyncratic, piece-meal, and short-term in nature. There is a need for more concerted, long-term systematic R&D efforts. More comprehensive and rational approaches and models allowing more accurate description and prediction of the conversion of dietary inputs into biomass would make possible the elaboration of effective strategies aimed at improving the economical and environmental sustainability of aquaculture operations worldwide.

Want to know more? Disagree? Have feedback and suggestions? Contact me at: dbureau@uoguelph.ca

## AQUACULTURE UPDATES

**Sparsholt College in** Hampshire, UK has unveiled its new aquaculture building and launched an apprenticeship in aquaculture. The £500,000 Salmonid Rearing and Trials Centre was officially opened on January 31, 2013 and will be home to students studying Fish Husbandry and Fishery Management.

**Vietnamese seafood producers** are planning to contest a US Department of Commerce anti-subsidy investigation to see whether the country and six others have been engaged in unfair trade practices. The Vietnamese Association of Seafood Exporters and Producers (VASEP) says that the shrimp industry in Vietnam is not subsidised by the government.

**Researchers in the Japanese** prefecture of Nagasaki have started a project to feed kelp grouper at an onshore facility. The experimental study aims to shorten the raising period to two years instead of four years it currently takes in offshore cages.

**Net pen aquaculture in** Washington State, USA may come to an end if a proposed bill is passed by the State House. Rep. Kevin Van De Wege, a Sequim Democrat, filed the one-page proposal to allow counties to ban net pen aquaculture. Unsurprisingly, fish farmers in the area have come out in opposition to the bill.

# Processed animal proteins (PAPs) in aqua feed formulations in Europe

The re-introduction of processed animal proteins (PAPs) derived from category 3 materials deemed fit for human consumption from non-ruminant sources is due within the EU member states from June, 2013 under revised legislation. The use of PAPs in all farmed animal diets, including those of fish, was banned in the EU in 2001 (part of animal health protection measures against Transmissible Spongiform Encephalopathies (TSEs).

Consequently, the EU aquaculture sector was disadvantaged within the global aquaculture market and alternative sources of protein (principally plant by-products such as soybean meal, various pulses and grain protein concentrates) were the main commodities used in combination with fishmeal. Animal by-products are however a valuable protein resource that have been avoided for over a decade and this has constrained the potential to reduce our dependence on marine sources of both protein and fat for aquafeeds.

Strategic research conducted by the Plymouth University Fish Nutrition and Aquaculture Health group from 2005 to 2011 commissioned by Stephen Woodgate (previously technical Director of EFPRA; European Fat Processors and Renderers Association) resulted in several peer-reviewed publications (Davies et al 2009; Laporte, 2007). These investigations validated the safety and efficacy of poultry by-product meat meals, feather meals and porcine blood proteins for use in diets for trout, sea bass, sea bream, turbot, tilapia and carp.

This work, carried out under Professor Simon Davies, has clearly demonstrated the feasibility of replacing fishmeal with these products at high inclusion levels resulting in excellent growth, feed efficiency and added health benefits for these species.

Whilst having excellent digestibility characteristics, poultry by-products were shown to increase bone density, support the immune response of fish and providing effective replacement of fish meal at up to 50 percent without compromising growth and development of fish. These investigations were highlighted in documentation forwarded by EFPRA to the EU European Food Safety Agency (EFSA) as supporting evidence to reconsider their introduction in aqua-feeds produced in Europe.

## FEFAC welcomes return of PAPs in the EU

The European Feed Manufacturers' Federation (FEFAC) President Patrick Vanden Avenne welcomed the European Commission decision to adopt and publish the new regulation on the reauthorisation of non-ruminant processed animal proteins exclusively for use for fish feeding. He stated that "this measure paves the way for our EU aquaculture producers to step up their efforts to encourage the sustainable development of EU aquaculture by creating a level playing field with seafood imports from third countries".

"EFSA has provided clear scientific evidence that non-ruminant PAPs produced in accordance with the high EU processing standards are safe. They can help in reducing the EU dependency on fishmeal imports thus contributing to the Common Fisheries Policy reform goals of pairing sustainable wild fisheries with the sustainable development of aquaculture".

He highlighted that "the European feed industry is fully committed to support the competitiveness and sustainability of aquaculture production in the EU, as set out in the Commission proposal on the Common Fisheries Policy and supported by the EP Committee on Fisheries in their December 2012 vote on the CFP report of MEP Mrs Ulrike Rodust". The new measure contributes to global food security, by reducing the EU dependency on seafood imports which account for more than 70 percent of the current EU consumption". He noted that PAPs are widely used by aquaculture producers in Asia and North- and South-America, who are exporting farmed fish to the EU.

## IFFO introduces new logo

IFFO (the International Fishmeal and Fish Oil organisation) logo has undergone a makeover. The organisation was formed in 2001, but has a collective history of over 50 years, encompassing the activities of its predecessors, namely the Fishmeal Exporters' Organisation (FEO), International Association of Fish Meal Manufacturers (IAFMM) and International Fishmeal and Oil Manufacturers' Association (IFOMA). The organisation continues to move with the times and is introducing a new look for 2013.

While the fishmeal and fish oil industries are still at the core of the organisation, recent years have seen members from the human nutraceutical sector, marine crustacean processing, algae cultivation and even retailing join the organisation as the importance of renewable, responsibly managed marine ingredients has grown. To reflect this broader membership, the IFFO board agreed a modernised logo and strapline, while retaining the name IFFO to maintain a link to the long history of the organisation.

IFFO
THE MARINE INGREDIENTS ORGANISATION

# Super chilled storage

Ice is the no-brainer way to keep fish fresh during transportation. However, scientists at Nofima, Norway believe that ice and insulated boxes create a false sense of security and restrict innovation in the sector. According to the feed research institute, in 2010 Norway exported 922,000 tonnes of salmon – the vast majority of this packed fresh in polystyrene fish boxes with 5–6 kg of ice per 22 kg of fish. This is equivalent to 7,500 articulated lorries full of ice (around 230 million litres of water).

Nofima has been working on alternative methods for transportation of fish including 'super chilling'.

This method involves reducing the temperature down to the equalisation temperature of the fish, typically -1 to -2 °C. Super chilling is the easiest way of increasing the primary quality period of the fish and may be combined with packaging in a protected environment of carbon dioxide and nitrogen, during both distribution and in consumer packaging. This enables high quality to be maintained for several weeks in a cooling chain that is in accordance with the regulations (0 to +2 °C).

## Friend of the Sea certification for Cloudy Bay Clams

Cloudy Bay Clams, New Zealand has successfully undergone both fishery and chain of custody audit and its surf clams can now carry Friend of the Sea international sustainability seal of approval.

The audited fishing vessels for storm clam (Mactra murchisoni), diamond (Spisula aequilatera) and moon shell (Dosinia anus) and Tua Tua (Paphies donacinia), were found to be compliant with all Friend of the Sea criteria for sustainable fishery.

The target stocks in the three identified fishing areas (within FMA 7 and FMA3 on the north-east coast of the South Island of New Zealand) are not over-exploited and overfishing is not occurring.

The Total Allowed Catch is set and monitored by both the company and the Ministry of Primary Industry (MPI). Based on stock assessments and the results of fisheries monitoring quota are allocated for each FMA every year.

The clams are harvested from a sandy substrate along the coastline. The fishing method is based on a hydraulic winnowing clam rake, designed and developed by the company itself. The Clam Rake mesh is 10 mm diametre and no nets are used.

The use of water jets is designed to maximize catch, minimize mortality of clams and minimise the effects of dragging the dredge through the sand. The only by-catch is the occasional paddle crab which represents less than 1 percent of the catch. If alive and unharmed, they are returned to sea.

Fishing is not allowed in protected areas. GPS records of the area harvested were available for every single vessel. Marine GPS tracking and navigation systems are fitted to all vessels supplying Cloudy Bay Clams, thus making all fishing trips traceable. Fishing areas are harvested in 'paddocks' within the designated fishing (QMA) areas. The downloading of this data is automated and hence unequivocal and non-forgeable.

According to NZ legislation all of the catch is recorded on the Catch Landing Effort Return (CLER) as well as any discards on the vessel (e.g. return of undersized live clams to sea) and brought onshore. Accurate data and information on every catch reporting fishing area, time, and quantity are available. Reporting activity is subject to MPI auditing.

Waste and energy management systems are in place and implemented.

"Friend of the Sea certification confirms our efforts and continuous commitment to sustainability" explains Mike Ponder, general manager Cloudy Bay Clams "and it represents an important added value for our product".

## Active salmon farm map shows small footprint

The argument that hundreds of salmon farms create a gauntlet for wild migrating fish has been challenged by a map showing active farms during 2012's outmigration season.

"Salmon farms are very well sited and chosen based on the conditions of the area and what's best for all fish – wild and farmed," said Mary Ellen Walling, Executive Director, British Columbia Salmon Farmer's Association (BCSFA). "These maps put into perspective what little space our farms actually take up while contributing to BC as an important farming sector in the province, particularly in our coastal communities."

This is the third year that the BCSFA has proactively produced this reference for the public, with the maps now complete back to 2007. Farmers have supported continuing this information release as part of their commitment to sharing news and facts about their farms with the public.

"Our farmers work hard each day to grow healthy food, so educating the public about that commitment is a key responsibility for us," said Walling.

The spring is a particularly important time for salmon farmers, who employ numerous management practices to protect the health of both farmed and wild fish year round. From March to July, the frequency of counts for naturally-occurring sea lice and fish health monitoring on farms increases to give special consideration to wild fish species migrating from freshwater out to their feeding grounds in the North Pacific.

These maps are particularly helpful following the release of the final report of the Cohen Commission of Inquiry into the Decline of Fraser River Sockeye, where Justice Bruce Cohen recommended further research in the Discovery Islands area.

"We've seen lots of estimates about how many farms are in that area, but this is a solid record for the public that they can use to inform themselves directly," said Walling.

The BCSFA represents salmon farm companies and those who supply services and supplies to the industry. Salmon farming provides for 6,000 direct and indirect jobs while contributing $800-million to the provincial economy each year.

The map can be viewed online at www.salmonfarmers.org

## FDA and JIFSAN announce online training for aquaculture producers and importers

The U.S Food and Drug Administration has partnered with the Joint Institute for Food Safety and Applied Nutrition (JIFSAN) at the University of Maryland to offer a training module for aquaculture producers to help them comply with FDA regulations for importing seafood. JIFSAN houses the online training on its website and provides certificates of completion to those who take it.

The United States imports approximately 90 percent of its seafood. The training course is designed for foreign producers who export their products to the US, and may also be useful for foreign regulators. FDA receives numerous inquiries each year from importers and producers of seafood, particularly about the chemicals or drugs they are using or would like to use. The new module is designed to clarify how FDA regulates drugs for aquaculture, and provides information to help identify what drugs may be used and how they should be used to prevent unacceptable residues. The course also includes a section on the judicious use of antimicrobials.

## Alltech conducts trials into algae applications

With the world's population set to break 9 billion by 2050, sourcing sustainable high quality protein and nutrients is becoming increasingly important. This is especially vital considering current food systems cannot sustain such a prominent influx.

Though according to Becky Timmons, director of applications research and quality assurance at Alltech USA, this is a great opportunity for the agriculture industry to sustainably provide the necessary nutrients for the ever-increasing population.

With a shortfall in the availability of Omega-3 fatty acids, vegetable sources are increasingly being substituted in the production of farmed fish. This substitution leads to lower levels of Omega-3 fatty acids in the meat. Although fish consumption has doubled since 2005, though the nutritional benefits still remain the same.

Recently, at Alltech's Global 500, Timmons spoke about the possibilities for alternative, value-added enriched products. Although these products are already available in today's markets, they are usually fortified with fish or algal oil after production. Timmons suggests that feeding the animals the oil directly would result in noticeable algal benefits in the meat itself.

Discussing the benefits of value-added solutions, Timmons explains, "Consider what your opportunities are and do not be afraid of science and forward thinking, stay curious! Look forward and say if there is a challenge then there is also an opportunity. There is a way for us to differentiate ourselves in those times of challenge."

Following trials, Alltech has seen a significant uptake of Omega-3 fatty acids in meat in various species.

## Environmental impact guideline for aquaculture in South Africa

Water and Environmental Affairs Minister, Edna Molewa has published the Environmental Impact Assessment (EIA) Guideline for Aquaculture in South Africa for public comment.

Published under section 24J of the National Environmental Management Act, 1998 (Act No. 107 of 1998), the guideline seeks to align the EIA process and environmental authorisations to the specific nature of aquaculture.

It also seeks to identify and promote awareness of the potential positive and negative impacts associated with aquaculture and present measures of mitigation to the potential impacts of aquaculture.

"Aquaculture does not take place in a vacuum and the guideline emphasises this and provides particulars around the authorisation requirements in aquaculture underpinned by various environmental legal frameworks, including the Biodiversity Act, the Protected Areas Act and the Waste Act," says the department.

The guideline also highlights the scale of the potential impacts of aquaculture and the risks posed to the environment if aquaculture is not implemented along the principles of sustainability.

Molewa says that the guideline will assist with the creation of an environmentally responsible and more sustainable aquaculture industry.

"It is envisaged that the principles outlined in this guideline will result in the development of environmentally sustainable projects and ultimately an environmentally responsible aquaculture sector for South Africa," Molewa says.

# Transforming aquaculture production using oxygenation systems

by Linde Gases Division, Germany

**With demand for world food supply intensifying year on year, forecasters predict that in the not-too-distant future, the average family is likely to find fish on the dinner plate far more frequently than protein from land reared animals. The world population needs large supplies of protein and it costs significantly less to cultivate fish, than to raise land animals such as cows, pigs and poultry for slaughter.**

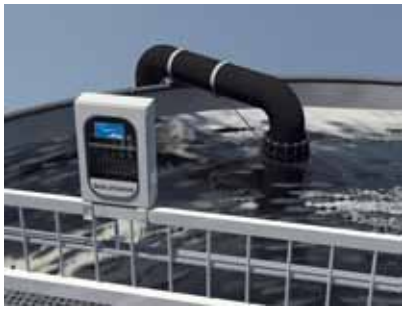
This scenario is expected to drive the world food business into the direction of aquaculture with increasing momentum in the years to come. Contemporary trends support this prediction. In the past 50 years, global demand for fish products has doubled and today nearly half of the world's seafood comes not from wild catches, but from land-based and offshore fish farms.

Aquaculture is poised to intensify across the world, not only in established fish-producing countries like Norway and Scotland, but also in China, Vietnam, India, Brazil and countries around the Mediterranean Sea. Chile's aquaculture sector, which was greatly impacted a few years ago by infectious salmon anaemia (ISA), a viral disease affecting Atlantic salmon, is also making a robust comeback.

According to projections offered by the Food and Agriculture Organization (FAO) of the United Nations, it is estimated that to maintain the current level of per capita fish consumption, global aquaculture production will need to reach 80 million tonnes by 2050.

Linde Gases, a division of The Linde Group and a global leader in aquaculture technology, has been closely tracking these trends and continues to invest heavily in developing the kind of technology required both now and in the future to support the expected expansion in world aquaculture. Linde anticipates growth in the world aquaculture industry between six to eight percent in 2013 alone. This means fish farms will need to gear up their operations to be equal to the challenges of maintaining optimal fish production conditions, such as appropriate nutrition, disease prevention and most importantly, maintaining a healthy water environment.

Controlling the concentration of oxygen dissolved in water is crucial to the success of aquaculture. Generally speaking, the closer the oxygen concentration is to air saturation, the better will be the environment for healthy and reliable fish growth. Maintaining the right levels of oxygen improves feed utilisation, shortens the growth period, reduces fish mortality and mitigates the need for vaccination and antibiotics.



## From land to sea

Depending on the fish species, the most common approach in today's aquaculture sector is to grow these fish on land in a controlled freshwater environment until the fish grow to weigh about 100 grams, as is the case with the salmon industry, which is the most dynamic area of the industry at the moment. Once the fish reach 100 grams, they are transferred to sea cages where they can be grown to approximately 4-5 kilograms during a period of 14-24 months.

The latest advance is a move to growing the young salmon up to 200 grams on land and the larger fish farming companies agree that this practice is likely to progress to a point where the fish are eventually grown to full slaughter size on land. Before this happens, however, the most likely development is expected to be an intermediate stage between cultivating the fish on land and transferring them to sea cages, that involves closed systems which float in the sea.

For technology partners like Linde, regardless of whether the fish are being reared in closed systems on land or in the sea, their task is to ensure that the oxygenation systems they supply keep pace with the dynamics of the changes the industry is experiencing.

This trend towards thinking beyond the traditional 16 to 20 metre diameter fresh and salt water tanks is taking hold in the leading aquaculture regions and it is likely that tanks as big as 40 metres in diameter and bigger will become a reality. To support this trend, Linde is focusing on developing technology that will get the hydrodynamics right and ensure oxygen is fully distributed throughout these large tanks.

An interesting potential benefit of increasing land-based aquaculture is that when intro-

duced on a large scale it could bring fish production to the place where the fish is actually consumed.

The Marine Harvest Group, the world's largest private fish producer, is building ever-larger tanks. At Kårstø, Norway, the company has plans to produce 6,000 tons of salmon per year, onshore, to an average size of 1 kilogram, in fish tanks 40 metres in diameter and 10 metres high, with volumes of water as high as 12,000 cubic metres. Marine Harvest also intends to explore the possibility of building a land based fish farm in a quarry at Mjølkevikvarden, in Askøy, Norway, where the company believes there is potential to build a plant big enough to produce 50,000 tons per year of 1 kilogram salmon.

This is equal to 5 percent of the total biomass production of salmon and trout in Norway today — currently about 1 million tons per year. Theoretically, if 20 of these plants where in operation today, all of Norway's salmon production to full slaughter size could be accomplished on land. Key parameters associated with this installation are 20,000 cubic metre fish tanks, 35 metres in diameter.

## Pioneering technology

One of the most pioneering technologies to be introduced to the industry has been Linde's SOLVOX® OxyStream system. The uniqueness of the technology is based on its ability to perform three critical functions in one system - dissolving oxygen in the water, producing the correct marine hydrodynamics and stripping out potentially harmful nitrogen - and all this via a very low energy requirement. The system is easily installed, as a new set-up or as a retrofit to existing fish farm tanks, and is maintenance-free because it is not associated with any ancillary equipment to manage water pressure.

SOLVOX® OxyStream significantly increases fish production volume, optimises fish meat quality and considerably improves operations from an environmental standpoint. It is a combined oxygenation and flow system that not only dissolves the optimal amount of oxygen in the inlet water flow, but also distributes it evenly at an adjustable flow pattern throughout the tank, ensuring that the fish stock benefit from the physical exercise involved in swimming against the flow. The flow regime can be fully tailored according to fish size, stock density and fish species, such as salmon or cod. The system comprises a standalone unit, allowing water flow and oxygen dosing to be individually controlled for each tank.

The micro-bubbles created by SOLVOX® OxyStream create the additional benefit of helping to reduce the concentration of dissolved inert gases such as nitrogen, argon and carbon dioxide. In particular, oversaturation of nitrogen, even in relatively small quantities, can endanger the wellbeing of fish stock, slowing growth and increasing the possibility of disease, and ultimately, even mortality. With the installation of OxyStream, external degassing units to prevent inert gas build-up will, in many cases, become obsolete.

Depending on the application, pumping pressures as low as 0.05 to 0.2 bar are normally sufficient to oxygenate the incoming water, strip nitrogen and create optimal tank hydrodynamics. This low operating pressure makes the system very energy efficient.

The capabilities of this technology were proved during trials conducted at a Marine Harvest facility in 2011. Results showed that OxyStream was the only oxygenation source suitable for rearing young salmon hatched in tanks running on fresh water, before gradually transitioning them to seawater. This creates an optimum environment in which to rear salmon, ensuring the correct oxygen levels throughout the entire production period and keeping fish stress levels to an absolute minimum.

Importantly, the technology makes it possible to precisely predict flow velocity and to adjust this velocity in the circular on-land tanks, Depending on their state of maturity, fish need a certain water velocity to remain healthy. If the velocity is not correct,

fish behaviour and swimming patterns can become erratic, utilising more energy and therefore requiring more food.

The global aquaculture industry has responded to the introduction of this system with immense interest and the Linde team currently has many units piloting at customer sites and has fielded enquiries from North America, the UK, Norway, France, Chile, Australia and even from Saudi Arabia and Israel.

## Future developments

As larger tanks are being contemplated, Linde is already investing in future developments and, to this end, in 2012 opened a state-of-the-art Innovation Centre for Aquaculture - a pioneering R&D and testing unit located at Ålesund, Norway. This location was specifically chosen for its proximity to the heart of the world's most industrialised fish farming community.

In addition to highly equipped laboratories, the centre features a number of test and demonstration aquaculture tanks, the largest of which is 55 cubic metres and has been built to a highly innovative specification. The tank allows both aquaculture technologists and customers alike to observe how the latest oxygenation technologies impact fish development within an optimal on-land farming enclosure. In addition to an overhead walkway extending the full diameter length of the tank, Linde has maximised observational opportunities via eye-level inspection windows and underwater lighting.

Outside of Norway, development in aquaculture is going on in many other countries. After being hit by the ISA virus, the aquaculture industry in Chile is ramping up again with a robust focus on oxygenation technology to support disease control. Technology capable of making more oxygen available at low energy is also attracting attention in countries planning to expand their aquaculture industries.

Linde is also doing research into the species of fish most likely to be produced in higher volumes in future years. While the existing salmon industry will continue to grow, indications are that other types of fish, particularly those capable of being harvested in warmer water temperatures of about 25 to 30 degrees Celsius, will come to the fore.

In fact, a research team at the new Linde Innovation Centre for Aquaculture is simulating conditions in tropical areas, both for fish cultivated in fresh and salt water. This is expected to pave the way for Linde to develop technology surpassing current state-of-the-art systems in this arena.

## Broader technologies

Linde's existing aquaculture offering, featuring broader technologies and products, will continue to play a role in the foreseeable future. Each facility, type of water and fish crop has different requirements which can be met, in combination, by elements drawn from an entire product family. Some of this equipment is dedicated to salt water and some is optimal for fresh water fish farming.

With 50 years of experience in aquaculture, Linde has accumulated the expertise to identify the right type of equipment for each customer's unique requirements via the most cost effective solution — minimum use of oxygen and energy.

In addition to SOLVOX® OxyStream, Linde's SOLVOX® technology line offers a wide range of oxygenation systems for the aquaculture industry, comprising equipment for optimised dissolution of oxygen in water, perfect distribution of oxygenated water to the fish and a regulation concept for smooth and reliable operation.

SOLVOX®Stream creates a better tank environment and improves the wellbeing of farmed fish. It provides good tank hydraulics and even oxygen distribution throughout the water volume. This makes the fish spread out throughout the entire water volume. Comprising of a slot tube with water flow indicator, SOLVOX® Stream ensures that oxygenated water is homogenously distributed over the complete depth of the tank. It is also designed to achieve an optimal circulation speed in the fish tank, appropriate to the fish species and size. SOLVOX®Stream is used in combination with oxygenation equipment such as SOLVOX®A, guaranteeing that the required environmental conditions, in terms of hydraulics and oxygen concentration, can be set individually for each tank. SOLVOX®Stream can be customised for flow rates ranging from 50 litres per minute to 20,000 litres per minute and an important feature is the water flow indicator that helps control water flow into each tank and optimises water usage.

SOLVOX®C, a pressure dissolver for seawater and fresh water, comprises cones designed to increase the concentration of gases in water to a high level. In standard operation, gas transfer efficiency is close to 100 percent. Since the cones can be operated at elevated pressure, the dissolved oxygen concentration can be increased significantly above saturation. SOLVOX®CV is an additional option to boost the oxygenation capacity of the cones, allowing up to 50 percent higher oxygen dosing without increasing the water flow rate or energy consumption.

SOLVOX®B is widely used as an emergency oxygenation system because it requires no auxiliary energy and supports the life of the fish in the event of a system failure. Operational energy is provided solely by the oxygen tank pressure.

Linde's SOLVOX®CD ceramic diffuser is a high-performance, aluminium-housed oxygen dissolving system that ensures uniform bubbles across the entire surface and minimises bubble coalescence. It is also suitable for dissolving oxygen into shallow tanks with water depths of less than 1 metre. Its main field of application is to provide additional oxygen to individual tanks and raceways, but it is also frequently installed for emergency oxygen supply.

Fish grow best at a constant oxygen level in the water, but the oxygen consumption of fish varies with stocking density, feeding regime, activity status, temperature etc. In order to keep the oxygen level as constant as possible, different amounts of oxygen have to be provided at different times. The SOLVOX®F oxygen dosing cabinet is designed to achieve this safely and reliably. ■

MORE INFORMATION:

*Website: www.linde-gas.com*

# Nutritional benefits of using Processed Animal Proteins (PAPs) in European aquafeeds

by Eric De Muylder[1] and Geert van der Velden[2]

**After the BSE crisis in the EU in late 2001, processed animal proteins (PAPs) were banned from utilisation in feeds for aquaculture and livestock. Some products were re-introduced in 2005 (blood products, milk products, hydrolyzed proteins, gelatin) as they did not pose any risk of transferring BSE to consumption animals. Meanwhile the bulk of processed animal proteins was used for other applications and exported to markets outside Europe.**

The ever-increasing cost of fishmeal has caused important increases in fish feed prices. It is therefore logical that fish feed producers continuously look for alternatives, but all other potential protein sources are becoming scarce and expensive. The re-introduction of PAPs into European aquafeeds, effective on June 1, 2013, would help the European aquaculture industry to solve part of the raw material problem.

## Sustainability

It would also reduce considerably the carbon footprint of aquafeeds, since these protein sources are locally available and will partially substitute imported soybean meal from the Americas and fishmeal from Peru and Chile.

The carbon footprint of PAPs is much lower than the footprint of vegetable meals (Figure 1). Also the emissions related to land use and land use change (LULUC) are higher for vegetable meals. The carbon footprint of poultry meal originates from the production of the by-products (based on a allocation according to economic value of meat and by-products), plus energy for transporting the by-products and drying of the material.

Aquaculture is often criticised for using more fish than producing fish (FIFO>1). The re-introduction of PAPs provides a chance to lower the FIFO considerably.

Apart from sustainability, also nutritionally, PAPs are the first proteins sources to be used to replace fishmeal, for a number of reasons:

## High protein and amino acid content

PAPs are rich in most essential amino acids except methionine. They are particularly high in arginine and other water soluble amino acids (proline, glycine, and glutamic acid), which act as attractant and palatant in aquafeeds.

## Digestible proteins

Digestibility varies a lot between different PAPs and is affected by quality of raw materials before drying and drying method. We can observe that good quality PAPs show digestibility levels which are as high as the highest quality fish meals. (Table 2)

## Partially soluble proteins

Both fishmeal and PAPs contain important amounts of water soluble proteins, in the form of peptides or longer chains. These water soluble proteins are highly digestible, but also will improve the attractibility and

Table 1: Table of composition of feather meal, poultry meal and meat and bone meal in comparison with the requirement of gilthead sea bream, rainbow trout and salmon

| | Feather meal | Poultry meal | Meat and bone meal | Salmonids | Gilthead sea bream |
|---|---|---|---|---|---|
| Crude protein | 85 | 63 | 50 | 35-45 | 38-46 |
| Amino acids (in % of CP) | | | | | |
| Arginine | 7,0 | 6,7 | 6,9 | 3.3-5,1 | 5.0 |
| Histidine | 0,8 | 1,8 | 1,7 | 1,6-1,8 | |
| Isoleucine | 4,9 | 3,5 | 2,8 | 2,0-2.3 | |
| Leucine | 8,2 | 6,3 | 5,3 | 3,6-4.0 | |
| Valine | 7,4 | 4,9 | 3,7 | 2.9-5,3 | |
| Lysine | 2,4 | 5,7 | 5,0 | 4.0-5,0 | 5.0 |
| Phenylalanine | 4,9 | 3,6 | 3,3 | 4,1-5,3 | |
| Meth+Cyst | 4,9 | 3,0 | 2,1 | 2,4-4,0 | 4.0 |
| Threonine | 4,8 | 3,6 | 3,0 | 1,8-2,2 | |
| Tryptophan | 0,7 | 0,9 | 0,6 | 0,5-1.4 | 0.6 |

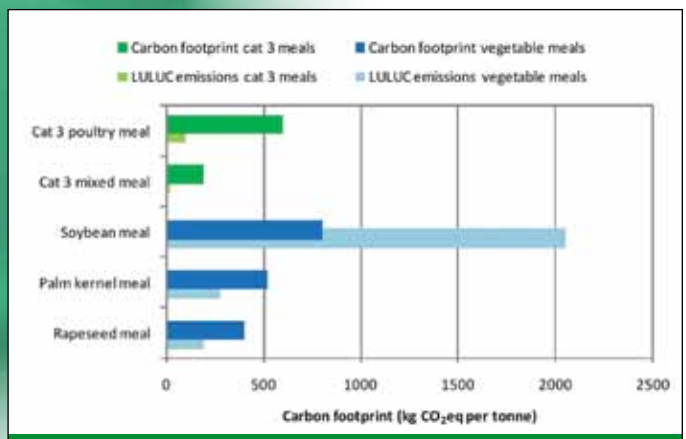



Figure 1: Carbon footprint of poultry meal and three vegetable meals per tonne of products (Ponsioen & Blonk, 2010)

palatability of aquafeeds. Highly digestible protein sources are essential in formulating larval and starter diets for fish. Palatability of diets becomes increasingly important when diets are formulated to contain less fishmeal, but more vegetable proteins.

## Presence of digestible P and Ca

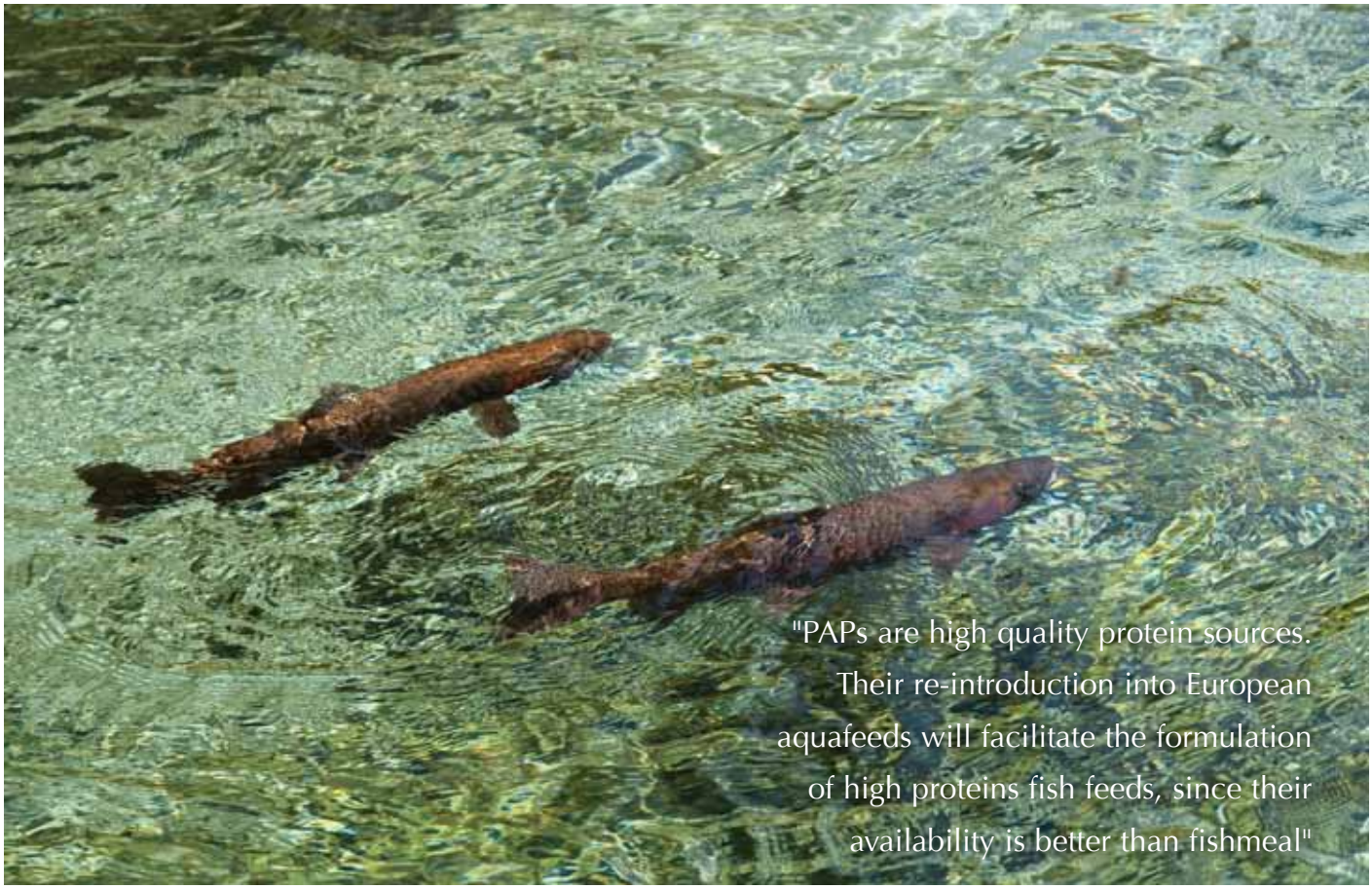
Phosphorus digestibility is a major problem in aquafeed formulation. The phosphorus present in vegetable proteins is mostly trapped in phytine and is not available for the fish. Utilisation of phytase can be a solution to increase the availability of phosphorus. The phosphorus present in meat and bone meal and poultry meal has a higher availability. As a consequence, the faeces of fish containing more animal proteins will contain less phosphorus which will find its way into the environment. This excreted phosphorus can cause eutrophication. This is particularly a problem for cage farming, and trout farming in flow through ponds.

## Low fibre content

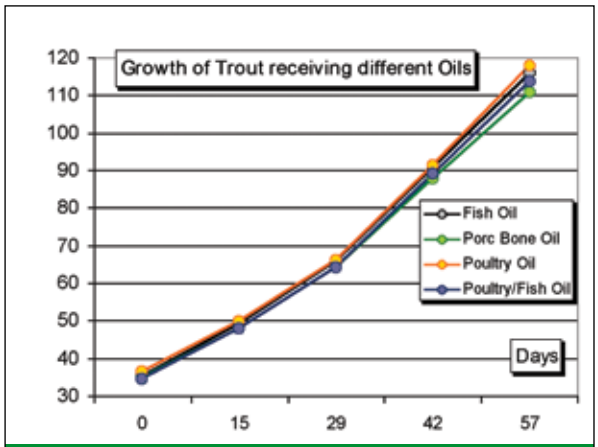
Most commercial fish species, cultured in Europe for human consumption are carnivorous species. Their ability to digest fibers is limited. Vegetable protein source are generally high in fiber content, while animal proteins contain very little amounts of fibers.

## Lipid content as energy source, but not as source of essential fatty acids

One disadvantage of PAPs could be the presence of lipids with saturated fatty acids compared to unsaturated fatty acids in fishmeal. Lipids in fish nutrition have a role for provid-



"PAPs are high quality protein sources. Their re-introduction into European aquafeeds will facilitate the formulation of high proteins fish feeds, since their availability is better than fishmeal"




Diets contained 17 % Fish oil, 12 % fish oil + 5 % poultry oil or porc bone oil. In treatment Poultry oil/Fish oil, the fish receive first the diet with poultry oil and than the diet with only fish oil

ing essential unsaturated fatty acids (linolenic, EPA and DHA for salmonids and EPA and DHA for marine fishes) and as energy source.

For fish species that can tolerate higher amounts of lipids in their diet, like salmonids, sea bream and sea bass, a combination of animal, vegetable and fish oil can satisfy both requirements, without altering the fatty acid content of the fish flesh.

## Presence of some nutrients which still need to be investigated

Due to the ever-increasing prices and scarcity of fishmeal, research is continuously searching for alternatives. This is often possible up to a certain level, but total replacement often results in growth loss, even though diets were formulated to contain the same amounts of essential nutrients for which the requirements are known.

Replacing fishmeal by PAPs generally results in better results than replacing fishmeal by vegetable proteins. There are probably some unknown nutrients still to be discovered, which are present in animal proteins but not in vegetable proteins. Hydroxyproline, taurine and nucleic acids are some nutrients that has attracted attention recently by researchers, but their requirements still need further investigation. There are probably more nutrients to be discovered in the near future.

Table 2: Overview of Apparent Digestibility Coefficients (ADC) and Apparent Digestibility of Proteins (ADP) observed for Rainbow trout and Gilthead seabream compared to other protein sources

| | Rainbow trout | | Gilthead sea bream | |
|---|---|---|---|---|
| | ADC | ADP | ADC | ADP |
| LT fish meal | 72,6 | 90,5 | 71,8 | 87,5 |
| Danish fish meal | | | | 95,8 |
| Hydrolyzed feather meal | 65,7-84 % | 71,6-87 | 48,8 | 51,6-57,7 |
| Meat and bone meal | 55,9-72 | 83-89 | | 35-79 |
| Poultry meal | 59,8-77 | 83-91 | | 80-89,9 |
| Soybean meal | 29,5-75,3 | 95,9 | | 86-90,9 |
| Soy protein concentrate | 53,2 | 90,4 | | |
| Corn gluten | 80-95 | 74,5-89,5 | | 90 |

## Conclusion

PAPs are high quality protein sources. Their re-introduction into European aquafeeds will facilitate the formulation of high proteins fish feeds, since their availability is better than fishmeal. This will also help the strive towards more sustainable aquaculture. PAPs contain a lot of interesting nutrients and are a better alternative to replace fishmeal than vegetable protein sources. ■

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# Bioenergetics - application in aquaculture nutrition

by Ingrid Lupatsch, Centre for Sustainable Aquaculture, Swansea University, United Kingdom

**Bioenergetics describe the flow of energy and nutrients within a biological system in our example a fish or shrimp. It describes the biological process of utilisation and transformation of absorbed nutrients for energy, for own body synthesis. The feed, that is consumed, is transformed in the body, complex chemical compounds are broken down into simpler components - protein into amino acids, carbohydrates into glucose, lipids into fatty acids and with this process energy is released - which is used for maintenance, for renewing worn out tissue and building new tissue - for growth. The major organic compounds in feeds such as lipid, protein and carbohydrates are the sources of energy but they also supply the building material for growth.**

There are different types of energy, chemical energy, electrical energy, mechanical energy and heat. These different forms of energy can be transformed into each other but only at a cost, the transformation is not 100 percent efficient. What is lost is mostly in the form of heat. Heat is also the only form of energy, into which all the others can be transformed and measured. The chemical energy stored in feed and animal tissue is measured using a bomb calorimeter. The amount of heat produced by complete oxidation of feed or tissue is known as the heat of combustion or gross energy (GE). Heat energy is usually expressed in kilocalories (kcal) or kilojoule (kJ). One kcal equals the energy needed to raise the temperature of one kg of water by one degree Celsius (°C). One kcal equals 4.184 kJ.

For the bio-energetic model, the two laws of thermodynamics can be applied

1. Energy cannot be created or destroyed within a system but may be changed into different forms (what goes in must go out)
2. In a system where energy is transformed (from feed to flesh) there is a degradation and loss of energy in the form of heat (nothing is 100 percent efficient)

The flow of energy from feed to growth in an animal is illustrated in Figure 1. Not all the energy from the feed is digested, substances such as fibre and cellulose from plant ingredients pass through the digestive system without being available to the fish. The consumed GE minus faecal energy losses (FE) is called the digestible energy (DE) which is then available for the metabolic processes of an animal.

The next major losses occur, when energy containing compounds (on DE basis) are transformed by the fish, broken down to smaller units and then used to build its own energy reserves or to deposit protein as growth. As mentioned above, this process of transformation is never 100 percent, there are always losses and they are mostly in the form of heat. In poikilotherms such as fish this heat is lost to the surrounding water, in homeotherms it is partly used to keep the body temperature constant. Only the net energy (NE) is now available for maintenance and for growth. Maintenance requirement represents energy needed for movements, osmo-regulation, blood circulation, first this energy has to be supplied before the remainder can be channeled into growth - the main product in fish culture.

## Quantification of energy demand in fish

By quantifying the energy budget - the energy input on one hand and the various energy losses on the other hand, valuable information can be gained in order to optimise feeds and guarantee optimal fish growth. By defining demands for maintenance and growth (Figure 1) and anticipating certain losses beforehand, feeds can be formulated and feeding tables established.

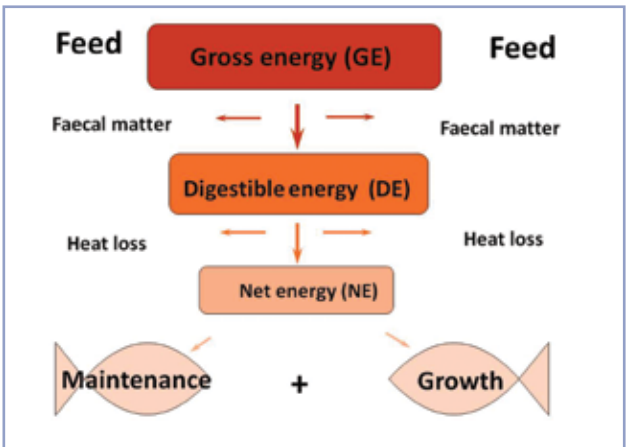


Figure 1: Schematic presentation of the energy flow through a fish

## Maintenance requirement

Fish require energy for maintaining basic processes of life such as blood circulation, osmo-regulation, excretion and movement, regardless of whether or not feed is consumed. An animal deprived of feed continues to require energy for those processes and will obtain it from the catabolism of own body reserves. Depending on the activity, several metabolic levels can be distinguished: basal, standard, routine and active metabolism.

Metabolic rate (Q) at all levels of activity, depends largely on the size of the fish and the water temperature, and is (at constant temperature) proportional to the metabolic body weight in the form of

$$Q = a\ BW(kg)^b$$

Where $(kg)^b$ : Metabolic body weight

*a* is the constant for given conditions (species, activity, temperature)

*b* is the scaling exponent of the metabolic body weight

Most metabolic studies on fish are carried out via indirect calorimetry. This is based on the assumption, that energy production in an animal is an aerobic process and requires oxygen for oxidising nutrients either from the food or from the tissue. In this case it is assumed that the amount of oxygen taken up by respiration will release an equivalent amount of energy which can be calculated from the oxy-caloric value. Another method is the comparative slaughter technique which measures the caloric value of the tissues utilised during fasting.

Figure 2 illustrates the relationship between metabolic rate of a fasting fish (gilthead sea bream) and weight.

The relationship between fasting metabolism and fish weight is not linear and results (Figure 2) were fitted to ln - ln functions as have traditionally been used by animal nutritionists to express metabolic body weight. The antilog of these functions describes the allometric relationship common in biological measurements.

$$Metabolic\ rate\ (kJ\ /fish\ /day) = 41.5\ BW(kg)^{0.80} \quad (1)$$

With an exponent of b = 0.80 for the metabolic body weight, the implication is that metabolic rate is increasing with increasing fish weight in absolute terms (kJ/fish/day), but smaller fish spend more energy per unit size than bigger fish. This concept of metabolic body weight will be clarified further on.

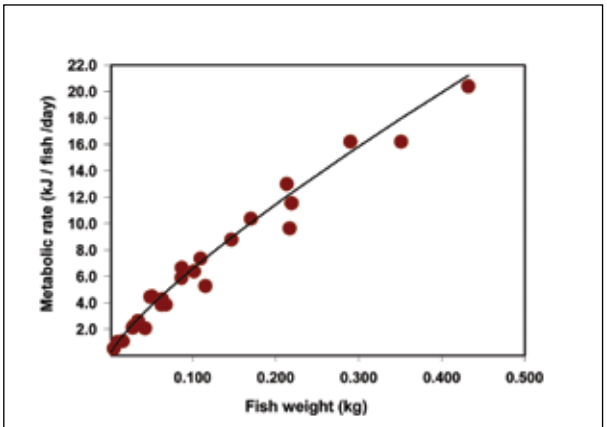


Figure 2: Metabolic rate (kJ/fish/day) of gilthead sea bream at increasing sizes

It should be noted that the fasting metabolism is only an approximation of the maintenance requirement; allowance must be made for the efficiency of utilisation of the dietary energy. This can be achieved by feeding fish graded levels from zero feed up to maximum intake. Energy gain or loss in fish is then determined by comparative slaughter technique. The following Figures 3 and 4 describe the relationship between energy fed (DE) and energy retained for sea bream of two different sizes. (at 210C).

It is obvious from Figure 3 that as more energy is consumed the more energy is gained, until the fish refuse to eat more. Figure 3 also demonstrates that the relationship between daily DE consumed (x) and energy retained (y) is linear and can be described by the following equations for each the two fish sizes:

$$Sea\ bream\ of\ 30\ g\ y = -2.2 + 0.66 \times \quad (2)$$

$$Sea\ bream\ of\ 100\ g\ y = -4.6 + 0.67 \times \quad (3)$$

During fasting the fish would lose energy as expected - 2.2 kJ per fish of 30 g and 4.6 kJ per fish of 100 g per day. The DE requirement for maintenance (no energy gain or loss) can be found where energy gain (y) is set at zero. According to the equations above, the maintenance requirement per day would amount to 2.2 / 0.66 = 3.33 kJ for the 30 g fish and 6.86 kJ for the 100 g fish. As mentioned before, absolute maintenance requirement is increasing with increasing fish weights, but regarded per unit of weight gain it is decreasing. Energy requirement of the smaller fish is 110 kJ / kg and for the larger fish only 69 kJ / kg.

The slopes of the lines are nearly identical at 0.67; they can be regarded as the efficiency of utilisation of energy. Per unit of DE consumed 67 percent is retained as growth, the remainder is lost as heat to the water.

In Figure 4 the same data set is used but daily energy retention in fish is presented referring to the metabolic weight of $kg^{0.80}$. By expressing DE intake and the subsequent retention of energy per metabolic weight ($kg^{0.80}$) the resulting regressions of the relationships for both fish sizes can be combined.

Thus the relationship between DE fed (x) and energy gained (y) both expressed in kJ / $kg^{0.80}$ / day is as follows:

$$at\ 21°C\ \ y = -33.7 + 0.67 \times \quad (4)$$

According to the equation (4), the maintenance requirement per day would amount to 33.7/0.67 = $DE_{maint}$ = 50.3 kJ x $kg^{0.80}$ (at 21°C). Again the slope of the line, the

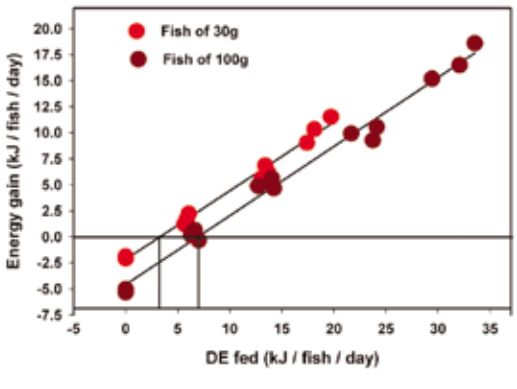


Figure 3: Relationship between DE consumed and energy gained (in kJ / fish / day) for two sizes of gilthead sea bream

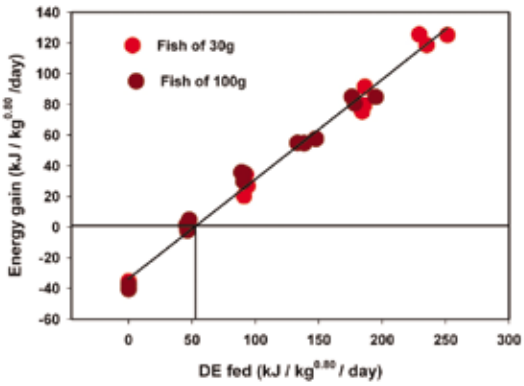


Figure 4: Relationship between DE consumed and energy gained (in kJ / kg0.80 / day) for two sizes of gilthead sea bream (at 210C)

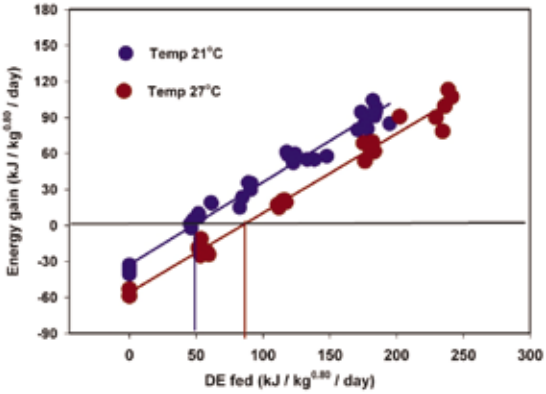


Figure 5: Relationship between DE consumed and energy gained (in kJ / kg0.80 / day) for gilthead sea bream at increasing temperatures.

efficiency of energy utilization for growth remains the same at 0.67. The reciprocal of 0.67 is 1.49 (1/0.67), which means that 1.49 kJ of DE have to be invested to produce 1 kJ of energy as growth, in other words, the energy cost to deposit one unit of energy as gain is close to one and a half units of energy from the feed (based in DE).

Besides fish weight, water temperature is one of the major factors to determine maintenance requirement. Adding data of an additional trial with sea bream performed at 27°C provides the following equation for the relationship between DE fed and energy gained per (kg)0.80 (Figure 5):

*at 27°C y = - 51.5 + 0.66 ×* *(5)*

According to equation (5), the maintenance energy requirement would amount to $DE_{maint}$ = 78 kJ $kg^{0.80}$ at a temperature of 27°C, while at 21°C the maintenance requirement was calculated as 50.3 kJ $kg^{0.80}$ as shown before. However in both instances the slope of the line (efficiency) remains the same even at the higher temperature.

## Requirements for growth

To be able to estimate feed requirements it is essential to predict the growth potential of the target species. In contrast to terrestrial animals fish seem to grow continuously, growth does not cease and reaches an asymptote, which in aquaculture however might never be attained. As growth is affected by temperature, it increases with increasing temperatures up to an optimum above which growth decreases, until the upper lethal temperature is reached.

Together with the anticipated increase in weight, the energy content of this gain is another factor determining the subsequent total energy demand of fish.

The following equations describe the daily weight gain of gilthead sea bream for water temperatures ranging between 20 and 28°C and the energy content per unit of weight gain.

$$\text{Weight gain (g / fish / day)} = 0.024 \times \text{body weight (g)}^{0.514} \times \exp^{0.060 \times Temp} \quad (6)$$

$$\text{Energy content of fish (kJ / g wet weight)} = 4.66 \times BW(g)^{0.139} \quad (7)$$

## Modelling requirements

The calculation of daily energy and consequently the feed demand (based on digestible energy DE, i.e. the amount absorbed through the gut) for fish can then be described as follows:

$$\text{DE intake (kJ/day)} = a \times BW\ (kg)^{b} + c \times \text{energy gain (kJ/day)}$$

*where DE = digestible energy intake*

*BW = body weight (kg)*

The expected live weight gain, which is dependent upon fish size and water temperature, can be predicted with the following common equation, where again a, b, and c are constants typical for a fish species:

$$\text{Weight gain (g/day)} = a \times BW\ (g)^{b} \times \exp^{c \times Temp}$$

The average energy content of the weight gain for a fish is dependent on the fish size and can be described as:

$$\text{Energy content (kJ/g fish)} = a \times BW\ (g)^{b}$$ *(i.e. it is body weight dependent)*

The expected daily energy gain is therefore:

$$\text{Weight gain (g)} \times \text{energy content of fish (kJ/g)}$$

For the quantification of daily maintenance requirement which is the energy requirement at zero growth:

$$DE_{maint}\ (kJ) = a \times BW\ (kg)^{b}$$

The cost of production as DE intake (in units of kJ for energy) for one unit of energy deposited as fish energy (as growth) is for many fish species around 1.50 or 1 / 1.50 = 0.67 = efficiency for growth

Combining those equations suggests that the feed allowance based on energy intake can be calculated as follows:

$$\text{Feed (g)} = [(\text{Maintenance} + (\text{weight gain}) \times (\text{composition}) \times (1.50)]$$

# Towards aquafeeds with increased food security

by Ioannis Zabetakis, assistant professor of food chemistry, University of Athens, Greece

**From both nutritionist and aquaculturist points of view, our aim is to sustainably produce aquatic food with superior sensory properties and high cardioprotective properties. The reason is that although preventable, cardiovascular diseases (CVDs) remain the top global cause of death and stroke. The prevention of atherosclerosis is, therefore, a major objective of modern medical and biochemical investigations into the mechanism of atherosclerosis and how the structure of food components determines their role in the mechanism(s) involved. The composition of aquafeeds and their impact on the nutritional value of aquatic food is a focal point of today's research and development both in academia and industry.**

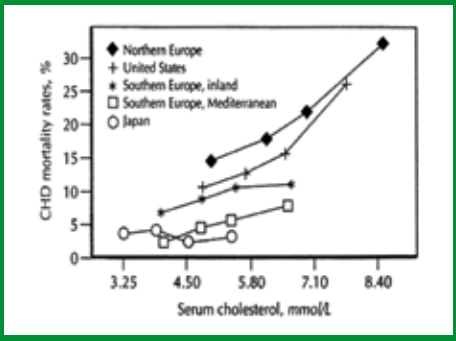


Figure 1: Rate of mortality due to Coronary Heart Disease (CHD) per quartile of serum cholesterol in pooled cohorts of the Seven Countries Study (adopted from de Lorgeril M *et al.* Cardiovasc Res 2002;54:503-515)

Since the study of the seven countries (Keys *et al.*, 1984), some unanswered questions still remain as to why cohorts in Greece and Italy had coronary heart disease (CHD) at low frequencies but high levels of serum cholesterol (Figure 1).

There is compelling literature on the beneficial role of omega-3 polyunsaturated fatty acids (omega-3 PUFAs) and there is a core belief that fish is good for our heart because of these PUFAs. Mechanistically, though, it is not clear how omega-3 PUFAs work. Their postulated mechanism in preventing atherosclerosis could be through lowering the levels of triacylglycerol, preventing arrhythmias, decreasing platelet aggregation or lowering blood pressure (Saravanan *et al.*, 2010).

On the other hand, the association of omega-3 PUFAs and CVDs has been revised recently by evaluating all randomized trials on the supplementation of omega-3 PUFAs to adults (Rizos *et al.*, 2012). In this review, the results of 20 studies on 68,680 patients were evaluated and omega-3 PUFAs were not found to be statistically significantly associated with CVDs in various patient populations. In the light of this study, we may need to refocus our research quests towards feed and food components with proved cardioprotective activities.

## Polar lipids of fish

Lipid microconstituents of specific food that constitute important ingredients of the Mediterranean Diet have been found that they have *in vitro* (in the test tube) important cardioprotective properties (by inhibiting the actions of the so called Platelet Activating Factor, PAF). PAF is the most potent inflammatory lipid mediator, a well-recognized agonist of platelet aggregation that plays a crucial role in atherosclerosis, i.e. the development of cardiovascular diseases. These lipid microconstituents can practically inhibit the onset of atherosclerosis and the development of CVDs (Zabetakis *et al.*, 2013). Such lipids have been found in a wide range of food such as red and white wine, yoghurt, fish, olive oil and olive pomace. Further *in vivo* (using rabbits) studies of olive oil, olive pomace and aquacultured fish (Nasopoulou *et al.*, 2010) have re-confirmed that it is the polar lipid fraction of these food sources that can reduce the thickness of atherosclerotic lesions in hypercholesterolaemic rabbits (Figure 2).

In a further mechanistic study, our group has recently demonstrated that the polar lipids of sea bream have down-regulated PAF biosynthesis and up-regulated PAF catabolism; practically the polar lipids of fish can inhibit atherosclerosis related enzymatic activities (Nasopoulou *et al.*, 2011b).

## Heavy dependency on fish oils

The steadily increasing population on Earth makes the sustainable production of food one of the major nutritional problems for mankind to address. In terms of food security in aquaculture, we need to face successfully a 'paradox' on the sustainable production of fish feed: today, high amounts of fish oil (FO) are required to produce fish feed. Currently, 40 percent and 60 percent of the global production of fishmeal and fish oil, respectively, are used in aquaculture. Salmonid diets alone consumed over 55 percent of the fish oil used by the aquaculture sector in 2006. About 50 percent of world marine fish stocks have recently been estimated as fully exploited, 32 percent as overexploited and only 15 percent as underexploited. These exploitation data suggest that the diminishing levels of available wild fish worldwide combined with the fact that aquacultured carnivorous species require large amounts of wild fish in their feed create an emerging necessity to improve our resource management practices.

## Need for novel sources

In order to reduce dependence on fish oil, significant breakthroughs have occurred over the past few years in replacing it with plant oils. By substituting feeds with plant oils, it also serves to reduce costs due to the fact that vegetable oils have steadily increasing production, high availability and better economic value. Several studies have been carried out to investigate certain vegetable oils as possible sustainable partial substitutes for fish oils in compounded fish feeds. The most common vegetable oils used for fish feed production have been soybean, linseed, rapeseed, sunflower, palm oil and olive oil.

Soybean and rapeseed oil are considered possible alternative lipid sources for salmonids, freshwater and marine fish since they are rich in PUFAs, especially linoleic (18:2 **ω**−6) and oleic acid (18:1 **ω**−9), but devoid of n-3 PUFA. However, in some cases, fish oil substitution by 60 percent rapeseed oil has been found to decrease European sea bass (*Dicentrarchus labrax*) growth. Soybean oil appears to be a better plant lipid source regarding gilthead sea bream (*Sparus aurata*) growth while considerable savings in feed costs could be achieved if it could be used as a partial dietary substitute for fish oil within compound feeds. The same is true of linseed oil and rapeseed oil, although to a lesser extent.

Furthermore, the use of palm oil in diets of Atlantic salmon and rainbow trout has given growth and feed utilization efficiency comparable to fish fed with equivalent levels of fish oil. Olive oil could also be used as a partial substitute for dietary fish oil in European sea bass culture, during growth out phase, Atlantic salmon (*salmo salar*) and rainbow trout (*Oncorhynchus mykiss*) with data showing similar growth rates to the ones when fish was fed on 100 percent fish oil diet. All these studies have been recently reviewed (Nasopoulou and Zabetakis, 2012).

New, alternative and in a way 'non-orthodox', sources of lipids need to be identified and valorised in order to achieve sustainable production of fish feeds and thus enabling the further development of aquaculture applications. Such promising lipid sources are vegetable oils (VO). The use of VO based aquafeeds has some strong advantages. Olive pomace (OP) and olive pomace oil (OPO) are natural by-products of olive oil production, which contain micro constituents with atheroprotective (substances) activity such as PAF-inhibitors and phenolic/polyphenolic mol-

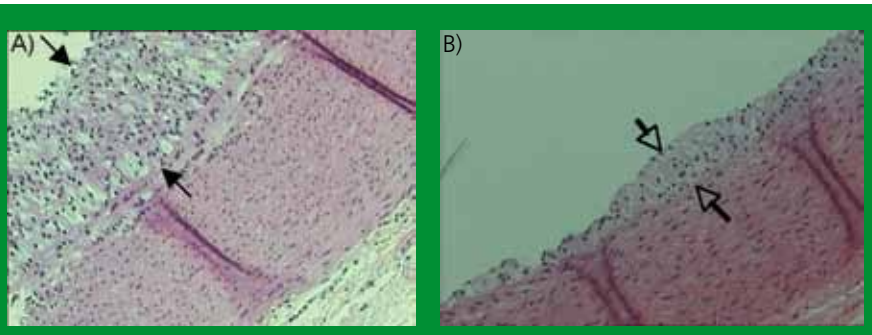


Figure 2: Representative optic micrographs x 100 of aortic wall sections stained with haematoxylin and eosin from the two experimental groups, where atherosclerotic lesions appear as foam cells (↑). (A) Group A (atherogenic diet); (B) Group B (atherogenic diet enriched with sea bream polar lipids) (adopted from Nasopoulou *et al.*, 2010). Copyright, "Food Chemistry" Elsevier

Negative environmental impact of olive pomace

ecules with antioxidant and other pleiotropic actions. Extensive research has been carried by our team on olive oil by-products and fish with regard to their capacity to prevent atherogenesis.

Recently, the possibility of partially replacing fish oil in gilthead sea bream and sea bass grow-out diet by lipids obtained from OP and olive pomace oil (OPO) has been reported. In actual fact, the feeding of OP to fish results in an improvement in its ability to prevent atherosclerosis and therefore cardiovascular diseases (Nasopoulou *et al*., 2011a).

## GM plants

There have been numerous studies on genetically modifying the plant oil profile so the plants increase the biosynthesis of either the precursors of omega-3 and omega-6 fatty acids or these fatty acids themselves. These modifications have focused on C 18 Δ6-desaturated fatty acids (such as γ-linolenic and stearidonic acid), omega-6- long-chain PUFAs (such as arachidonic acid) and omega-3-long-chain PUFAS (often referred to as 'fish oils') (such as EPA and DHA) and they have been recently revised (Haslam *et al*., 2012). The research approach is based on the assumption that omega-3 and omega-6 PUFAs have considerable nutritional value and thus efforts have focused in enhancing the bioformation of these molecules in the 'designer' oils (after genetic modification).

However, under the light of recent evidence that omega PUFAs have less nutritional value that previously considered (Rizos *et al*., 2012), these genetically engineering approaches need to be carefully considered. Scientifically, we need to assess any related environmental impact when GM plants are cultivated and commercially, we need to address the public concerns and need of the consumers (at least in EU) for 'GMO free' food.

## Food for thought / future actions

In today's rapidly changing world, we are asked to face conflicting problems and issues such as the overproduction and waste of food, obesity, CVDs and diabetes in the developed countries, famine and malnutrition in the developing countries, climate change, scarcity of water, rational use of cultivated land and sustainable use of resources and energy. In this complex and swiftly changing environment, the issue of food security and on how we can secure nutrition for the entire human population becomes a top priority for all of us in the feed and food arena. The sustainable production of food is a complex challenge. Some insights in approaching this challenge have been highlighted with this article. ■

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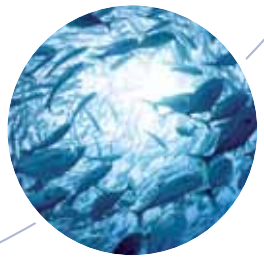

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# ESCAPES

## primarily caused by equipment failure

by Torkil Marsdal Hanssen, Norway

**Equipment failure or operational errors are behind three out of four farmed salmon escapes. Two out of three escapes are due to holes in sea cage nets according to a new study.**

Researchers working on the SECURE project (Securing fish – farming technology and operations to reduce escapes) have analysed all escape incidents between 2006 and 2009 reported by Norwegian fish farms. Their efforts provide the industry and researchers with new insights into the factors leading to loss at Norwegian production facilities.

### Structural failures most common

Equipment failure or damage is the major factor behind the escape of farmed salmon. Figures from the SECURE project show that 68 percent of escapes occurred because of structural failure. An additional 8 percent were able to escape due to human error during operations. Eleven percent of escapes took place from land-based facilities and an equal percentage escaped due to external factors. All in all, the researchers have revealed clear explanations for 96 percent of the total escapes reported from 2006 to 2009.

### Factors changing over time

"Common structural failures include problems with mooring lines, collapsed floating collars and holes torn in the netting of a sea cage. Bad weather is another factor contributing to structural failure and escape. We have also documented incidents of automatic feeding devices loosen and causing damage," says Østen Jensen, research manager with SINTEF Fisheries and Aquaculture and project manager of the SECURE project.

The escape incident reports reveal that equipment suppliers and fish farmers have managed to solve some of the equipment problems that previously led to a high number of escapes.

"Escapes caused by mooring or floating collar failure have become more and more rare. The greatest challenge now facing producers of salmon and trout is how to prevent wear and tear to the netting. Holes formed from chafing contact between the net and the sinker tube chain were responsible for more than 50 percent of total escapees between 2008 and 2010," Dr Jensen says.

### Fewer large-scale escape events

Operational error during activities such as delousing or maintenance, combined with fish transfer, account for close to 20 percent of the escape figures. The last large-scale salmon escape event, in which 175,000 fish escaped a production facility in Trøndelag, occurred in connection with delousing.

"Large-scale escape events in which more than 10,000 fish are involved comprise 19 percent of the total number of escapes during the period studied. As much as 91 percent of all fish that escaped can be attributed to large-scale events," says Dr Jensen.

The reduction in the number of large escape events is the most significant factor behind the substantial reduction in the number of production salmon escapees from 2006 to 2009.

### Characteristics of fish likely to escape

Behavioural differences among the various species of farmed fish also play into the risk of escape. Whereas only one percent of salmon escapes can be attributed to biological factors, one out of every four escaped farmed cod got out through holes in the nets caused either by predators or the cod themselves.

"In contrast to salmon and trout, cod will often bite the netting and tear the net wall. The cod also display more interest in such holes and are far more eager than salmon or trout to try to swim through them," adds Dr Jensen.

### The Houdinis of the sea

Cod are better escape artists than other species of production fish, opting to swim through obstacles rather than around them.

As part of the SECURE project, researchers at Norwegian Institute of Food, Fishery and Aquaculture (Nofima) have analysed the behavioural characteristics of cod which make them more likely to escape than other production species. Using controlled experiments, researchers have studied how they behave in sea cages.

Cod constantly bite and nibble on the net threads, showing great interest in investigating anything that appears unnatural to their environment. This affects how net repair should be approached at cod-production facilities. Repairs are most effective when colours and shapes of the repaired netting conform to the original. The ends of threads need to be affixed so that the repair will not deviate in appearance from the rest of the netting.

### Improved reporting

Fish farmers are required to report all escape events to the Directorate of Fisheries. Jensen says that escape incident reporting has improved substantially since the Norwegian

Aquaculture Escapes Commission (AEC) introduced a notification template five years ago.

## Placing responsibility on suppliers

Two problem areas stand out in the efforts to reduce the risk of escapes in Norwegian aquaculture. Jensen believes that both can be solved by the suppliers of aquaculture equipment.

"If the aquaculture industry is ever going to realistically realise its vision of zero escapes from sea-based production facilities, it must solve two big challenges. The first is that weighting systems currently in use to maintain the shape and volume of the net pens lead to wear and tear in the netting. The second is finding ways to decrease the incidence of operational – or human – error."

## Solutions can be developed

Dr Jensen points out that the key to solving both challenges can be found in the supplier industry.

"Improved product design and procedures can mitigate and, in part, prevent both wear and tear as well as human error during operations at sea. Much of the equipment in use in sea-based facilities should be redesigned and simplified to make it difficult or impossible to use incorrectly. Under the SECURE project we have acquired the knowledge needed to develop better and more secure solutions. The next step is up to the suppliers."

Suppliers have already begun applying the documented findings from the SECURE project to test new solutions. The Research Council of Norway allocated funding to two new research projects this year (Towards sustainable fish farming at exposed marine sites [SUSTAINFARMEX 2011-2014] and Exposed Farming) that have carried out modelling tests using nets with integrated sinker tubes.

## Certification scheme improves safety

The SECURE project has documented a number of factors significant for avoiding net abrasion and tearing:

- Insufficient weighting of net-cages, use of exceedingly large nets, sea-current conditions and biofouling lead to net deformation and risk of abrasion and tearing.
- Washing nets by machine reduces the strength of net threads by 10-20 percent after 4-5 washings.
- Attaching the sinker tube to the net has proven to be a more secure solution than using sliding connectors.
- Conic net pens create more distance between the net and the chain, reducing the risk of abrasion and tearing. In spite of this, the majority of net pens are currently cylindrical in shape.

"Fish producers are able to buy freely on the market and can purchase nets and floating collars separately. It is by no means automatic that the net chosen will suit the selected floating collar when assembled. We need to have a more integrated approach to the design of fish-farming systems to ensure that components are compatible," explains Dr Jensen, who believes the introduction of facility certification is a step in the right direction.

## Providing input for regulations

As of January 1, 2013, all fish-production facilities in Norway must have certification stating that the facility is using compatible components.

"The SECURE project has provided knowledge of importance to the design of regulations that that will form the basis for facility certification, among other things. We have seen that the layout of a facility combined with wave size can have unforeseen consequences. The highest wave does not always carry the greatest force. We have found examples where a low-crested wave exerts much greater force on a facility than a steep wave. Twice the force is not unusual, and this should obviously be incorporated into the specifications for the design and dimensions of a production facility," Jensen concludes.

*More information: www.forskningsradet.no*

# The role of bioremediation in water quality management

by Goncalo A. Santos, MSc, technical manager – aquaculture, Biomin Holding GmbH, Austria

**With the expansion and development of the aquaculture industry, several challenges arise. The intensification of production systems increases the pressure on the environment, which can severely affect water quality and as a consequence fish or shrimp performance and the incidence of diseases.**

In aquaculture, the application of beneficial bacteria (probiotics) is not only associated with gut health (feed probiotics), but also with bioremediation improving the environment (water and soil) in which the animals are reared. The effects of biodegrading strains (such as *Bacillus sp.*, *Paracoccus sp.*, *Thiobacillus sp.*) added directly to the water involve the modulation of the microbiology profile in ponds, degradation of undesirable waste compounds (ammonia, nitrite, hydrogen sulfide), enhanced mineralization of organic matter, decreased anaerobic conditions in pond soil and reduced sludge accumulation.

Moreover, enzymes can be an effective tool in the degradation of organic matter in very intensive production systems. These positive changes in the environment are supported by proven benefits for the performance and survival of shrimp from the larval to grow-out stages.

## Toxicity of nitrogenous compounds

Nitrogen compounds, such as nitrite, nitrate and ammonium ions / ammonia are toxic when their concentrations exceed a certain level in the rearing water. Ammonium nitrogen that occurs partly in the form of ammonium ion ($NH_4$+) and ammonia ($NH_3$+) originates from decomposing organic waste and animal excretions in the farm. The sensitivity to ammonium nitrogen depends largely on the species.

Some fish have developed strategies, for example, the formation of glutamine in the brain to detoxify ammonium to urea, to protect themselves from toxic ammonia levels (Randall and Tsui, 2002). Nitrite (NO2-) is usually present below dangerous concentrations in fresh and marine water.

However, prolonged exposure to high nitrite levels, especially when oxygen is limited, leads to anoxia and slow suffocation of the animals, because nitrite changes hemoglobin into methemoglobin, a form that is not able to bind oxygen (Lewis and Morris, 1986).

Nitrate ($NO_3$-) is the least dangerous compound and low concentrations are not problematic. Similar to nitrite, nitrate converts hemoglobin, into a non-binder for oxygen. Permanent exposure to high nitrate levels causes weight loss and a higher occurrence of infectious diseases. To avoid these complications, excess nitrate needs to be removed to reach lower, non-toxic concentrations (Camarga *et al.*, 2005). This is often achieved by water renewal at the farms.

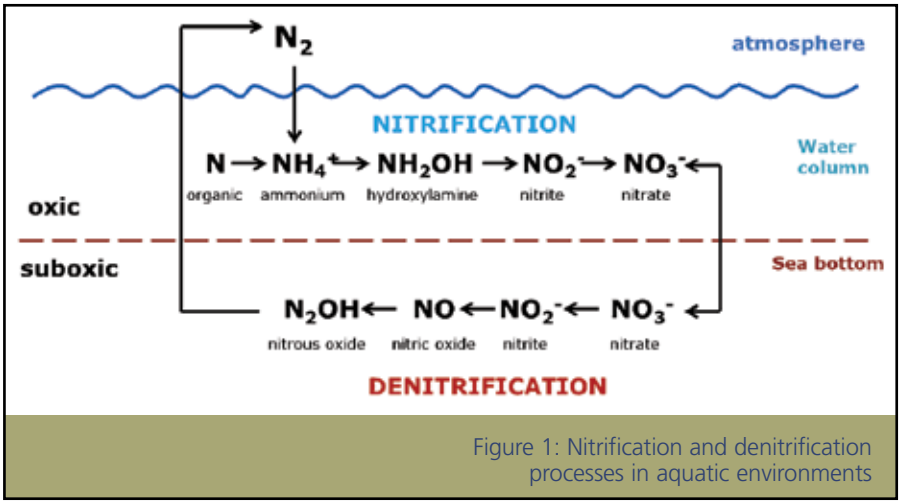


Figure 1: Nitrification and denitrification processes in aquatic environments

## Bioremediation in aquaculture

Watewater management in aquaculture systems is crucial to maintain a good health status of the animals as well as to counteract the negative impacts on the environment. Bioremediation, the application of microorganisms like bacteria to remove dangerous waste products, is a promising tool for onsite treatment of watewater and contaminated sediments. For the bioremediation of nitrogenous compounds, bacteria have to perform nitrification and denitrification. Bacterial nitrification is the oxidation of ammonium / ammonia ($NH_4$+, $NH_3$+) to nitrate ($NO_3$-) via hydroxyl amine and nitrite ($NO_2$-). Denitrification

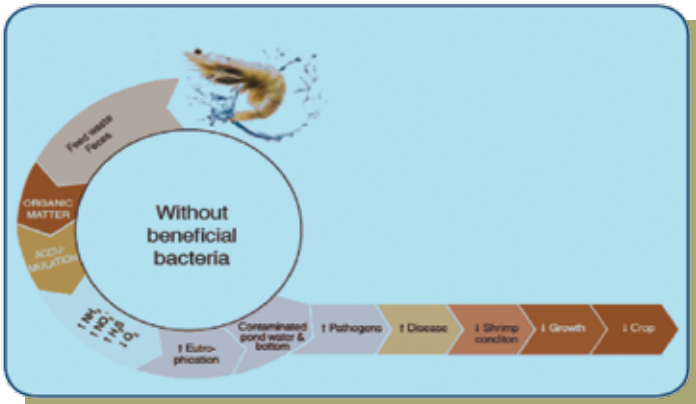


Figure 2: Pond interactions without the addition of beneficial bacteria

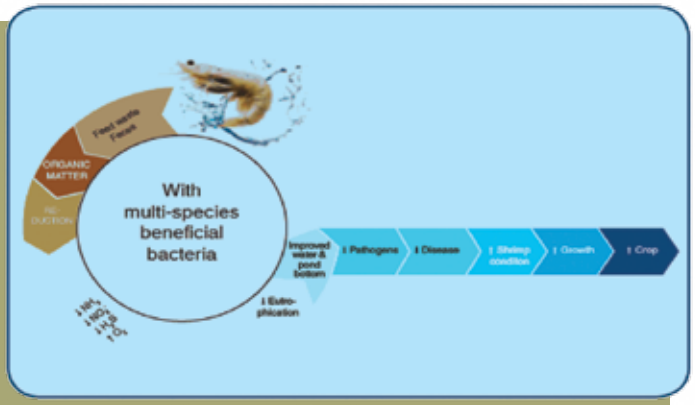


Figure 3: Pond interactions with the addition of beneficial bacteria

describes the reduction of nitrate to nitrous oxide and finally to nitrogen gas, which returns into the atmosphere (Chávez-Crooker and Obreque-Contreras, 2010). Although a range of bacterial species are capable of nitrification and / or denitrification, not all species are applicable for bioremediation products. Recently strains such as *Paracoccus sp.* and *Thiobacillus sp.* have gained interest due to its degrading capabilities. Also *Bacillus sp.* is also well suited to perform several functions in the water cleanup application (Nakano *et al.*, 1998).

A single strain, rarely harbours all desired qualities necessary for an efficient degradation of toxic compounds, therefore a combination of strains that perform best for one or several compounds is more likely to ensure a stable performance.

## Beneficial bacteria and enzymes to improve water and soil quality in aquaculture ponds

A key factor for successful aquaculture is to understand the interactions between the microbial environment, gut flora and immune system of the shrimp, as well as the factors that determine the persistence of microbial species in the internal and external microbial ecosystems. While natural environments are balanced, the farming environment favours the growth of micro-organisms as it is rich in nutrients and feed waste. Farmed species are constantly exposed to and challenged by micro-organisms from the surrounding environment.

These environmental challenges are obviously influenced by different factors, including farm management and rearing methods. Aquaculture operations generally involve the stocking and feeding of shrimp in open or semi-closed water systems. Semi-closed pond systems have a low water turnover and can accumulate gases, nutrients, metabolites, waste, etc., which can deteriorate the water quality and create anoxic conditions in the soil. This can strongly affect the performance of the farmed species. Thus, good pond manage-

Table 1: A diverse range of enzymes used as bioremediation agents in aquaculture

| Enzyme | substrate |
|---|---|
| Amy;lase | ß-Glucoside |
| Cellulase | Cellulose |
| Lipase | Lipids and fat |
| Protease | Protien |
| Xylanase | Xylan, Hemicellulose |
| Peectinase | Pectin |


ment is crucial for high production and a healthy crop. Since water quality plays an important role, it is of great value to understand the various interactions taking place within the ponds. These are quite complex and depend directly on the pond environment, stocked biomass, input of nutrients and pond management.

As can be seen in Figure 2, the accumulation and degradation of organic waste in the pond will result in an increased consumption of oxygen ($O_2$) and production of waste compounds such as ammonia ($NH_3$), nitrites ($NO_2$ -) and hydrogen sulfide ($H_2S$), which can lead to a phytoplankton bloom. Massive growth of phytoplankton can further deplete oxygen during the night and contribute to a phytoplankton bloom crash. All these factors contribute to the contamination of water and soil, creating favourable conditions for pathogens to grow and affecting the condition of the shrimp. Under these poor conditions, the shrimp faces higher levels of stress and is more susceptible to diseases, which could result in poor growth or a failed crop through disease outbreaks.

With the inclusion of beneficial bacteria (Figure 3), organic matter is utilized as a source of nutrients by the bioremediation bacteria, which reduces the amount of waste accumulating in the pond. Additionally, specific nitrifying and denitrifying bacteria will convert $NH_3$ and $NO_2$- into nitrogen gas, reducing the level of such toxic compounds. Some beneficial bacteria can also degrade toxic $H_2S$, improving water quality and odor. The combination of all these factors will improve water quality and the condition of the pond soil, resulting in a better environment for shrimp with better growth and health status.

In the bioremediation process, enzymes play the role of catalysts that accelerate biochemical reactions in pond soil and water. When added to the culture water or spread on top of the pond soil, enzymes are able to degrade the major organic constituents normally found in shrimp and fish ponds. Each enzyme has its mode of action and is very specific in the chemical reaction it catalyzes (Table 1).

Enzymes are also naturally produced and excreted by some microbes. These extracellular enzymes, such as cellulase, protease and amylase, are produced during the aerobic fermentation of organic matter by micro-organisms, for example by some *Bacillus* species. Bacilli are commonly found in pond sediments and can also be added to the pond water for bioremediation purposes. Some *Bacillus sp.* are also able to degrade nitrogenous compounds. In addition, their large variety of excreted (extracellular) enzymes helps to speed up the degradation of organic matter and toxic compounds such as ammonia. The efficient removal of nitrogenous compounds can also be carried out by nitrifying and denitrifying bacteria such as *Thiobacillus* and *Paracoccus*.

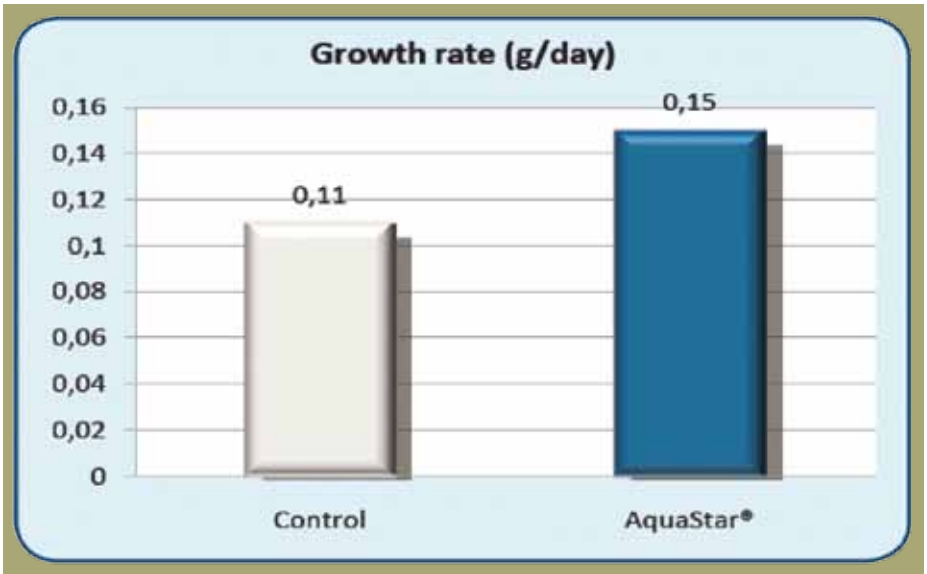


Figure 4: Average growth rate (g/day) of shrimp during the production period

While some micro-organisms proliferate in a narrow range of environmental conditions (pH, oxygen, availability, etc.), certain enzymes are able to act in multiple environments.

Nevertheless, some products combining the positive effects of beneficial bacteria and enzymes are already being used as bioremediation agents in aquaculture.

## Efficacy of enzymes in bioremediation

Enzymes have the capacity to stabilize the soil organic matter and can be used effectively to manage soil quality and rearing conditions for aquatic species. There is not one specific enzyme that works best in all cases. A blend containing a variety of enzymes may be the most effective means for bioremediation in aquaculture. Enzymes greatly reduce sludge accumulation and anaerobic conditions in pond bottoms. They promote a faster degradation of the accumulated organic matter especially under intensive production conditions. This organic matter comprises uneaten feed, dead plankton, mineral soils, faeces and pathogenic micro-organisms in the soil where the conditions are often anaerobic. However, for all these bioremediation processes catalyzed by enzymes, the presence of beneficial bacteria is important as well. Enzymes accelerate microbial processes by breaking apart large sludge particles, thus creating wider surface areas which can then be fermented by microbes. This reduction of sludge and dead organic matter can be seen visually not only through better water quality, but also through better soil quality.

## Field trial

In a field study in China, it was observed that the combined application of the bioremediation products AquaStar® Pond (*Bacillus sp.*, *Enterococcus sp.*,*Pediococcus sp.*, *Paracoccus sp.*, *Thiobacillus* sp) and AquaStar® PondZyme (beneficial bacteria and a blend of amylases, xylanases, cellulases and proteases) to the water, according to a specific application programme, improved water quality, soil condition and ultimately, shrimp performance.

Four earth shrimp ponds (0.7 – 0.8 ha/pond) with a depth of 1 – 1.2 m were stocked with juvenile shrimp (approximately 1.4 g/shrimp) with a density of 50 shrimp/m². The trial was carried out for a period of 57 days with a dosage of 500 g/ha of product applied once a month to the treatment group (two ponds). The control ponds consisted of two ponds with normal production operations.

The soil of the AquaStar® ponds in Picture 1 was of yellow colour which is regarded as the best bottom type, while the soil of the control ponds in Picture 2 exhibited a dark black colour, an indication of the accumulation of dead organic matter.

Results suggested that with the combined use of beneficial bacteria and enzymes, pond soils containing black and glutinous organic sludge turned into a more yellow soil.

In terms of performance, the average daily weight gain of shrimp in the AquaStar® group increased by 36 percent and feed conversion ratio improved by 9 percent compared with the control (no probiotic inclusion). The results are shown in Figure 4 and 5.

Based on these results, it was concluded that in the search for more effective and environmentally-friendly treatments, beneficial bacteria have emerged as a viable alternative. The application of bioremediation solutions in aquaculture can also benefit from the inclusion of enzymes, especially in intensive productions. AquaStar® positively affects the performance of shrimp while maintaining a stable environment in the pond, proving to be an effective management tool in aquaculture.

More Information:
*Website: www.biomin.net*


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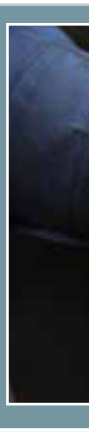
WorldFish, a member of the CGIAR Consortium, is an international, nonprofit research organisation dedicated to reducing poverty and hunger by improving fisheries and aquaculture. From new syntheses and analysis to targeted, on the ground delivery and knowledge sharing, WorldFish technologies, products and services help to make development happen in more than 19 countries around the world.

With its partners, WorldFish has raised incomes for millions of poor people by developing sustainable aquaculture value chains that generate equitable benefits to participants, and has empowered poor communities to participate in the sustainable co-management of their fisheries. It has helped countries cope with disaster and conflict by restoring fisheries, helping develop aquaculture based on livelihoods, provided nations with tools to improve the planning and management of major river basins, and developed widely-consulted global databases and strengthened national capacities for fisheries management.

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Founded in 1975, the centre is committed to meeting two key development challenges: improving the livelihoods of those who are especially poor and vulnerable in places where fisheries and aquaculture can make a difference; and achieving large scale, environmentally sustainable, increases in supply and access to fish at affordable prices for poor consumers in developing countries.


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Working in partnership with private and public sectors and civil society, WorldFish develops pro-poor sustainable and equitable aquaculture value chains that support the Millennium Development Goals. WorldFish takes a comprehensive, multidisciplinary research approach that acknowledges the complex and multi-faceted problems that face fisheries and aquaculture. Failure to embrace this complexity has led to piecemeal efforts in the past and undue faith in single technology or development approaches. The centre prioritizes its research efforts to include those areas in which it will have the biggest impacts, and assumes the role of broker and catalyst of research among the full range of development partners needed to close the gap between research and development action.


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WorldFish is the lead centre on the CGIAR Research Program on Aquatic Agricultural Systems, a multi-year research initiative launched in July 2011. The programme is designed to pursue community-based approaches to agricultural research and development that target the poorest and most vulnerable rural households in aquatic agricultural systems.


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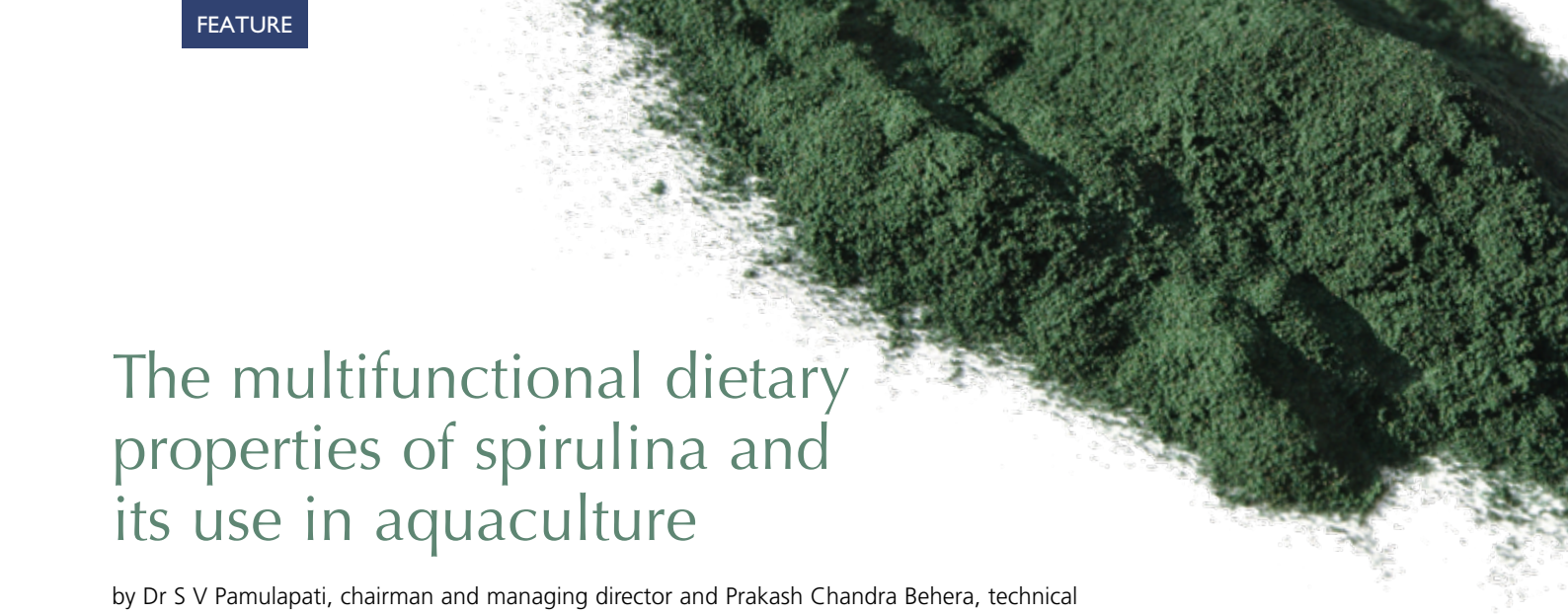

# The multifunctional dietary properties of spirulina and its use in aquaculture

by Dr S V Pamulapati, chairman and managing director and Prakash Chandra Behera, technical manager (aqua), PVS Group, India

**In commercial and high stocking density culture practices, feeding plays a significant role in fast growth and high yields. Aqua feed contains many ingredients in highly balanced nutritious components for enhancing the digestive mechanisms in fish and shrimp bodies. It leads to better body weights and health, optimum immunity and greater survival rates. Spirulina is a unique high quality natural diet with enriched optimum protein for fish and shrimp which is proven to be a suitable supplementary feed in aquaculture.**

Spirulina is a blue green algae like a spiral of long thin threads under genus Arthrospira, the phylum Oscillatoriaceae. Spirulina is called blue green algae (cynobacteria) because of presence of both green (chlorophyll) and blue (phycocyanin) pigments in its cellular structure. The two species which are most important for their nutritious values are Spirulina maxima and Spirulina plantensis.

## Nutritional food value

The use of spirulina as complementary feed in various sectors of aquaculture can result in fast growth factors, enhanced pigmentation and better immune systems. It is considered as an excellent food, lacking toxicity and having corrective properties against the pathogenic micro-organisms. It lacks cellulose cell walls and therefore does not requires chemicals or processing in order to become digestible. The digestibility is 83 – 84 percent. Spirulina is regarded as a rich source of protein, vitamins, essential mineral, amino acids, EFFA like gamma LNA and antioxidant pigments like carotenoids.

Table 1:

| Physical properties | | General analysis | |
|---|---|---|---|
| Composition | 100% | Protein | 60-70% |
| Appearance | Fine powder | Carbohydrate | 15-25% |
| Colour | Dark blue green | Fats (lipids) | 06-08% |
| Odour & taste | Mild like weed | Minerals (Ash) | 07-13% |
| Digestibility | 83-84% | Moisture | 03-17% |
| Particle size | 64 mesh through | Fibre | 08-10% |

## Biochemical composition

Protein and amino acids: Spirulina contains 60-70 percent protein along with phenolic acids, tocopherols, carotenes and linolenic acids for which represents an important staple in diets. The essential amino acids are present around 47 percent of total protein weight. The spectrum of amino acid represent that the biological value of proteins in spirulina is very high.

Amino acid and biological function of fish and shrimp

- Isoleucine: Required for optimal growth, nitrogen equilibrium in the body. Used to synthesize other non-essential amino acids.
- Leucine: Increases muscular energy levels.
- Lysine: Building block of blood antibodies strengthens circulatory system and maintains normal growth of cells.
- Methionine: Vital lipotropic (fat and lipid metabolizing) amino acid that maintains liver health. An anti-stress factor.
- Phenylalanine: Stimulates metabolic rate.
- Threonine: Improves intestinal competence and digestive assimilation.
- Tryptophane: Increases utilization of B vitamins, improves nerve health.
- Valine: Stimulates muscle coordination.

Carbohydrates: Spirulina contains about 15-21 percent carbohydrates in the form of glucose, fructose, sucrose, rhamnose, mannose, xylose and galactose. It provides the appropriate and important foodstuffs for aquatic culture animals with poor intestinal absorption. Carbohydrates occur in sufficient quantities of mesoinositol phosphate which is an excellent source of organic phosphorus and inositol. A high moleculatory weight polysaccharide are believed to have effect on DNA repair mechanisms, immune-stimulatory and immunoregulatory properties.

Nucleic acids: Spirulina contains 2.2-3.5 percent of RNA and 0.6-1 percent and DNA, which represents less than 5 percent of these acids based on dry weight.

Essential fatty acids: Spirulina has a high amount of polyunsaturated fatty acids (PUFAs) and 1.5–2.0 percent of total lipid. Spirulina is rich in γ-linolenic acid (ALA), linoleic acid (LA), stearidonic acid (SDA), eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA) and arachidonic acid (AA).

β-carotene and vitamins: Spirulina contains vitamin B1 (thiamine), B2 (riboflavin), B3 (nicotinamide), B6 (pyridoxine), B9 (folic acid), B12 (cyanocobalamin), vitamin C, vitamin D and vitamin E. The β-carotene, B-group vitamin, vitamin E, iron, potassium and chlorophyll available in the spirulina can promote the metabolism of carbohydrate, fats, protein, alcohol, and the reproduction of skin, muscle and mucosa. Spirulina contains large amounts of natural β-carotene and this β-carotene is converted into vitamin A.

Minerals: Spirulina is a rich source of potassium, and also contains calcium, chromium, copper, iron, magnesium, manganese, phosphorus, selenium, sodium, zinc, molybdenum, chloride, germanium and boron.

Photosynthetic pigments: Spirulina contains many pigments including chlorophyll a, xanthophyll, betacarotene, echinenone, myxoxanthophyll, zeaxanthin, canthaxanthin, diatoxanthin, 3-hydroxyechinenone, beta-cryptoxanthin, oscillaxanthin, plus the phycobiliproteins, c-phycoc yanin and allophycocyanin.

Natural pigment enhancers: Phycocyanin

Table 2:

| Amino acid | Per 10 gm | % of total | Amino acid | Per 10 gm | % of total |
|---|---|---|---|---|---|
| Isoleucine | 350mg | 5.6 | Cystine | 60mg | 1.0 |
| Leucine | 540mg | 8.7 | Arginine | 430mg | 6.9 |
| Lycine | 290mg | 4.7 | Histidine | 100mg | 1.6 |
| Phenylalanine | 280mg | 4.6 | Threonine | 320mg | 5.2 |
| Tyrosine | 300mg | 4.8 | Proline | 270mg | 4.3 |
| Methionine | 140mg | 2.3 | Valine | 400mg | 6.5 |
| Glutamic acid | 910mg | 14.6 | Alanine | 470mg | 7.6 |
| Aspartic acid | 610mg | 9.8 | Glycine | 320mg | 5.2 |
| Tryptophan | 90mg | 1.5 | Serine | 320mg | 5.2 |

(blue): 14 percent, chlorophyll (green): 1 percent, carotenoids (orange/red): 47 percent.

## Nutritional supplementary properties

Spirulina can be used as a partial supplement or complete replacement for protein in aqua feeds. Spirulina is a feed supplement for the all fishes, giant freshwater prawns and marine water shrimps and significantly improvement occurs on growth, survival, immunity, viability and feed utilization. It is a cheaper feed ingredient with higher protein levels than other ingredinets of animal origin.

Feeding on spirulina helps to improve disease resistance and an improvement in their survival rate. Fast growth occurs when fed a diet containing spirulina meal (Britz, 1996).

Chelating of toxic minerals (neutralisation of toxic minerals)

Spirulina has a unique quality to detoxify (neutralise) or to chelate toxic minerals, and this characteristic is not yet noticed in any other microalgae (Maeda and Sakaguchi, 1990; Okamura and Aoyama, 1994). Spirulina can be used to detoxify arsenic from water and food. It also may be used to chelatize or detoxify or neutralize the poisonous effect of heavy metals (minerals) from water, food and environment. Spirulina provides phycocyanin, a source of biliverdin, which is among the most potent of all intra-cellular antioxidants.

## Immunomodulatory properties

Spirulina is an effective immune modulator. It exhibits anti-inflammatory properties, in particular by inhibiting the release of histamine from mast cells with mediated allergic reactions. It shows antioxidative and free radical scavenging properties. Spirulina exposure enhances the phagocytic functions of macrophages in aquatic culture animals.

It also has antiviral and anti-carcinogenic properties. It improves the bacterial gut tract clearance potential of fish/shrimp and spirulina supplements develops the phagocytic cell.

Spirulina is a safe diet to use in terms of improved immune competence without compromising the performing behaviors of aquatic culture animals. A novel sulphate polysaccharide of spirulina inhibits the replication of several enveloped viruses.

The nutrients of spirulina help to fight free radicals, cell-damaging molecules absorbed by the body through pollution, poor diet, injury, or stress. By removing free radicals, the nutrients help the immune system fight cancer and cellular degeneration. Spirulina is a powerful tonic for the immune system. This enzyme is a major source of super oxide in an animal's body, and is involved in dozens of degenerative processes involved in disease resistance, aging and similar processes in fish, shrimp and other aquatic animals.

## Spirulina in building red blood cells and stem cells

Spirulina is rich in a brilliant blue polypeptide called Phycocyanin. Phycocyanin

affects the stem cells that make up the cellular immune system and red blood cells that oxygenate the body. Phycocyanin stimulating hematopoiesis, (the creation of blood), emulating the affect of the hormone erythropoetin, (EPO). Phycocyanin also regulates production of white blood cells, even when bone marrow stem cells are damaged by toxic chemicals or radiation.

## Spirulina anti-viral and anti-cancer abilities

Calcium-Spirulan is a unique polymerized sugar molecule extract of spirulina and containing both sulphur and calcium. The treatment of this water-soluble extract has better recovery rates when infected with a lethal Herpes virus. This mechanism occurs because Calcium-Spirulan does not allow the virus to penetrate the cell membrane to infect the cell. The virus is stuck, unable to replicate. It is eventually eliminated by the body's natural defenses. Spirulina can prevent or inhibit cancers in aquatic animals, and fishes. The unique polysaccharides of spirulina enhance cell nucleus enzyme activity and DNA repair synthesis.

## Antimicrobial properties

Spirulina excretes variable quantities of products from its metabolism such as organic acid, vitamins and phytohormones. Cell extract of spirulina has shown antimicrobial activities against pathogenic bacteria as like *Bacillus* sps, Streptococcus sps, Saccharomyces sps etc.

## Bio-mineralisation activities

Spirulina thrives in high alkaline waters and it incorporates and synthesizes many minerals and derivative compounds into its cell structure. Transformed into natural organic forms by spirulina, minerals become chelated with amino acids and they are more easily assimilated by the body. Along with adequate calcium and magnesium in the water (especially for marine organisms), Spirulina helps insure proper electrolyte function, calcium levels over calcium and other mineral.

## Enhancing reproduction

Research has shown that fresh and saltwater fish and shrimp exhibit superior growth, maturity, energetic behavior, and more elegant coloring when fed spirulina. It is also well documented that spirulina improves spawning, fecundity, fertility and hatching rates. It stimulates the reproductive processes, increases survival rates of younger fish, post larvae and promotes the appetite of fish or prawn to attain full maturity.

## Spirulina as a colourant

The colour appearance is the most important characteristic in shrimp and fish for choice and demand in the food market. A diet containing spirulina promotes the physiological activities for generating colour pigmentations and glazing appearance in various parts of body. Carotenoids are responsible for the development of various colours of crustaceans (Britton *et al.*, 1981). Astaxanthin has been shown to be the predominant carotenoid associated with the red body colour of the black tiger prawn Penaeus monodon (Howell and Matthews, 1991). Spirulina platensis and pacifica stain contains the highest levels of β-carotene and zeaxanthin of any natural source. They both are converted to astaxanthin through an oxidative process for the desire red pigment. A marked increase in carotenoid content of the carapace of black tiger shrimp (*Penaeus monodon*) occurred when spirulina-supplemented diets are given. A practical strategy for the improved pigmentation of cultured *P. monodon* is the incorporation of spirulina diet for one month before harvest.

## Conclusions

Spirulina appears to have considerable potential for development, especially as a small-scale crop for nutritional enhancement, livelihood development and environmental mitigation. As natural feed, spirulina can play an important role in aquaculture, especially in aquatic farming and hatcheries where the results are quite significant. If spirulina feeds further improve, its effects will be more obvious and the prospects of spirulina will be very bright. ■

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# Effect of dietary inclusion of seaweeds on intestinal proteolytic activity of juvenile sea bream, *Sparus aurata*

by María Isabel Sáez, Tomás Martínez and Javier Alarcón,
Universidad de Almería-CEIA$_3$, Spain

**In the last years considerable attention has been paid on the use of seaweeds (SW) as a possible ingredient for aquafeeds. Red, green and brown SW can be taken from their natural habitat and brought to the shore by the action of winds and tides. Otherwise, biomass can be obtained from secondary and tertiary treatment of effluents. Wastewater treatment utilising photosynthetic organisms is an interesting alternative to reduce the ecological impact of domestic, industrial or aquaculture effluents. Generally, high-quality algal biomass is yielded from algal cultivation, representing an excellent source of hydrocolloids, carotenoids, and bioactive substances, which allows different industrial applications. In addition, there is currently an increasing interest for the potential of SW in human and animal nutrition.**

Figure 1: Detail of experimental feeds. UL-25 percent (above) and control (below)

## Seaweed as ingredient in aquafeeds

Although nutritional properties of SW are not as well known as are those of land plant-based ingredients, their chemical composition may be characterised by low content in lipids, moderate in protein, but rich in non-starch polysaccharides, minerals and vitamins. Lipid contents range from 0.3 to 7.2 percent, although algal lipids are rich in PUFA such as C20:5n3 (eicosapentaenoic acid, EPA) and C22:6n3 (docosahexaenoic acid, DHA). The protein contribution is ranged from 10 to 30 g/100 g dry weight, which may vary greatly among SW species, environmental conditions (especially under nitrogen-enriched condition) and season.

The high biological value of algal proteins makes algae suitable for inclusion both in animal feeds (especially marine species) and in human diets. The high carbohydrate content (30 to 60%) is a very marked characteristic in most SW, comprising mainly soluble carbohydrates, like sugars, and pectins, alginic acid, agar and carrageenan as well. Besides their potential nutritional value, from a technological point of view, SW can also be used as additives in the feed industry, for instance, as excellent feed agglutinants (improving texture and water stability of pellets), or as attractants (increasing feed intake).

## The effects of seaweeds on fish

Several studies have proved that addition of small amount of SW in aquafeeds resulted in considerable positive effect on growth performance and feed utilisation efficiency, carcass quality, physiological activity, intestinal microbiota, disease resistance, and stress response (Valente *et al*., 2006). Nonetheless, it has been also noted in other publications that high SW inclusion reduces fish growth and feed efficiency. From the literature available it can be deducted that the response of animals to SW seems to be dose-dependent and species-specific. Moreover, certain substances with antinutritive activity may be present in SW, like lectins, tannins, phytic acid, and protease and amylase inhibitors (Oliveira *et al*., 2009). Such antinutritional factors might interfere with bioavailability and/or digestibility of nutrients.

Special emphasis should be focused on protease inhibitors. Binding of protease inhibitors to proteolytic enzymes causes the pancreas to secrete larger amounts of digestive enzymes to overcome the negative effects of inhibitors on the digestion of dietary protein. This fact can lead to decreased weight gain, and pancreatic hypertrophy in some fish species. For this reason, studies aimed to include SW in aquafeeds must also bring up their possible effects on fish digestive physiology. To date, there is scarce literature analysing if SW inclusion causes negative consequences on digestive physiology of fish.

## Evaluating the effect of seaweeds on digestive proteases

In a recent study, we evaluated the effect of inclusion of two SW as dietary ingredients on intestinal proteolytic activity of juvenile sea bream. *Gracilaria cornea* (GR) and *Ulva rigida* (UL) were chosen in the present study owing to its fast growth, low-cost production and

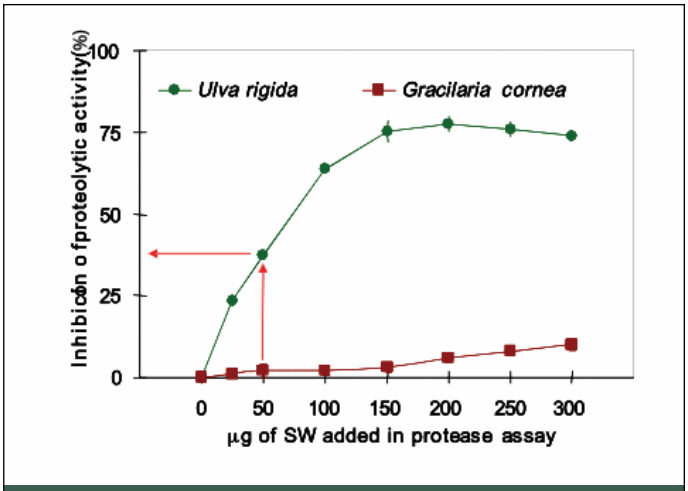


Figure 2: Dose-response curves obtained when different amounts of SW meal (0 to 300 µg) were incubated with a fixed amount of proteolytic activity (1 U) in the inhibitory assay. Protease inhibition was expressed as the percentage of reduction in proteolytic activity. Such curves are a simple way to evaluate how hypothetical variations in the inclusion of SW might affect sea bream digestive proteases

successful integrated culture in fish-farm effluents. Biomass was obtained from the Marine Biotechnology Centre (ULPGC, Spain). SW were cultivated in 750 L semicircular fibreglass tanks filled with seawater plus the fishpond effluents of a pilot aquaculture system (11 $m^3$ with an optimal density of *Sparus aurata* of 20 kg $m^{-3}$, and a water renovation rate of 6–8 vol $day^{-1}$). Red and green SW were washed with sea water, sun-dried for 48 hours, ground and sieved through 0.1 mm sieve before being used as a dietary ingredient.

Dry algal biomass was incorporated into six experimental diets (40% crude protein and 12% crude lipid) at increasing levels (5, 15 and 25%). A feed without SW served as a control diet. Feeds were made at the University of Almeria-$CEIA_3$ facilities (Service of Experimental Diets; http://www.ual.es/stecnicos_spe). Every experimental feed was randomly assigned to triplicate group of fifteen sea bream juveniles (15.4 g initial body weight). Fish were fed by hand twice per day (9:00 and 17:00) at a rate of 3 percent of their body weight for 70 days. At the end of the trial, fish were killed according to the requirements of the Directive 2010/63/UE, and digestive tract was removed, and then processes to obtain enzymatic extracts. Intestinal proteases were analysed by two different approaches: a) quantifying the level of intestinal proteolytic activity, and b) visualizing the profile of intestinal proteases in zymograms (Alarcón *et al*., 1998). In addition, the presence of protease inhibitors in SW was tested according to Alarcón *et al*. (1999).

## Checking the presence of protease inhibitors in SW

Results revealed the presence of protease inhibitors in SW. Dose-response curves showed that UL contained substances able to reduce digestive proteolytic activity in sea bream (up to 77%), whereas a negligible inhibition by GR was found (4%). Obvious differences in the kinetic of inhibition of protease activity were found for UL. Equation defining such curve may be used to predict the expected percentage of reduction in protease activity, once protease activity in the digestive tract and the amount of feed ingested are known. For instance, in the case of 40 g sea bream, total protease activity released after a meal is around 1,300 units. Those fish that consumed 0.5 g of a feed containing 15 percent of UL, showed a ratio mg UL per unit of activity of 50, which determined a reduction nearly 40 percent in the activity of digestive proteases. Fortunately, fish have mechanisms to compensate the effect of dietary antinutrients.

Zymograms obtained after electrophoretic separation of proteins is a useful tool to know in detail the type of inhibition caused by protease inhibitors. From the zymogram, it is clear that *Ulva* produces a generalised inhibition in alkaline proteases of sea bream. On the contrary *Gracilaria* did not affect any of the active bands.

The same results were observed after incubation of digestive proteases with extracts of the experimental diets. The mean inhibition ranged from 11 to 48 percent. In general, UL-supplemented feeds showed inhibition values higher than the GR-supplemented diets, which did not exceed 16 percent. For UL diets, it was found that percentage of inhibition was positively correlated with the SW inclusion level, which agrees with the above mentioned dose-response curve. Inhibition produced by GR feeds cannot be associated to the use of this SW.

## Effect of seaweed on digestive proteases of sea bream

Digestive enzymes were affected by diets, as fish had different enzyme activity level of alkaline proteases after 70 days of feeding experimental diets. In general, a decrease in alkaline protease activity was evidenced when feeds included UL or GR. In particular, the proteolytic activities of fish fed *Ulva* supplemented-feeds were significantly lower than those of fish fed on control diet. The presence of protease inhibitors in SW may be the reason of the progressive decrease in the proteolytic activity in fish fed diet with increasing levels of *Ulva* meal. Supporting this hypothesis, it has been confirmed that aqueous extracts of *Ulva* meal inhibit alkaline proteases of *S. aurata*. Moreover, the drop in


Figure 3: Inhibition of intestinal proteolytic enzymes by *Gracilaria cornea* and *Ulva rigida* meal. Qualitative analysis: visualization of inhibition of active fractions in zymograms

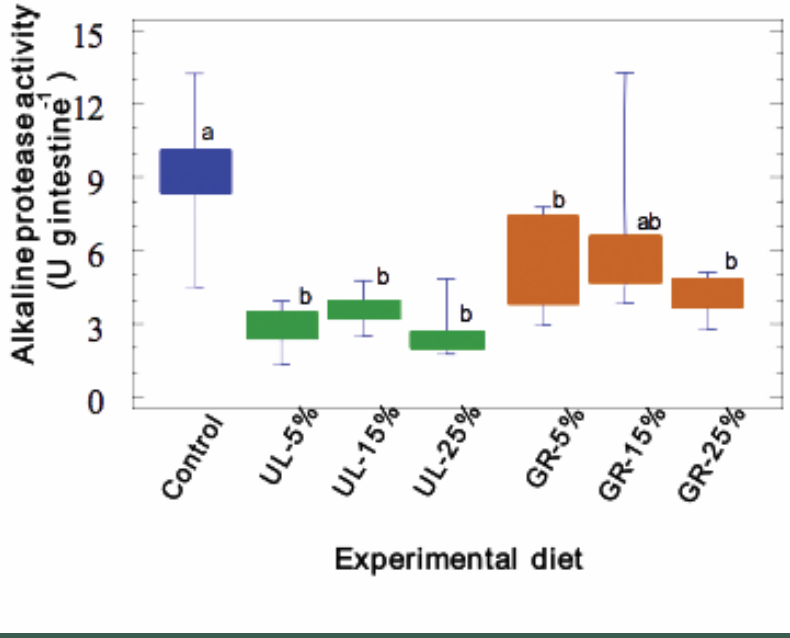


Figure 5: Total alkaline protease activity measured in extracts of sea bream fed different experimental diets containing graded levels of SW

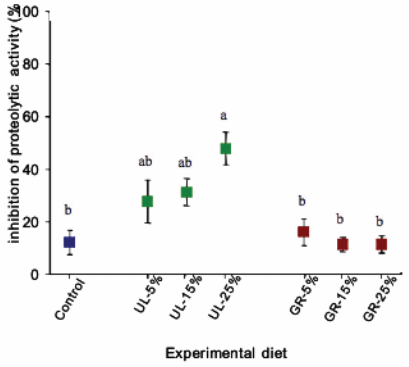


Figure 4: Inhibition of sea bream intestinal proteases after incubation of extracts with solutions prepared using experimental diets containing 5, 15 and 25 percent of *Ulva* (UL) and *Gracilaria* (GR) meal

the level of alkaline protease activity was not accompanied by a decrease of fish growth and feed utilization, since all fish grew equally (unpublished data). Santigosa *et al.* (2008) reported a similar finding when trout were fed on diets including plant proteins.

On the other hand, the analysis of zymograms revealed that the pattern of intestinal proteases was not modified by inclusion of SW. All sea bream specimens showed the same number and distribution of active fractions as in control group (after electrophoretical separation, the pattern of intestinal proteases in this species is characterized by five groups of active bands). These results confirmed that the type of alkaline proteases secreted into the intestinal lumen was not modified by any of experimental diets. The existence of a compensation mechanism against dietary protease inhibitors in juvenile sea bream has been previously proved by Santigosa *et al.* (2010), who found similar results when fish were fed diets with soybean trypsin inhibitor.

According to the results, it is clear that the amount of the pancreatic proteases secreted into the intestinal lumen in juvenile *S. aurata* is affected by the use of SW, particularly *Ulva*. Nevertheless, it is also evident that these ingredients did not cause qualitative changes in the composition of alkaline proteases, given that all fish showed the same pattern of proteolytic enzymes in their intestines, and that growth performance of fish was not affected, as deduced from the *in vivo* feeding trial.

## Conclusions

*In vitro* protease inhibition assays are a useful tool to assess the presence of antinutrients in SW with potential use in aquafeeds. Based on the results of this study, SW, especially *Ulva rigida*, have antinutritive factors able to inhibit digestive proteases of *S. aurata*. Feeding juvenile *S. aurata* on seaweed-based diets decreased the amount of proteolytic activity secreted into the intestine. However, the inclusion of SW does not alter the pattern of proteolytic enzymes in sea bream, which reveals a compensating mechanism in this species. Research is being currently conducted to assess the effect of SW on other digestive enzymes, intestinal microbiota, blood and tissue metabolites, and intestine and liver histology after 70 days of feeding SW-based diets. Further research is needed in order to known the impact of SW in a long-term feeding assay. ■

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*Email: msc880@ual.es*

# Challenges facing the aquaculture feed industry

We talk to feed producers about the challenges that the industry is facing, what products they are currently developing and what the future holds.

## Environmental foot print

**ALLER AQUA:** At Aller Aqua, we are committed to meeting a number of environmental targets, complying with strict product and manufacturing standards. The 1989 Danish Act on the Protection of the Marine Environment sets strict standards for feed intended for the Danish market. Danish legislation stipulates that the feed conversion rate of grower feed must not exceed 1.0. At the same time, 82 per cent of the feed must be digestible, and there are low maximum limits for phosphorus and nitrogen.

**BIOMAR:** The BioMar Group is eco-conscious and continuously focuses on reducing environmental impact from the production of fish feed. All BioMar factories have modern production facilities, which meet high standards for environmentally friendly production.
Furthermore, BioMar has developed and improved its product ranges over the years to reduce the environmental impact of fish farming. This happens through focusing on sustainability in the development and production of feed and through a focus on developing efficient feed types, where the nutrients are utilised by the fish for growth rather than lost to the farm environment.

## Feed costs and efficiencey

**BIOMAR:** Organic food products are rapidly gaining importance among consumers. BioMar produces a number of different feed types certified for farming of organic fish to cover this growing need. New feed concepts are constantly being developed in order to cater for new consumer trends and help our customers grow their business.

## Sustainable feeds

**REED MARICULTURE:** Reed Mariculture's Instant Algae products are closer to nature than any other feed on the market. We produce whole-cell, whole-food microalgae feeds and enrichments from marine algae using proprietary processes. Our products provide fish, bivalve and shrimp hatcheries with clean, convenient, long shelf-life feeds that are superior choices to replace or supplement live microalgae. Our feeds ensure stable and rapidly-reproducing rotifer populations that offer rich nutritional value.

**BIOMAR:** Sustainability is decisive to the continuous long-term development of the aquaculture industry. It entails that the industry is run on a commercial basis which meets the needs of the present without compromising the needs of the future. BioMar focuses through the development program BioSustain on increasing sustainability in fish farming. -

## Fish health

**BIOMAR:** BioMar's Smart Feeds comprises feed products with active ingredients or different types of premixes of vitamines and minerals, which are key to keep fish healthy and provide optimal fish growth and thereby contribute to a healthy farm business.

## Alternative proteins

**BIOMAR:** As the world production of fish meal and fish oil cannot be increased significantly without risk of damaging natural fish stocks and the need for fish products for human consumption obtained through aquaculture is growing, one of BioMar's long-term goals is to reduce our dependence on marine raw materials. This is achieved by including alternatives such as vegetable proteins and oils, thus reducing the need for marine raw materials. This change is a complex task with a number of issues to be addressed. BIOMAR

## Alternative proteins

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## The future

**NOVUS:** "We expect to continue to grow our existing markets and expand our footprint in these markets through new technologies and partnerships. We will grow through market relevancy, for example, over the past 25 years the salmon industry has achieved an increase in productivity from 15 to 20% while reducing nitrogen waste four fold. Novus probiotics (live microorganisms which confer a health benefit) assist with the stability of pond cultures, thereby helping to maximize pond water carrying capacity and enhancing overall fish health. In this way, more fish are grown with less water, as the water is less toxic, and less overall waste results.

**"Novus is a participant in the farm-to-table nutrition continuum and because of this, we have a distinct responsibility to the communities we serve. Novus's vision is 'To Help Feed the World Affordable, Wholesome Food and Achieve a Higher Quality of Life'. Our performance as a company and our vision are not separate - each is connected inextricably with the other. In everything we do over the next five years and beyond you can expect to be able to connect our actions with our vision".**

*See the full interview with Thad Simons, Novus president and CEO on page 62*

## Feed solutions – working with the farmers

**BIOMAR:** In BioMar we see the reduction of farm impact as an important mean to facilitate continued growth for the aquaculture sector, especially in the land based aquaculture, where scarce water resources need to be preserved and protected. Environmental regulation has over the last years in many countries lowered the limits for the acceptable amounts of nutrients in the waste water. BioMar therefore focuses on developing feeds with an optimal balance of nutrients, so that the fish utilises a maximum of the nutrients in the feed for growth, while a minimum of nutrients are lost to the water. A more efficient uptake of nutrients in the fish does not only benefit the environment, but it also improves farm economy.

# Aquafeed production



INTERNATIONAL AQUA FEED

| | ABALONE | ALLIGATORS | AQUARIUM FISH | BASS | CARP | CATFISH | CONCH | CRAWFISH | CRUSTACEAN | EEL | HALIBUT | LARVAL | MARINE SPECIES | MOLLUSC | PRAWN | REDFISH | SALMON |
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| Aquaculture equipment Ltd | | | | | ✓ | | | | | | | | | | | | |
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| Coastal Aquatic Proteins | | | ✓ | | | | | | | | | | | | ✓ | | |
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| Norel | | | | | | ✓ | | | | | | | | | | | |
| NutraKol Pty | | | ✓ | | | | | | ✓ | | | ✓ | ✓ | | | | |
| Ocean Star International | | | ✓ | | | | | | ✓ | | | | | | | | |
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| Reed Mariculture | | | | | | | | | | | | | | ✓ | | | |
| SAP Int Corp | | | | | ✓ | ✓ | | | | ✓ | | | | | | | ✓ |
| Salt Creek Inc. | | | | | | | | | | | | | | | | | |
| Service Aqua LLC | | | | | | | | | | | | ✓ | | | | | |
| Skretting | ✓ | | | ✓ | ✓ | ✓ | | | | ✓ | ✓ | ✓ | ✓ | | | | ✓ |
| San Francisco Bay Brand | | | ✓ | | | | | | | | | | ✓ | | | | |
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| Uni President Enterprises Corp | | | | | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| V.D.S. BVBA | | | | | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | ✓ |
| Washington Fish Growers | | | | ✓ | ✓ | ✓ | | | | | ✓ | | ✓ | | | | ✓ |
| Zagro Asia | | | ✓ | | | | | | | | | | | | ✓ | | |
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# worldwide

| SEA BREAM | SHRIMP | STRIPED BASS | STURGEON | TILAPIA | TROUT | TURBOT | WEANING DIETS | NURSERY DIETS | EUROPE | NORTH AMERICA | CENTRAL AMERICA | SOUTH AMERICA | AFRICA | MIDDLE EAST | RUSSIA | CHINA | INDIA | SOUTH EAST ASIA | AUSRTRALASIA |
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INTERNATIONAL AQUA FEED

# PRODUCT SHOWCASE 2013

## BÜHLER

Bühler's new hammer mill Granulex - **The hammer mill Granulex is the new dynamic grinding machine from Bühler.** Designed for ultimate power, high capacity grinding up to 75 tph. The company said its Swiss-made reliability and supreme ease of maintenance minimize downtime, so you can make maximum use of this productivity

Bühler says it is an investment in quality that is sure to show a rapid return and deliver a hammer blow to your operating costs.

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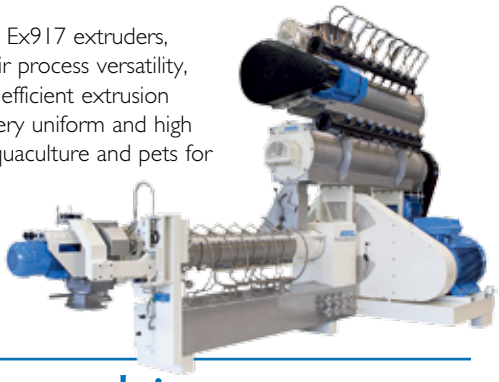
## ANDRITZ Feed & Biofuel

New extrusion programme - **ANDRITZ FEED & BIOFUEL has launching a new and improved extrusion programme for the production of all kinds of fish feed, and pet-food.** The new improved extruders are based on the experience gained from the popular ANDRITZ FEED & BIOFUEL

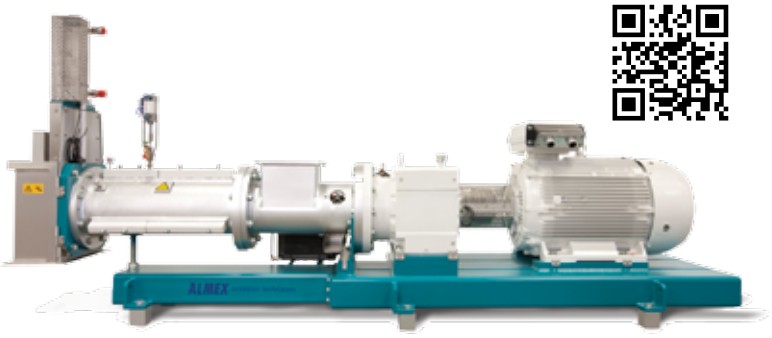
Ex620, Ex920, Ex617, and Ex917 extruders, which all have proved their process versatility, controllability, and energy efficient extrusion performance, leading to very uniform and high nutrient value feeds for aquaculture and pets for many years.



www.andritz.com

## ALMEX extrusion techniques

Almex - **specialises in single screw extrusion equipment, from the extrusion unit to complete installations.** Almex extruders and Contivar Expanders are in use worldwide at fishfeed-, oil extraction-, petfood-, animalfeed plants, the foodindustry and the processing and chemical industries. Please visit our websites for more information.



www.extruder.nl www.expander.nl

## EXTRU-TECH, INC.

Extru-Tech, Inc. - **Introduces New Valve Options.** Extru-Tech, Inc. SABETHA, KS. February 2013— In a continued effort to improve product performance and production control, Extru-Tech, Inc. has introduced a new Mid-Barrel Valve (MBV), as well as a new Energy Management Valve (EMV). Used independently, or together, both products offer increased control of SME (Specific Mechanical Energy).

Because it is an internal component, the MBV can be added in any position along the length of the barrel for on-line control of SME and product density. Used with the company's highly adaptable single screw extruders, the new MBV allows manufacturers to achieve higher SME, higher cook and lower bulk density, even with fresh meat and high-fat recipes.

The new EMV located at the barrel discharge, meanwhile, controls the final characteristics of the product by dynamically adjusting the extruder die restriction — even when the machine is in operation. Because of the advanced EMV design it also allows the flow of off-spec extrudate to be diverted away

www.extru-techinc.com

## Biomin

AquaStar® - **With the development of the AquaStar® product line, BIOMIN serves the needs of the industry for natural and sustainable solutions.** AquaStar® is a well-defined, multi-strain probiotic product for fish and shrimp which promotes a beneficial gut microflora as well as an improved environmental condition in ponds, thereby improving efficiency in production:

- *Controls pathogenic microorganisms*
- *Stabilizes water quality and pond bottom*
- *Improves gut health and performance*

aquastar.biomin.net

GePro Aqua

Gold Mehl FM - Gold Mehl FM is a processed poultry protein with high protein content and high protein digestibility.

This is achieved by using drying process with optimal conditions using Low Temperature (LT) drying technology.

A comparison between Gold Mehl FM and demand of EAA by fish and shrimp indicates that a balance exists within most EAA thus positioning Gold Mehl FM as a replacer of Fish Meal.

With 85% crude protein content and more than 85% in vivo digestibility, the product is a unique offering in the category of Animal Proteins and is being used widely in different parts of the world.

www.ge-pro.de

Leiber
Excellence in Yeast

Beta S – The natural Immune Modulator - **Leiber Beta-S® consists of isolated 1.3-1.6-β-D-Glucan molecules from brewers' yeast cell walls.** Thanks to a patented and gentle production process, their native structure stays intact so that they have an effective and immune-modulating impact during intestinal passage.

MULTIBIOTIC POWER

Leiber Beta-S® has a scientifically proven positive effect on the immune variables of fish including the antibody titer, the immune globin level, and the mortality rate.

**Excellence in Yeast – Excellent for fish!**

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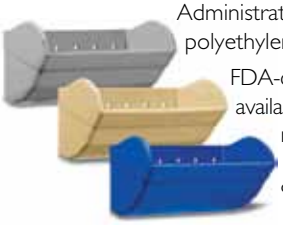

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Developed and manufactured by Zhengchang, SZLH1068 has attained domestic largest capacity of 45-55 ton per hour. It will be put in use in 160t/h feed factory for the company of Hewei. The successful manufacture of SZLH1068 has laid solid technology foundation for the massive and intensive development of China feed industry. The adoption of SZLh1068 pellet mill will greatly save the investment, production and management costs for feed factory and create more values for them.

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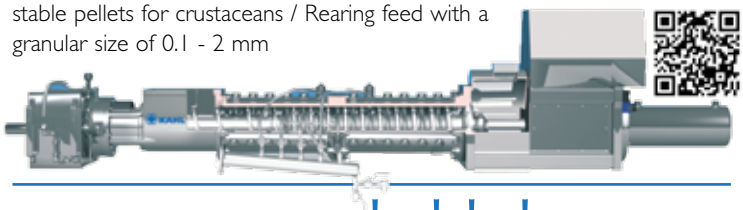

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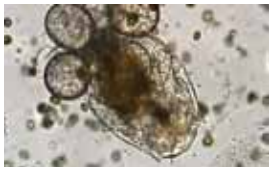
Rotifers **- are small (50-1000 µm) zooplankton that occur in freshwater, brackish, and marine environments.** Rotifers feed on microalgae and are consumed by a wide variety of fish, shellfish, corals, and other organisms. They are used extensively in aquaculture and aquariums because of their very high reproductive rates (as great as doubling or better every 24 hours), ease of culturing, optimal size for larval fish, and nutritional profile that can be tailored to the needs of prey species by use of special feeds such as Reed Mariculture's RotiGrow® and N-Rich® microalgae feeds.



The most commonly used marine rotifers are the species Brachionus plicatilis (L-type) and Brachionus rotundiformis (S-type and SS-type). Reed Mariculture supplies pure cultures of a strain of Brachionus plicatilis (L-type rotifers) with a typical lorica length of about 160 µm. This species is euryhaline, capable of thriving in salinities of 5-40 ppt.

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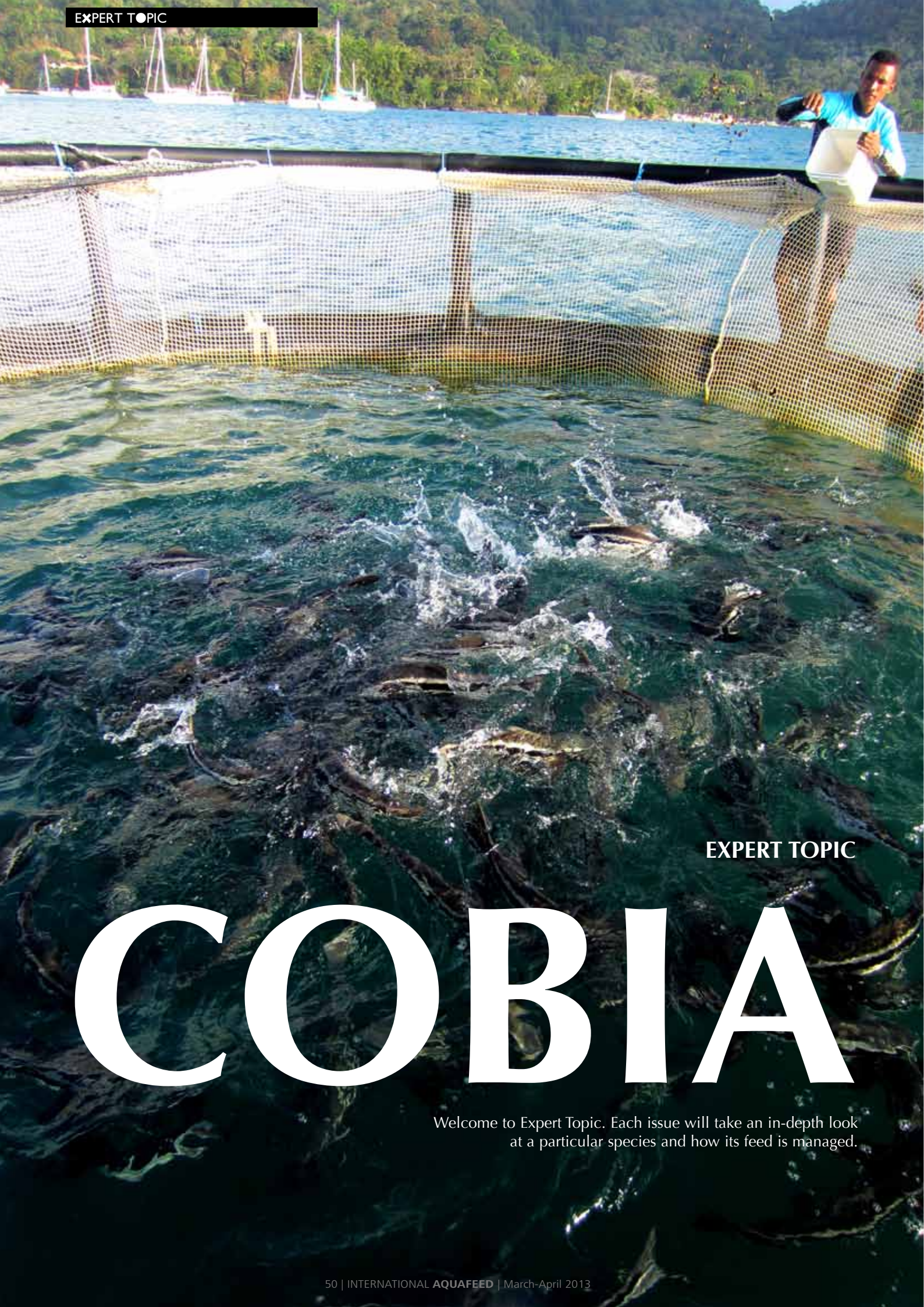
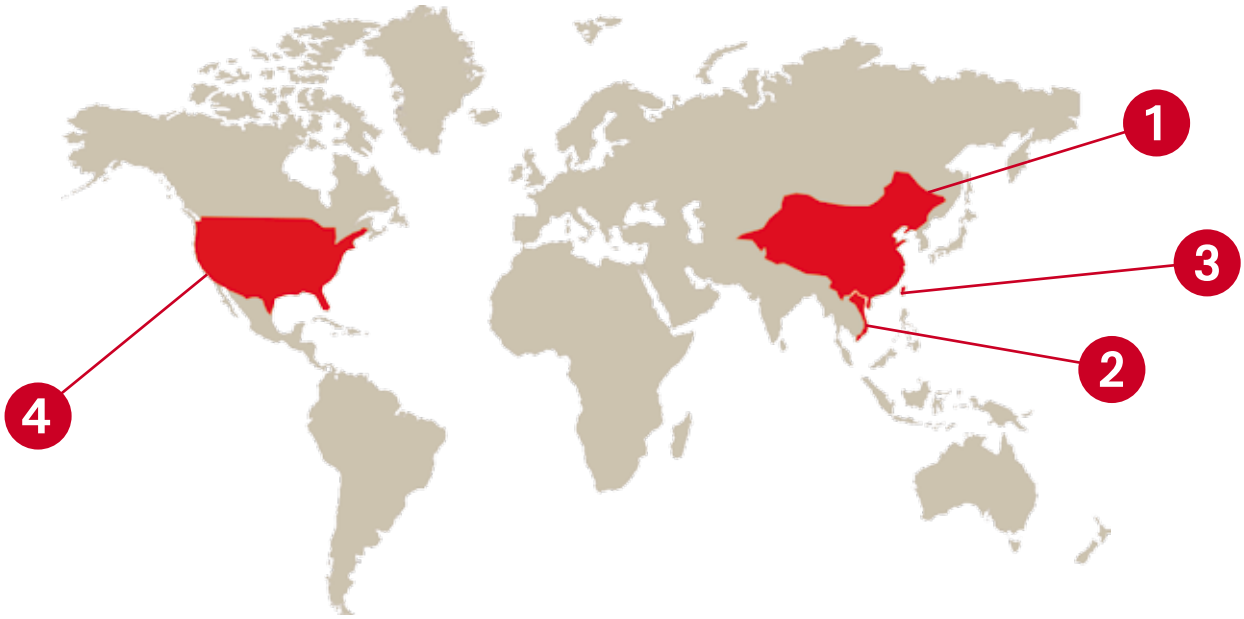


EXPERT TOPIC

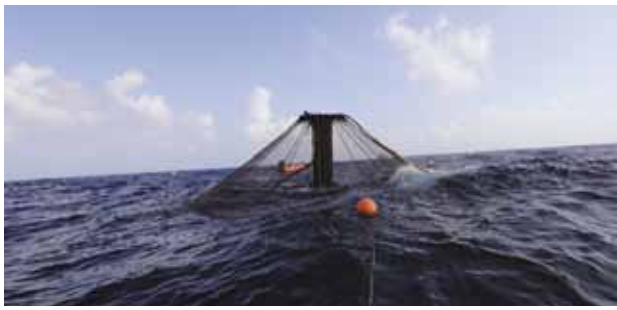
# COBIA

Welcome to Expert Topic. Each issue will take an in-depth look at a particular species and how its feed is managed.




## 1 China

The vast majority of the world's cobia is produced in China. In fact in 2004, the country produced 80.6 percent of global exports according to the FAO. However, despite this, there is little available information on cobia feeds or farming strategies used by Chinese farmers.



## 2 Vietnam

In 2008, Vietnam produced 1,500 tonnes of cobia, making it the third largest producer behind China and Taiwan.

One of the largest cobia operations in the country is run by Marine Farms Vietnam, a subsidiary of Marine Farms ASA, Norway. The company has a shore base facility, hatchery site and ten sea sites, which range from 20 m to 32 m in depth. The farms, which are located north of Nha Trang, produce more than 1,500 metric tons of cobia per year, with the capacity to produce more than 6,000 tons if needed.

Not content with only Vietnamese cobia production, Marine Farms also has a cobia operation in Belize which has been growing cobia in offshore cages since 2006.

## 3 Taiwan

Taiwan is one of the pioneers of cobia aquaculture. Initially broodstock fish were caught from the wild but in the 1990s, the country became the first in the world to successfully spawn cobia. By 1997, the technology and know-how was in place to raise sizeable quantities of cobia. Today, broodstock are taken from grow out cages and transported to onshore ponds to spawn. Juvenile cobia (1.5-2 years) is sent to grow out ponds, nearshore cages or offshore cages.

According to FAO data, cobia producers in Taiwan use both floating and sinking pellets comprised of 42-45 percent crude protein and 15-16 percent lipid. The FCR is approximately 1.5:1.

## 4 USA

Eighty-five percent of seafood in the USA is imported but there is burgeoning interest in increasing domestic aquaculture production. Cobia is a promising candidate for aquaculture production due to its rapid growth rate and good flesh quality. The first aquaculture research on the species was noted in 1975 in North Carolina, USA. Cobia eggs were collected off the coast and raised in a rearing trial.

Like Taiwan, there have also been successful spawning efforts on the USA.

While the early production cycle in Taiwan favours outdoor ponds, juvenile cobia in the USA tend to live in fibreglass tanks. According to the FAO, these tanks are either operated as recirculation systems, flow-through or a combination of both.

Research efforts have focused on extending the cobia spawning season with the aim of reaching year-round egg production. To date, eggs have been successfully fertilized during 10 months of the year.

# Developing ecologically efficient, economically viable and nutritionally adequate feeds for cobia *Rachycentron canadum*

The University of Miami and other US institutions have teamed up with feed manufacturing companies, producers and the American Soybean Association to develop competitive practical feeds for this emerging aquaculture species

by Jorge A Suarez, Carlos Tudela, Drew Davis, Matthew Taynor, Lindsay Glass, Ron Hoenig and Daniel D Benetti

**Cobia is the only member of the family Ranchycentridae. It is a tropical and subtropical species widely distributed worldwide (Briggs, 1960; Shaffer and Nakamura, 1989; Ditty and Shaw, 1992; Benetti *et al*., 2008), except in the eastern Pacific, where it rarely found (Briggs, 1960; Collette, 1999; Benetti *et al*., 2008). Cobia are recognised for their fast growth, excellent meat quality, and have been intensively farmed since the 1990s (Liao *et al*., 2004; Benetti *et al*., 2007).**

These characteristics, along with excellent meat quality and good market demand and price, raised enormous interest in commercial aquaculture development of this species. Indeed, while cobia was a little known candidate species for aquaculture about a decade ago, today it has established itself as a top quality cultured marine fish tropical/subtropical in Asia and the Americas.

Technology for reliable broodstock spawning and mass production of fingerlings has been mastered at the University of Miami Experimental Hatchery (UMEH) and other private companies and government institutions around the world. However, while the fundamental technology for cobia production from egg to market is in place (Liao *et al*., 2004; Benetti *et al*., 2008; 2010), many years of research and development are still needed to refine the culture process, allowing cobia to develop on an industrial scale, especially at the grow-out stage.

Those working with the species both at the R&D and production concur that the most crucial remaining roadblocks to be addressed and resolved at this juncture are related to feeds and nutrition.

At the present time, feeds represent the most expensive item of the production costs for cobia, and the inability to provide a sustainable, high-quality feed that meets the energetic and nutritional requirements of these fast growing fish continues to elude producers. Top quality diets with high inclusion levels of fishmeal and fish are available but costs are prohibitively high from both ecological and economical perspectives. Therefore, the collective goal of researchers, feed manufacturers and producers is to formulate, develop and manufacture ecologically efficient and economically viable diets that will meet the nutritional requirements of this species. This review summarises these efforts.

The evaluation of feed ingredients is crucial to nutritional research and feed development for aquaculture species. In evaluating ingredients, there are several important points that must be understood to enable the judicious use of a particular ingredient in feed formulation (Glencross *et al*., 2007). The determination of nutrient digestibility is the first step in evaluating the potential of an ingredient for use in the diet of an aquaculture species (Allan *et al*., 2000).

A constraint for the expansion of cobia aquaculture is the availability of high quality formu-

lated diets which reduce or eliminate fishmeal protein. Suitable replacements are often of plant origin, but the evaluation of nutrient digestibility in new ingredients should be an initial step in evaluating its potential for fishmeal replacement. Therefore, the apparent digestibility coefficients (ADCs) of protein and amino acids of a novel variety of non-GMO soybean meal, Navita™, and an industry standard soybean meal (defatted soybean meal/roasted solvent-extracted), were evaluated at University of Miami for juvenile cobia, *Rachycentron canadum*. Results indicated that the Navita™ is highly bio-available to cobia, as ADCs for protein and amino acids obtained for this ingredient were significantly higher for nearly every analysed component of the feed than the ADCs of the conventional soybean meal. ADCs crude protein were 81.8% and 68.5%, respectively, for Navita™ and conventional soybean meal. Similarly, ADCs of selected amino acids ranged from 68.3-108.6% for the Navita™ meal, whereas the same coefficient ranged from 41.4-97.8% for the conventional soybean meal. Findings from the present experiment highlight the potential of Navita™ as a suitable FM replacement in cobia diets and should help to maximize cobia growth while minimising the excretion of fish metabolites (Davis *et al*., 2012).

## Reviewing cobia nutrition

In their thorough review of cobia nutrition, Fraser and Davies (2009) pointed out the importance of paying special attention to the amino acid requirements when replacing fishmeal with alternative protein sources. Chou *et al*. (2004) mentions that methionine is the primary limiting amino acid replacement in studies of fishmeal with soybean meal. Lunger *et al*. (2007) found that the amino acid taurine supplementation at a level of 5g $kg^{1}$ dry weight, increased weight gain and feed efficiency in cobia fed diets with high levels of plant protein.

Fraser and Davies (2009) conclude that nutritional studies on cobia are limited because most have been conducted using juvenile fish with much lower weights than harvestable size. The cobia commercial weight is between 4 and 10 kg; however nutritional requirements have only been examined in juvenile fish weighing 50 g. Although differences in the requirements were minimal, it would still have a high important commercial impact, especially considering protein and lipids are the major dietary components in fish diets. The accuracy of the nutritional requirements would not only have a positive economic impact on the industry, but also decrease the environmental pollution by decreasing nutrient loading in the aquatic ecosystem. As reviewed by Welch *et al* (2010), the importance of the responsible use of natural resources such as fishmeal, fish oil and vegetable crops to ensure the environmental sustainability of aquafeeds is well recognised.

Although nutritional principles are similar for all animals, the amounts of nutrients required vary among species. There are about 40 essential nutrients in fish diets (Akiyama *et al*., 1993). According to Tacón (1989), nutritional requirements in the diet of all cultured aquatic species may be categorized under five different nutritional groups: proteins, lipids, carbohydrates, vitamins and minerals.

## Major nutrient requirements for juvenile cobia

**Protein:** One of the most important nutrients in the diet of marine fish is protein. This is attributed to two factors, which are the high cost of the ingredient and the organisms' high protein nutritional requirement. Excess protein not only increases feed costs but it also increases the excretion of nitrogen into the environment. The first article used to determine protein requirements in cobia was that of Chou *et al*. (2001), who determined by regression analysis, a protein requirement of 44.5%. Craig, Schwarz and McLean (2006) conducted a factorial study with two levels of crude protein (40% and 50%) and three lipid levels (6%, 12% and 18%). The authors found a significant difference in feed efficiency of 7.4 g cobia fed with the lowest level of protein. On the contrary, when the authors used larger cobia (49.3 g) no significant differences in feed efficiency were found between the different levels of protein.

**Amino acids:** The nutritional value of a protein diet is influenced by the composition of its amino acids. For this reason, the protein to be used in practical diet formulations must be based on digestible amino acid profile and quantitative amino acid requirements in the targeted species. In cobia, studies of amino acid requirements are limited, only two of the ten amino acids have been considered essential (Wilson 2002). Zhou *et al*. (2006) determined methionine requirements in juvenile cobia. The authors state that for maximum growth and lower feed conversion ratio, the requirement of methionine is 1.19% (dry diet) in the presence of 0.67% cysteine, corresponding to 2.64% dry weight of dietary protein.

For lysine, Zhou *et al*. (2007) determined the requirements in juvenile cobia. The result for lysine requirements were 2.33% and 5.30% dry weight of dietary protein. These values of methionine and lysine are in accordance with the requirement values of other important fish species in aquaculture (Wilson 2002). Recently, Ren *et al*. (2012) determined the requirements of arginine on the basis of SGR and FER. The optimal dietary arginine requirements of juvenile cobia were estimated to be 2.85% of the diet and 2.82% of the diet, respectively.

**Lipids:** Lipids are an important source of highly digestible energy, in particular, free fatty acids derived from triglycerides constituting the major energy source for muscle in almost all animals. They are also key components of cellular and subcellular membranes (phospholipids, sterols, etc.). Performing functions as biological transporters in the absorption of fat-soluble vitamins are precursors of prostaglandins and hormones (Fenucci and Haran 2006). For juvenile cobia, the lipid requirement was estimated at 5.76% (Chou *et al*., 2001). Wang *et al*. (2005) used three isoproteic diets (47% protein) with three lipid levels (5%, 15% and 25% dry matter). The authors found no significant differences in growth between the cobia (7.7 g) fed diets containing 5 percent and 15 percent lipids. However the cobia fed 25 percent lipid had a significant reduction in daily diet consumption, suggesting that lipid levels above 15 percent reduced growth due to decreased feed consumption.

**Carbohydrates:** Because cobia commercial feeds contain starch and cereal products, related research on carbohydrate requirements are very important. Schwarz *et al*. (2007) suggests that cobia are able to use up to 360$g/kg^{-1}$ of dietary starch from low molecular weight carbohydrate such as dextrin. Webb *et al*. (2009) determined that cobia can use carbohydrates to levels of 340$g/kg^{-1}$ (dry diet) with an optimum energy protein of approximately 34mg protein $kJ^{-1}$ metabolisable energy.

**Vitamins:** Vitamins are nutrients necessary for growth, health, and reproduction of organisms and are required in very small amounts in fish diet. Mai *et al*. (2009) determined the requirements of choline in juvenile cobia. The requirement determined by 'broken line' for weight gain was 696 $mg/kg^{-1}$ choline diet as choline chloride. Unfortunately there is not enough information on the requirements for vitamins and minerals in Cobia.

## Future research areas

For the future we propose the following research in the area of cobia nutrition:

- Determine nutritional requirements at different sizes classes
- Further requirements of amino acids, vitamins and minerals
- Continue research replacement of fishmeal and fish oil to alternative sources of protein and lipid
- Complement existing information on digestibility and energy balance of protein ingredients of plant and animal origin
- Monitoring the quality of commercial feeds, used by the industry
- Implementation of management practices

In conclusion, the collaborative effort of researchers, feed manufacturers and producers are driving steadfast progress towards developing practical and economical diets for

cobia at all developmental stages. Government support as well as interest and funding generated by American Soybean Association and its various affiliated groups have been of paramount importance in advancing knowledge and technologies the field. The industry is much further ahead than it was about a decade ago. It is recognised that enhanced knowledge and better nutrition are allowing cobia aquaculture production to continue to expand exponentially worldwide while moving away from inadequate diets and trash fish. The development of an ecologically efficient and economically viable cobia aquaculture industry is and will continue to benefit all stakeholders, from producers to consumers.

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**Web:** *www.wplgroup.com/aci/conferences/eu-eal3.asp*

**25th - 26th April 13**
GLOBALG.A.P Public Workshop, Aquaculture, Brussels, Belgium
**Contact:** *Daniela Fabiszisky, GLOBAL G.A.P, Spichernstr.55, 50672 Cologne, Germany*
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**Fax:** *+49 2215 799389*
**Email:** *fabiszisky@globalgap.org*
**Web:** *www.globalgap.org*

**22nd - 24th May 13**
VIV Russia 2013, International Crocus Exhibition Center, Moscow, Russia
**Contact:** *Guus van Ham, P.O. Box 8800, 3503 RV Utrecht, The Netherlands*
**Tel:** *+31 302 952302*
**Fax:** *+31 302 952809*
**Email:** *viv.russia@vnuexhibitions.com*
**Web:** *www.viv.net*

**30th May 13 - 2nd June 13**
Aquarama 2013, Hall 401-403, Suntec Singapore, International Convention & Exhibition Centre, 1 Raffles Boulevard, Suntec City, Singapore 039593
**Contact:** *Ms. Jennifer Lee, 3 Pickering Street, #02-48 China Square Central, Singapore 048660*
**Tel:** *+65 65 920891*
**Fax:** *+65 64 386090*
**Email:** *Jennifer.lee@ubm.com*
**Web:** *http://aquarama.com.sg/*

**5th - 7th June 13**
INDO LIVESTOCK 2013 EXPO & FORUM, Bali Nusa Dua Convention Center, Bali, Indonesia
**Contact:** *Didit Siswodwiatmoko / Devi Ardiatne, Jl. Kelapa Sawit XIV Blok M1 No. 10, Kompleks Billy & Moon, Pondok Kelapa Jakarta 13450, Indonesia*
**Tel:** *+62 218 644756 ext: 118 & 123*
**Fax:** *+62 218 650963*
**Email:** *info@indolivestock.com*
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**9th - 12th August 13**
Aquaculture Europe 2013, NTNU – Trondheim, Norway
**Contact:** *Conference manager, Slijkensesteenweg 4, 8400 Ostend, Belgium*
**Tel:** *+32 59 323859*
**Fax:** *ae2013@aquaculture.cc*
**Web:** *www.easonline.org*

**9th - 12th September 13**
BioMarine Business Convention 2013, World Trade Congress Centre, Halifax, NS, Canada
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**Tel:** *+1 6139 912060*
**Fax:** *+1 6139 937250*
**Email:** *biomarine2013@nrc-cnrc.gc.ca*
**Web:** *www.biomarine.org*

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20th Annual Practical Short Course on Aquaculture Feed Extrusion, Nutrition and Feed Management, Texas A&M University, College Station, Texas, USA
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**Fax:** *+1 9798 452744*
**Email:** *mnriaz@tamu.edu*
**Web:** *www.tamu.edu/extrusion*

**6th - 10th October 13**
Tenth International Symposium on Tilapia in Aquaculture (ISTA-10), Crowne Plaza Hotel, Givat Ram, Haaliya St. 1, Jerusalem, Israel
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**Email:** *vlaqua@volcani.agri.gov.il or Email: kevfitz@ag.arizona.edu*
**Web:** *www.ista10.com/*

**10th - 12th October 13**
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**7th - 9th November 13**
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**Web:** *www.thaiscorp.com*

**7th - 11th June 14**
World Aquaculture 2014, Adelaide Convention Centre, SA, Australia
**Contact:** *Australia - Sarah-Jane Day, International – John Cooksey, Marevent, Begijnengracht 40, Ghent, 9000 Belgium*
**Tel:** *+32 92 334912*
**Email:** *sarah-jane.day@aquaculture.org.au*
**Email:** *worldaqua@aol.com*
**Web:** *www.aquaculture.org.au*

## Aquarama,

### May 30- June 2, 2013

Suntec, Singapore

Singapore is an apt location for Asia's biggest ornamental fish show. The country is the world's largest exporter of ornamental fish, with exports totalling 20.3 percent of global production in 2008. Aquarama returns for a thirteenth year with an exhibition dedicated to all things aquarium-related. With a focus on international ornamental fish, invertebrates, plants and accessories, the show offers plenty of opportunities to get immersed in aquatics.

International industry players attend Aquarama to source new products, set new industry standards, or learn about the latest technology and industry developments. There will be farm visits, a new products showcase and a variety of trade and public seminars.

This year the three trade seminars will focus around the theme of 'current aquatics – future perspectives'. Session 1: Industry-related Conservation will look at hot issues in the aquatics world including, the ongoing studies on the plight of the Banggai cardinalfish, the Amazonian ornamental fishery, conservation and management strategies for Indian ornamental fish, and CITES and CBD issues surrounding the dragon fish.

Session 2: Health and Biosecurity in the Ornamental Aquatic Industry will examine biosecurity issues in Australia, fish health management in commercial premises and barcoding of ornamental fish.

Finally Session 3: Husbandry and Legislation covers governmental perspectives on the ornamental aquatic industry, the live rock trade, wild-caught and captive-bred seahorses, nano aquaria, Brazilian legislation and the next CITES Conference of the Parties.

MORE INFORMATION:
*Website: www.aquarama.com.sg*

## VIV Russia — May 21-23, 2013

International Crocus Exhibition Center, Moscow, Russia

VIV is synonymous with high-quality agriculture shows. Formed in the 1970s, Vakbeurs Intensieve Veehouderij (or intensive animal farming) catered for the burgeoning interest in arable farming, milk and cattle production in the Netherlands. Since then, VIV has grown from a national trade event into seven separate shows held around the world. Today VIV shows attract over 1,000 international companies and visitors from over 140 countries.

VIV Russia is one of the success stories of the VIV family. At the beginning of the century the Russian economy began to grow rapidly again after the crisis at the end of the 1990s. A strong emphasis from central government on self-sufficiency for the Russian meat industry proved fertile ground for VIV Russia. Starting in 2004 this VIV show quickly became a point of reference for the Russian meat industry.

Now in its sixth edition, VIV Russia 2013 showcases new products and services, state-of-the art technologies and the latest trends in the animal protein industry. In addition to the exhibition an extensive conference and seminar programme is also planned.


Guus van Ham, project manager, VIV wants to provide Russian companies with a platform, offering everything that is needed to build efficient supply chains for the intensive production of poultry meat, eggs and pork. Animal feed and animal health – at the beginning of the supply chain – and product processing – at the end of the chain – will play a very important role in this. "We want to share our knowledge with the Russians in these areas in particular. We will also be presenting solutions for the effects of antibiotics use during a series of congresses and seminars. These congresses will be high-level, objective and non-commercial," says Guus van Ham.

VIV's central theme remains the conversion of vegetable products in to animal protein, primarily in the form of meat and eggs. But the growing economies of the world are also responding to an increasing demand for fish products at VIV

MORE INFORMATION:
*www.viv.net*

## Plans underway for World Aquaculture Adelaide 2014 — June 7-11, 2014

Plans are already in full swing for World Aquaculture Adelaide 2014 (WAA14) which takes place June 7-11, 2014.

"The theme for the conference is 'Create, Nurture, Grow' which reflects the dynamic nature of aquaculture development in the region," says Dr Graham Mair chairman, World Aquaculture Adelaide 2014

"Agreeing the theme early on has given us a head start and we have a number of strong teams already working on a range of conference development tasks and we are confident that, with the support the event is receiving from industry and government, this will be an exciting and rewarding event," adds Mair.

The Program Committee headed by Professor Jose Fernandez-Polanco and Dr Jenny Cobcroft have their Call for Papers ready to roll out soon after the conference.

Workshops and tours, both pre and post conference, will be featured additions to the strong conference program in Adelaide and they will include important activities for farmers, researchers and students alike.

Mair emphasised, "We are grateful for the support we are receiving from all our sponsors and the willingness of the many organisers to put in time and effort to develop the wide range of planned activities. I am certain that the end result will be excellent and memorable experience for delegates and we look forward to seeing everyone in Adelaide in June 2014".

MORE INFORMATION:
*www.was.org*


# Innovations & Products Review

- from key industry events

## Review Aquaculture 2013, Nashville, USA

*International Aquafeed's Tom Blacker heads to the 'music city' for Aquaculture 2013*

**The World Aquaculture Society's popular event, Aquaculture 2013 took place in a downtown conference centre in the 'music city', Nashville, Tennessee between February 22-24, 2013. Roger Gilbert, proprietor of Perendale Publishers Ltd and Tom Blacker, marketing and sales and directories coordinator were exhibiting, along with hundreds of others in the main exhibition hall.**

From early on the first morning, participants gathered in the main ballroom for the Opening and Plenary. The official Steering Committee's opening address, the session moved to official awards, speeches and presentations with great enthusiasm and an optimistic note prevailed for the imminent event at large. Notably, Novus Inc.'s Craig Browdy won the US Aquaculture Society Distinguished Service award and Dr Edward Allison presented an interesting lecture on global warming and aquaculture. The beginning was fantastically impressive and Dr Allison's speech placed aquaculture superbly well in the context of global warming. Overlapping this was the expo and the seminar room the exhibition hall was alive with many visitors browsing the long aisles filled with all kinds of stands, products, prize draws and publications.

From the first moment onwards, our stand in the centre of the exhibition hall had visitors interested to see and hear about our titles. We noticed a genuine interest in both the English and Español International Aquafeed issues on show. Regular readers gave great feedback and new readers had some insightful opinions. Hundreds of copies of our magazines were distributed, In fact, there were limits needed on the distribution so as to ensure participants over the entire event could receive copies!

The atmosphere was relaxed throughout the various areas and the food and drinks at some exhibitor's stands were a welcome opportunity to mingle and network. Some of our regular advertisers were in attendance and were very pleasant to meet indeed.

There were no shortage of academic seminars with question and answer all over three floors of a large conference centre; the ones we attended were fantastic and inspirational to spur us on to standards. I managed to find time to attend two. The first was an Alltech seminar entitled 'Successful fish oil sparing in white seabass feeds using saturated fatty acid-rich soy oil' on Friday and Reed Mariculture's Eric Henry presenting 'Practical rotifer culture for zebrafish facilities' on Saturday. Both were informative and interesting and provided good question and answer sessions.

The presence of feed producers, academics, manufacturers and organisations all in the vibrant capital of Tennessee was truly unique and it exceeded our expectations of the value it would bring. The next aquaculture exhibition has to reach the high standards as this one!

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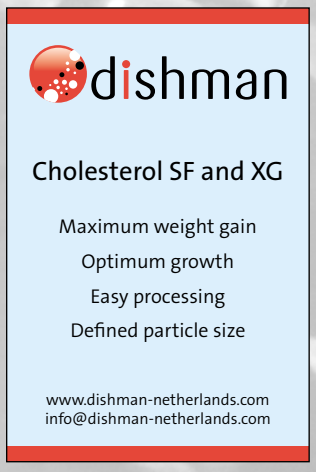


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# The aquafeed interview

Novus will soon celebrate its 22nd birthday! Novus International, Inc. was founded in 1991, but their scientific roots and history originated over 50 years ago. In the 1950s, St. Louis, Missouri-based Monsanto Company began conducting livestock and poultry feed metabolism studies. In 1959, one of its products received FDA approval as an animal feed additive, which helped launch the Monsanto division that would become Novus. In 1991, in an effort to focus on its core businesses—seed, herbicide and biotechnology—Monsanto sold its Feed Ingredients division to Mitsui & Co., Ltd. and Nippon Soda Co., Ltd. The new owners saw Novus's strategic potential for growth.

International Aquafeed had the opportunity in London recently to interview the head of Novus, President and CEO Thad Simons, who says his organization's Vision is to "help feed the world affordable, wholesome food."

## To set the scene, what are Novus' principle technologies especially for aquaculture?

Consumer demand for fish-based protein in emerging and developed markets is on the rise. At current market demand, 7 million tons of aquaculture fish are produced annually and this figure will continue to increase. Yet, the traditional model uses ocean fish for producing fish meal to supply aquaculture production. As producers look for cheaper, more renewable feedstocks, vegetable protein, especially soybean, has become an increasingly attractive ingredient in the feed mix. However, vegetable protein requires assistance to increase its bioavailability for aqua species.

Novus technology, which enhances the digestibility of vegetable protein, allows for considerable reductions of fish meal inclusion in aqua diets, up to 80%, depending on the species. This optimised Health-through-Nutrition approach is accomplished through a highly cost efficient feed supplement solution blend. Novus's proprietary blend of Gut Environment Modifiers influences the gut flora (microorganisms that live in the digestive tracts) of shrimp and other species, effectively enhancing their ability to cope with stressful culture conditions. As a result, animals eat better, digest more and grow faster, all the while reducing the waste of uneaten or non-digested feed into the surrounding system

## Can you put Novus into a global context for feed?

Our total sales worldwide are over US$1.3 billion. Over half this revenue is accrued through methionine product sales, but in terms of growth and over the past ten years we have seen non-methionine products growing rapidly to over US$300 million from US$30 million – this we have achieved not just through internal development but also through acquisition.

Liquid methionine has been on the market for 30 years while methionine itself has been available in powder form for almost half a century. Methionine is a US$1 billion market worldwide and is a very important ingredient in the production of poultry. That is likely to remain and increase as we search for a replacement to Chilean fishmeal in livestock diets. For example, as we start to feed more soybeans as a protein replacement for fishmeal we will need more methionine to help balance the protein in fishmeal-free diets.

## Methionine is one product, but what other innovative products are you working on?

From methionine we have developed other products such as chelated trace minerals that can be delivered to animal in an efficient way. These products have the potential to reduce the amount of minerals we feed to animals by improving bio-availability. That will mean less minerals in the diet and thereby reduce the impact on the environment while still remaining competitive. We have now brought this technology to aquaculture and supply the market with both straights as with full organic mineral premixes.

I see the company moving into supra-nutritional products that improve health of animals while at the same time reducing or eliminating much of the drug usage we see today. We have a strong focus in Therapeutic nutrition and our technology portfolio includes organic acids, manufacture red in Germany pre- and probiotics, and extracts of essential oils now coming out of our research and development programmers in Spain. We have been successful in launching and customizing these technologies for aquaculture applications, ranging from vibriosis in Asian shrimp, to enteritis in Mediterranean sea bream or sea lice in salmon.

## Are there other non-dietary products under development?

Feed quality can be augmented with mold inhibitors based on organic acids to detoxify raw materials by using a mycotoxin binder. This is a very important area for feed manufacturing, especially in drought years when corn quality for instance is poor and contamination is high.

We are also looking at preserving fat profiles for their nutrient values, using for example, protease enzymes to assist in getting more protein value out of the final feed. We are in partnership with Verenium to developing new heat-stable, phytaze products which will ultimately have applications for aqua feed industry.

## How important are differences between markets when it comes to product development?

If we look back 21 years we were clearly focused on the poultry industry which was a very fast growing sector at the time. Ten years ago we increased production and our global footprint by building infrastructure in Asia, mostly through a distribution network supporting the growth of methionine sales coupled with our liquid application systems, which proved highly suitable in feed mills.

Today we are leveraging a deep understanding of nutrient absorption and gut health. Good nutrition can reduce costs to farmers and reduce the amount of waste that is left for the environment to absorb. We are in the 'waste reduction' business and by producing products that allow various species to grow to their genetic potential supports that cause.

In human terms it shouldn't be about taking drugs or multi-vitamins every morning, but to have more control over our health that we can achieve through our own diets.

Even with less quality feed now available we should be able to achieve more through sound diets.

An extended version of this interview can be found on the Aquaculturist blog.

*Thad Simons, Novus president and CEO*

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Point your phone at the image below and watch it come to life with the full interview

## AkerBiomarine recognised for sustainability efforts

Aker BioMarine has won an award from the *Nutrition Business Journal* for its role in building the krill fishery infrastructure. The Norwegian company gained the 'Investing in the Future' award for its work in creating a controlled krill supply chain in the Antarctic with a long-term focus on sustainable harvesting. Sustainability has been a key concern of Aker BioMarine's business since its inception. The company has cooperated with World Wild Fund for Nature, Norway, has Marine Stewardship Council certification and has collaborated with the Commission for the Conservation of Antarctic Marine Living Resources.

"With a sensible approach to krill fishery governance by external management, and taking the responsibility for our own harvesting activities seriously, we have always believed this to be a win-win relationship; otherwise there would be no reason to invest," says Webjørn Eikrem, EVP, Upstream Operations, Aker BioMarine.

*www.akerbiomarine.com*

## US perch farm wins 'Industry of the Year' award

Bell Aquaculture, the largest yellow perch farm in the USA has been named 'Industry of the Year' at the Jay County Chamber of Commerce at its Annual Meeting and Awards Banquet. The Indian-based company was cited a "an international pacesetter in the field of aquaculture," by Bill Bradley, executive director, Jay Country Development Corporation for its work converting waste fish into fertilizer.

"I was very surprised and both thrilled and humbled that Bell Aquaculture was chosen for this special honor. On behalf of our entire company, I thank the Jay County Chamber for singling out Bell Aquaculture and our industry as a whole with this much appreciated public recognition," says Norman McCowan, president, Bell Aquaculture.

*www.bellaquaculture.com*

## Evonik contribution to assist Hurricane Sandy relief efforts

In light of the devastation caused by Hurricane Sandy on October 29, 2012, speciality chemical company Evonik has donated $5,000 to the Piscataway Office of Emergency Management. The donation is a token of gratitude to the emergency personnel who work to keep the community of Piscataway safe.

The largest tropical storm ever recorded in the Atlantic, Sandy is one of the costliest natural disasters the United States has seen. Along with a death toll of over 100, Sandy is estimated to have caused billions of dollars in property damage and lost business. "We hope the funding will help the department as they work with our community to recover from the storm," says George Mossaad, Piscataway's site manager.

This is not the first time Evonik has been linked to natural disaster support. In recent years, the corporation has also provided relief and rebuilding efforts following hurricanes Katrina, Rita and Ike and tsunamis and earthquakes in the Asian Pacific.

Tom Bates, president of Evonik Corporation says, "Evonik is actively involved in helping make the quality of life in local communities better by participating in non-profit, charitable and community organisations."

*www.evonik.com*

## BioMar Baltic sees change in management after 22 years

Managing director for BioMar in the Baltic Market Area, Lars Rahbæk, has resigned following a 22-year career. R&D manager in Biomar Continental Europe, Ole Christensen, will take over the role.

Originally a BioMar sales assistant in the Danish market, Rahbæk took over as sales and marketing manager at the end of 2001 and also became a member of the Danish management team. Rahbæk has held the managing director position since early 2007 and following his resignation, intends to pursue opportunities outside of BioMar.

As regional R&D manager since 2007, Christensen has actively participated in designing and implementing a new R&D strategy and new product development processes. Alongside this, Christensen has also been involved in a large number of projects with the aim of improving operational efficiencies in BioMar's European factories.

To ensure continuity during this takeover, Rahbæk and Christensen will work closely together until April 2013.

*www.biomar.com*

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