A Passion for Quality
Headquartered in Seattle, USA, and with tilapia production in Hainan, China, HQ Sustainable Maritime Industries is dominating the market with a business built on toxin-free, sustainable aquaculture.

Effects of liquid potassium diformate as acid-based preservative for the storage control of sardines under tropical conditions.

Fish feed extrusion: Upgraded BC160 from Clextral reaches record 30 tons per hour capacity.

Novel digestibility enhancers improve performance, feed cost efficiency and filleting yield in fish.

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Industry Round-Up.
A PASSION FOR QUALITY

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By Suzi Dominy

Ten years ago the United States Department of Agriculture estimated that only three percent of U.S. consumers - somewhere near eight million people - had even heard of Tilapia, let alone eaten it. Last year the country imported 179,500 tonnes of the mild and versatile freshwater fish, worth US$734.4 million.

Most U.S. imports of tilapia originate from China, which produces around half of the world’s supply. In a recent FAO report, Helga Josupeit said that in 2008 China exported more than 119,000 tonnes of tilapia to the U.S., with a market value of more than US$ 436 million.
Demand for tilapia keeps on growing. Worldwide, tilapia production is predicted to reach three million tonnes by 2010, (compared with 2.6 million tonnes in 2007) of which China expects to produce 1.2 million tonnes, with exports worth US$ 460 million.

China’s leading producer of quality tilapia fish exports to the U.S., with a large share of the market, is HQ Sustainable Maritime Industries, Inc. (HQS), a fully integrated aquaculture operation with a focus firmly on quality.

With production facilities in the environmentally pristine island province of Hainan, in the South China Sea, and headquartered in Seattle, Washington, USA, HQS is dedicated to sustainability and natural practices and can boast a slew of awards and certificates to prove it. For example, it holds HACCP certification from the U.S. FDA and the EU Code assignment of quality, which permit its products to be sold in these international markets. The Aquaculture Certification Council, Inc. (ACC) has also certified that tilapia processing standards meet Best Aquaculture Practices, as developed by the Global Aquaculture Alliance (GAA).

**FEEDS—CENTRAL TO QUALITY**

Norbert Sporns, President and Chief Executive Officer of HQS said the company sources and deploys the best available technologies from China and abroad to deliver the highest quality products to the market. To this end HQS controls every aspect of production - and feed is no exception.

**NUTRACEUTICAL AND HEALTHCARE PRODUCTS**

HQS has developed a line of nutraceutical products that includes over 20 different products manufactured from fish by-products and sold currently in China. These include those manufactured from Tilapia by-products, including a unique Alzheimer treatment that utilizes various Tilapia proteins, and a line of collagen products made from rich collagen found in the scales and skin of Tilapia. The product uses other fish extracts in pill and cream formats to increase subcutaneous water helping to reduce wrinkles. HQS’s nutraceutical and healthcare products are nationally certified by the Chinese Ministry of Health and HQS’s processing plant has met the new GMP standards in China.

The Chinese market for personal health care products, including nutraceutical and marine-bio products, is robust and growing. Currently 8% of China’s 1.3 billion people are over 65. By 2050, 24% of the population or more than 300 million Chinese will be over 65. China also benefits from double-digit annual growth in disposable income.
To consolidate its position as a leader in organic aquafeeds for use both internally by HQS’s co-operative farmers and for the Chinese market, the company has created a partnership with the Marine Products College of Huazhong Agriculture University in Wuhan, a leading aquaculture institute and pioneer in the formulation of new feeds for aquaculture, as well as other leading American and Chinese scientists.

HQS’s trade marked “TiLoveYa” tilapia products are all grown and fed under natural, toxin-free conditions certified by the Chinese government as organic. Feed is formulated without the use of fish meal or fish oil. All-natural algae meal is added to increase significantly Omega-3 levels in the inland farmed tilapia. HQS also owns a nutraceuticals and health products company. Nutraceuticals from this plant are used to enrich feed used by HQS’s cooperative aquaculture operations.

**NEW FEEDMILL**

In December 2006, HQS broke ground for a 100,000 tonnes capacity feed mill for extruded feeds, in Hainan, which was commissioned in September 2009.

Norbert Sporns said the mill would allow HQS not only to provide superior feeds to its cooperative farmers in Hainan, but also to tap into the highly lucrative specialty aquaculture feeds market, servicing other China based and international aquaculture operations growing everything from grouper to abalone and crab.

The Buhler mill was brought online following months of quality and efficiency testing in order to optimize production and to ensure that it met or exceeded the highest global HACCP and ISO standards as well as the European Regulation on Feed Hygiene FAMI-QS. Management believes that this is an important step to control the quality of its fish products, vertical integration and traceability.
Buhler, through Buhler Changzhou, designed and manufactured the equipment that was chosen for the feedmill. The flow sheet was designed to ensure the feed is handled carefully and efficiently. HQS required a wide spectrum of particles size and degrees of homogeneity for its various feeds. This was achieved with a reduction system that includes a hammermill (AHZC 06125) and vertical pulverizer (SWFL130).

The hammermill has a reliable and flexible sieve clamping system for different sieve thicknesses. The unique rotor structure, low wear, long service life and easily changed sieves and hammers, gives this machine an important role in the feed mill.

Homogeneity is achieved thanks to the high-speed mixer, with its pear-shaped trough and adjustable paddles and large discharge gate, which extends from wall to wall and features a locking lever and inflatable seals that ensure tightness. This machine meets fundamental requirements such as CV≤5%, minimal residue of 0.05%, and no contamination.

The pellet mill is one of the most important machines for the feed mill. The automatic roller gap adjusting mechanism and hotsil technology and retention unit ensures high quality pellets. The hot air circulating system creates a hygienic environment in the machine to ensure the production of safe feed.

The extruder is at the heart of the plant. It consists of a feeding system, a two-stage conditioner for pre-cooking and modular design screws that can be set up as single or double flight. The split-barrel enables quick and easy recovery in the event of a blockage as well as easy change of the wear-resistant liner. The cutting unit is designed so that the distance between blades and die plate can be adjusted without stopping production.

“We are very pleased to have the new feed mill now fully operational”, Norbert Sporns said. “Improved feed conversion rates at competitive pricing allows HQS to provide the ideal feed for our operations in Hainan, significantly improving the efficiency of the farms themselves. The extruded floating feed produced by the mill reduces waste, and, in turn, improves the feed conversion ratios of the farms.

“We thank Buhler for making this a ‘showcase’ of the latest technologies available in aquaculture feed. We are able to improve efficiency and reduce costs for our clients, and we are able to better control the quality of the final product.”
Fatten up your bottom line. Buhler high-performance animal and aqua feed production systems are used by leading companies around the world. These producers know they can rely not just on the technology itself, but also on the support that accompanies it. A service combing local presence with global expertise both lowers feed mill operating costs and increases capacity utilization. So the question is not whether you can afford to choose Buhler – it’s how a solution from Buhler will feed your profits. To find out more, visit www.buhlergroup.com.
Almost a third of the world fish harvest is not used for direct human consumption, but is converted into fish meal or fish oil for further application in animal feed. Of the 75 million tons of fish about 25 million tonnes is therefore handled and processed in other ways than fresh, frozen, smoked or canned (Balios, 2003). The supply of huge volumes of high quality fish meal is necessary to supply the aquaculture industry, which has been growing with around 8.8% annually since the 1950ies (FAO, 2007). It was recently estimated that 25% of the produced fish meal world-wide comes from usage of waste from the fish processing sector (FeedInfo, 2009). The world-wide supply of fish meal is presently stable at 6 to 6.5 million t a year. On the other hand the percentage of high quality fish meal of the total amount of fish meal is expected to grow from 8% to 50% during the next 30 years (Hydro Norway, 2000). However, according to an IntraFish.com report (2001), access to premium quality fish meal, without dehydration damage to proteins and / or rotting which make the final product rancid, is still limited.

The present studies examined the effectiveness of a liquid blend of potassium diformate, antioxidant and corrosion inhibitor (FISHFORM) as a preservative for sardines, caught in the Indian Ocean, under Asian fish storage conditions.

During the sardine preservation a storage temperature of 12°C was chosen, which reflects the situation of the South East Asian fish storage conditions (on ice) on modern fishing vessels. The potassium diformate blend was added in one concentration (0.40%) next to a negative control. Samples (3 replicates) of the fish were taken after 24 h, 48 h and 72 hours storage time, for Total Volatile Nitrogen (TVN), histamine and dry matter content of fish.

TVN is often used as a criterion for the freshness of fish raw material (Haaland and Njaa, 1987). This value in the fish before processing is known as the most important quality criteria for raw industrial fish and the fishermen is paid according to the measured TVN level when landing the catch at the fishmeal factories.
The main constituents of TVN are trimethylamine and ammonia. Its amount increases with time of storage in the unfrozen state. Trimethylamine originates from bacterial decomposition, and the presence in fish is therefore taken as an indication for bacterial growth, while the ammonia comes from decomposition of amino acids - thus reducing the quality of the available protein. Levels of mainly 40 mg TVN per 100 g fish mass are regarded by the industry as limits for a good quality fish meal for instance. Furthermore biogenic amines, like Histamine (Hist.), are formed if the bacterial degradation of protein (amino acids) has started and is therefore an important criterion for the quality of the fish too. Histamine, for instance, is formed during the bacterial degradation of Histidine, which is an essential amino acid in fish nutrition. Contamination with histamine can cause food poisoning and allergic reactions (Diel et al., 1997). Finally, the dry matter content (DM) of fish is an important economic criterion, since it indicates how much fish meal can be produced with the fish raw material.

The total Volatile Nitrogen values in the negative control increased rapidly and exceeded the above mentioned 40 mg already after 48 hours at 12 °C storage temperature. The fast TVN development was significantly delayed by the addition of the potassium diformate blend. After 48 h the TVN-level in the group treated with FISHFORM was only half compared to the negative control (see table 1).

Table 1: Quality parameters of sardines for fish meal production (TVN, Histamine and dry matter) stored with or without FISHFORM (potassium diformate blend) at different storage times (at 12 °C)

<table>
<thead>
<tr>
<th>Storage time (h)</th>
<th>24</th>
<th>48</th>
<th>72</th>
</tr>
</thead>
<tbody>
<tr>
<td>KDF</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0%</td>
<td>TVN (mg/100g)</td>
<td>DM (%)</td>
<td>TVN (mg/100g)</td>
</tr>
<tr>
<td>0.0%</td>
<td>26.0a</td>
<td>24.9</td>
<td>59.4a</td>
</tr>
<tr>
<td>0.4%</td>
<td>25.2a</td>
<td>26.1</td>
<td>30.2a</td>
</tr>
</tbody>
</table>

Values with a different superscript differ significantly (P<0.05)

Furthermore the analysed values of histamine after 48 hours of storage in the negative control clearly prove the bacterial degradation of non-treated fish, while the amount of histamine in the preserved fish was nearly 3 times lower - indicating an improved quality of the fish raw material.

Finally, the average dry matter content over the whole experimental period was in the non-treated fish 25.1%, while the fish preserved with FISHFORM had an average dry matter content of 25.8% - this is an increase in dry matter of nearly 2.8% and would lead to a more optimized fish meal production.

The determined results clearly indicate that due to the addition of a potassium diformate blend the quality of the stored fish can be improved and also the amount of possible fish meal production can be increased. This seems to be a very important finding, since the higher quality of the produced fish meal will allow a more economic and sustaining use of the limited resource fish meal.

For more information or to obtain literature references, please contact Dr. Christian Lückstädt
Global aquaculture production has grown rapidly during the past decades, contributing significant quantities to the world’s fish supply for human consumption. As aquaculture expands and develops, an increase in problems and challenges arises. Some of the most relevant problems currently confronting the aqua industry are related to the widespread occurrence of disease, e.g. parasitic infestation, bacterial and viral infections, which can lead to heavy losses to the industry. The aquatic environment is rich in microorganism (up to 105 to 106 per ml), with hosts and microorganisms sharing the same ecosystem. Thus, much more than terrestrial animals, aquatic farmed animals are surrounded by an environment that supports their pathogens independently of the host animals, as such, pathogens can reach high densities around the animal. Surrounding bacteria are continuously ingested either with the feed or when the host is drinking, causing a natural interaction between the microbiota of the ambient environment and the gut environment. If the bacterial challenge exceeds a certain level, the health of the animal is in danger, as the animal alone cannot defend itself sufficiently (Verschuere et al., 2000). Hence, gut health management is one of the most important factors for the prevention of increased mortalities, reduced growth, enhanced FCR or any other effect that reduces the commercial value of the fish/shrimp being produced.

Different strategies have been used to face the bacterial and viral threats, chemotherapy being the most used approach, using large amounts of antibiotics and chemical products. Nonetheless, the development of drug-resistance in bacteria, the accumulation of chemicals in the environment and in shrimp/fish muscle have led to strict regulations that limit the use of antibiotics and other chemicals in aquaculture operations. Closely connected with the state of gut health is a well balanced intestinal microflora, which helps the digestive and absorptive process and protects the host against invading pathogens. Floral health is a new concept, which underlines the importance of the microbiota to the intestinal health and performance.

Several studies have shown that different feed ingredients and changes in diet composition can affect gut structure and intestinal microbiota balance (Ringø and Olsen, 1999). Replacing marine ingredients with plant-based ingredients exposes fish to a series of “foreign” components, for example, starch and anti-nutritional factors that may upset natural processes occurring in the intestine.
Nowadays, we have learned about more sustainable ways to manage fish health and performance using functional feed ingredients that modulate the health of farmed animals. The microbiota associated with the fish intestinal system can be affected by products and substances that, directly or indirectly, give an advantage to a particular group of microorganisms, reduce or even inhibit the growth of other bacterial groups. The possibility to modulate the gut microbiota by a choice of natural solutions is real, considering the documented ability of particular ingredients, e.g. plant-derived (phytogenic) compounds to alter the intestinal structure, modulate the innate and adaptive immune response, increase stress resistance and directly affect the growth of potential pathogens, reducing their ability to colonize the digestive tract or affect them in a way to reduce their growth-depressing effects.

Phytogenic compounds represent a relatively young class of feed additives and the knowledge regarding their mode of action and application strategies is increasing rapidly. Phytogenics are plant-derived products which are added to the feed in order to improve palatability of feeds and/or animal performance. These plant active ingredients (e.g. phenolic compounds and flavanoids) can exert multiple effects on the organisms, including improvement of feed efficiency and digestion, reduction of nitrogen excretion and improvement of gut flora and health status (Kroismayr et al., 2009). Many mechanisms have been proposed for the beneficial actions of phytogenics in different species. These range from direct reduction of gut bacteria and stimulation of growth and acid production by beneficial species such as Lactobacillus, to the enhancement of specific elements of both humeral and cell-mediated arms of the immune system (Cardozo et al., 2008).

Phytogenic feed additives are a heterogeneous group of feed additives originating from leaves, roots, tubers or fruits of herbs, spices or other plants. They are either available in a solid, dried or ground form or as extracts or essential oils. A series of trials conducted at the Aquaculture Center of Applied Animal Nutrition, Bangkok, confirmed that essential oils derived from oregano, anise and citrus peel (Biomin P.E.P.) have a positive effect on Pangasius catfish (P. hypothalamus) and red tilapia (Orechromis niloticus × O. Mussambicus.) growth performance, confirming the potential benefit of phytogenic substances in aquaculture nutrition.

Sustainable aquaculture development requires the use of safe and effective solutions to tackle the industry challenges. There is increasing evidence that natural products such as essential oils could have application in aquaculture, including prophylactic and therapeutically agents to control some major bacterial and fungal diseases and also for growth promotion.

For more information please contact Dr. Tobias Steiner
AMINO ACIDS IN LIVESTOCK FEEDS

By Torben Gosvig Madsen and Sheila Heidi Ramos, Evonik Degussa - Health and Nutrition

In any modern livestock operation, the main focus is how to optimize production efficiency. With continuous improvements of genetics, modern livestock breeds have an impressively high growth potential combined with efficient feed utilization when nutrient requirements are fulfilled. Thus, feeding the livestock sufficient nutrient levels is very critical as feed cost comprises 55 to 70% of the total production cost.

As the building blocks needed for protein synthesis amino acids plays a very important role in animal nutrition and here it is important to note that livestock do have requirements for amino acids and not for protein as such. It is also important to remember that protein synthesis is an all or nothing process meaning that all the essential amino acids must be present in the right proportions for protein synthesis to take place. Aqua species, Poultry, Ruminants and Swine all have different requirements for amino acids. In general their requirement for these amino acids is covered by plant or animal components in the feeds. However, to achieve the right proportion of these amino acids in the diet and prevent over supply of the other amino acids, individual amino acids like lysine, methionine, threonine and tryptophan are now commercially available for supplementation.

AMINO ACID SUPPLEMENTATION IMPROVES LIVESTOCK PERFORMANCE

Responses to increased amino acid levels and amino acid supplementation has been repeatedly demonstrated and observed in swine and poultry feeding. In aquaculture, amino acid supplementation has been proven to be beneficial especially when diets are based on plant-proteins. Trials on Atlantic salmon showed that the performance of fish fed various plant protein-based diets compared to that of fish fed a conventional fishmeal based diet indicated that it is possible to reduce the dietary fishmeal without impairing feed intake and growth performance (Espe, et al., 2006). In addition, the trial showed that fat retention was reduced when feeding plant protein based diets whilst the utilization of dietary amino acids for protein accretion was not affected indicating that supplemental amino acids are utilized as well as protein bound amino acids. A recent trial on hybrid catfish showed that with methionine supplementation the dietary protein can be reduced by 3 percentage points without affecting performance (Lemme, et al. 2009). The study also showed that methionine plays a crucial role in catfish metabolism and that a level of 0.6% dietary methionine may not meet the methionine requirement of hybrid catfish. In another methionine trial involving common carp, results showed that responses reported by Schwarz et al. (1988) that supplemental DL-methionine is utilized for growth. The optimal dietary methionine level was estimated at 1.19% which is in good agreement with the NRC (1993) recommendation of 1.20% for juvenile carps.
AMINO ACID SUPPLEMENTATION SUPPORTS SUSTAINABLE LIVESTOCK PRODUCTION

It is a common practice to supplement amino acids in livestock feeds due to balance out the requirements for these amino acids that are present in both animal and plant feed ingredients. In addition, amino acid supplementation allows feed formulation with lower crude protein levels. Through the years, the use of synthetic amino acids has been more acceptable due to more competitive prices and quality issues, as compared to the use of highly variable plant and animal protein sources. In addition, there has been a growing concern on the excess nitrogen that is being released in the environment. In EU it has been reported that one fifth of the agricultural land already shows a considerable surplus of nitrogen. It has been extrapolated that pork production across EU, with adequate amino acid supply of amino acids, could eliminate 300,000MT of nitrogen from the manure each year (Kelfe, 2009). In aquaculture, the amount of crude protein in the feeds is extremely high. For some species it is estimated that up to two kilograms of fish meal is consumed per kilogram of fish that is produced. Thus there has been growing concern on its enormous impact to the environment. Amino acid supplementation can help reducing the consumption of expensive protein rich raw materials like fishmeal. It has been estimated that to substitute 1 kilogram of DL-Methionine and 2 kilograms of Biolys (Lysine Sulfate) would require to 54 kg of fishmeal and 25 kilograms of Soybean meal (Figure 1). Following this concept the increased use of amino acids can help promote a sustainable livestock operation.

![Figure 1. Balancing 1 kg DL-Methionine and 2 kg Biolys would require huge volumes of protein sources](image)

AMINO ACID SUPPLEMENTATION PROMOTES LOWER TOTAL FEED COST

Raw material prices have been very volatile over the past years. Table 1 below illustrates that for layer diets with 0.83% digestible lysine content formulation cost can be lowered with the supplementation of other amino acids other than methionine and lysine such as threonine and tryptophan. The sample calculation illustrates that by supplementing all 4 amino acids feed cost can be reduced by up to 3%. This observation is dependent on the existing raw material prices. Nowadays feed formulators are even looking into the benefits of looking beyond the 4th limiting amino acid. Tests are conducted regarding the supplementation of Valine and Isoleucine.
### Table 1. Layer diet based on 0.83% digestible lysine content (Prices as of May 2009)*

<table>
<thead>
<tr>
<th></th>
<th>Price US$/MT</th>
<th>Met</th>
<th>Met, Lys</th>
<th>Met, Lys, Thr</th>
<th>Met, Lys, Thr, Trp</th>
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<tbody>
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<td>236</td>
<td>29.2</td>
<td>31.1</td>
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<tr>
<td>SBM (46%)</td>
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<td>16.5</td>
<td>15.7</td>
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<td>12.5</td>
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<td>Ricebran</td>
<td>183</td>
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<td>2000</td>
<td>-</td>
<td>0.116</td>
<td>0.116</td>
<td>0.208</td>
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<tr>
<td>DL-Met</td>
<td>5200</td>
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<td>0.155</td>
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<tr>
<td>L-Thr</td>
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<td>-</td>
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<tr>
<td>L-Trp</td>
<td>30000</td>
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<td>-</td>
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<td>0.04</td>
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<td>Premix</td>
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<td>0.39</td>
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</tr>
<tr>
<td>Cost (US$/MT)</td>
<td></td>
<td>322.02</td>
<td>313.57</td>
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<td></td>
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<td>97.4</td>
<td>97.4</td>
<td>97.4</td>
<td>96.9</td>
</tr>
</tbody>
</table>

*Based on the ideal protein ratio of 100, 88, 70, 20, 104, 76 and 88 for Lys, M+C, Thr, Trp, Arg, Ile and valine, respectively.

### CONCLUSION

With the continuous improvement in livestock breeds and intensified production systems the use of supplemented amino acids has been proven to be beneficial in terms of providing the amino acid requirement to exploit the full genetic potential and to meet the production expectations set by breeder companies. In addition amino acid supplementation provides opportunities to formulate diets with low protein levels thereby reducing the nitrogen that is released in the environment as well as reducing the cost of the diets.

For more information or to obtain literature references, please contact Sheila Ramos or visit www.evonik.com
Fish feed extrusion

Upgraded BC160 from Clextral reaches record capacity of 30 tons per hour

The upgraded BC160 represents Clextral’s best performing production tool with up to 30 t/h final fish feed - the highest capacity ever reached for this type of production. These twin-screw extruders help the fish feed processors achieve unrivaled performance while processing high energy, easily digestible fish and shrimp feed.

Since the late 70s, Clextral has played a major pioneering role in the field of aquaculture, with the introduction of its twin-screw cooking-extrusion systems for fish farming applications. Clextral says this technology assures a better physical presentation and a much improved absorption of the feed ingredients. The common goals shared between Clextral, industrial fish feed manufacturers and research institutes (such as the Inra-Ifremer in France, Sintef of Norway or Fraunhofer in Germany for example) led to the massive development of this technology in fish feed extrusion.

Nearly 100 aquafeed twin screw extrusion systems have been installed by Clextral, including a large number for productions above 10 t/h of fish feed pellets. Thanks to its long term experience, to ongoing developments and close partnerships with the users, the company has particularly developed a specific expertise in fish feed production at very high capacities. This specific technical expertise and process skill
has been transferred to the production of very large range of products with pellet diameters over 30 mm as well as to micro fish feed pellets as small as 0.5 mm diameter.

Clextral twin screw extruders of the BC and Evolum ranges can produce sinking and floating fish feed from small capacities to the maximum throughputs, thanks to the possibilities achievable through accurate regulation and control of all the parameters. New recipes can be developed using the specific functions of mixing, cooking, cooling, shaping of the twin screw extruder. The quick die change is a major asset as well as the highest commitment to reduce the energy consumption and decrease downtime (quick cleaning, reduced maintenance, start up and shut down procedures) therefore lowering the carbon footprint. With the back-up of the two research and test centers in France and the USA, Clextral experts help the fish feed processors develop high quality products at the best cost.

In summary, Clextral twin screw extrusion technology brings valuable advantages such as:

- utilization of a very wide range of raw materials
- complete cooking of any source of proteins;
- high feed digestibility and high feed conversion ratio
- consistent pellet structure
- accurate control of pellet density and pellet durability
- hygienic, salmonella-free pellets
- high process productivity and flexibility

In addition to mastery of this twin screw extrusion technology for fish feed, Clextral has also focused these last few years on optimizing the Rotante type rotary dryer previously designed to dry other cereal based products. Through gentle stirring of the product to eliminate build-up, the “Rotante” design achieves excellent heat exchange close to that obtained in a fluidised bed. Other advantages include perfectly controlled residence time with virtually no dispersion, of type FIFO (First In, First Out) and precise product moisture homogeneity at dryer output. Clextral Research & Test Center in France is equipped with a “Rotante” and tests have proven this dryer to be particularly efficient for micro fish feed ensuring complete homogeneity of drying with less energy consumption.

For more information, please contact Aïda Rochas
Significant price increases have occurred during the past years for major aquafeed ingredients, including fishmeal, fish oil, vegetable proteins and fats. In the livestock industry the combined efforts of industry and academic institutes resulted in the development of a wide range of additives to improve nutrient utilization helping to reduce feed formulation costs and increase cost-efficiency. Various types of feed additives have been developed which enhance the digestibility and/or utilization efficiency of nutrients, including exogenous enzymes, compounds aiding in the digestive process, stimulators of enzyme secretion, feeding stimulants, pre/probiotics, and botanical extracts modulating the gut microflora. In the 2009 summer issue of *Aquafeed - Advances in Processing & Formulation*, we illustrated the potential of some of these innovative additives for use in aquaculture. The development of aquaculture additives is a relatively new but promising field. In this article we report on our recent progress with the development and application of species-specific digestive aids to increase growth, feed utilization and meat yield in various fish species.

**SCREENING FOR OPTIMAL PERFORMANCE & COST-EFFICIENCY**

A wide variety of concepts and products is being investigated for improving digestion and feed utilization in pigs and poultry. However, it is difficult to predict the functionality of many of these products for a wide range of fish species, covering carnivorous/omnivorous/herbivorous feeding habits, marine/freshwater habitats, cold/tropical climates, and extremely different feed formulations.

At the NUTRIAD Technology Center, a continuous program of empiric screening for different aquaculture species aims at identifying promising compounds for application in aquaculture. Preselected synergistic blends of digestibility enhancing additives are being screened for their capability to improve growth and food conversion in a number of model species (rainbow trout *Oncorhynchus mykiss*; European seabass *Dicentrarchus labrax*; Nile tilapia *Oreochromus niloticus*; Tra catfish *Pangasius hypophthalmus*).
Test feeds are formulated to be representative for average industry standards per species and processed using industrial extrusion technology. Trials executed under controlled lab conditions at Caditec Testing, Spain, and at the Department of Marine Affairs and Fisheries, Sukabumi, Indonesia, have revealed enormous differences in efficacy among different additive concepts designed to improve digestion (Fig. 1).

Fig. 1: Screening of synergistic blends of digestibility enhancers at lab scale comparing product efficacy and cost-efficiency for each fish species.

Data show results for growth (SGR, %/day) and food conversion (FCR) relative to the performance of the non-supplemented control group. Feeding trials were run in triplicate tanks for rainbow trout (trial duration 64 days; starting from 19g); Nile tilapia (56 days; starting from 9g); Pangasius catfish (70 days starting from 16g); and European seabass (84 days; starting from 224g);
Some digestibility enhancers seem to be incompatible with the digestive physiology of certain fish species and affected fish performance negatively. The addition of selected blends of digestive aids improved growth/FCR in trout (up to +6/-8% change versus non-supplemented control group), tilapia (+5/-9%), pangasius catfish (+6/-15%), and seabass (+5/-5%). These results show the potential of digestibility enhancers to improve feed efficiency in fish farming, resulting in improved economics, more sustainable use of feed ingredients and reduced environmental impact.

**DOSE-RESPONSE TRIAL WITH TILAPIA**

Dose-response trials under lab conditions provide useful data to explore the most cost-efficient dosage to be recommended for field verification. The supplementation of 1.5 kg per MT of feed of a digestive aid (AQUAGEST® OMF) yielded significantly better FCR (-5%), growth (+4%) and protein efficiency ratio (+4%; Table 1). When increasing the supplementation from 1.5 kg to 3 kg per MT of feed, all these factors were further improved. The hepatosomatic index was reduced by increasing the level of the feed additive, amounting to a reduction of 11% for the 3 kg/MT supplemented diet. The viscerasomatic index was reduced by 8% in the 1.5 kg/MT supplemented diet. The decreased viscerasomatic and hepatosomatic indexes and increased protein efficiency ratio indicate that more dietary energy/protein is made available for growth. This allows the farmer to improve feed conversion, fillet yield and reducing visceral wastes.

**OPTIMIZING THE APPLICATION REGIME TO IMPROVE FEED UTILIZATION AND FILLET YIELD IN PANGASIUS CATFISH FARMING**

Pangasius catfish production has grown very rapidly in Vietnam to reach more than a million tonnes in recent years. This rapid growth has resulted in the industrialization of feed production as well as in culture technology. Whereas traditional catfish farmers produce farm-made feeds by mixing and cooking local raw materials in large kettle cookers, larger integrators have installed state-of-the-art extrusion lines producing compound feed following stringent quality control schemes. Due to declining market prices for Pangasius, farmers and feed producers are continuously searching for ways to improve feed performance and optimize fillet yield to maintain profitability.
The optimal application of novel feed additives requires field evaluations to provide information in terms of farm economics and processing qualities of the fish. The effect of different application regimes for a digestibility enhancer was evaluated for Pangasius hypophthalmus ("Tra") in two farm locations of Hung Vuong Mien Tay breeding joint stock company in the Mekong Delta (Van Halteren et al., 2009). The various treatments differed in the inclusion level of the digestibility enhancer (AQUAGEST® OMF, Nutriad, Belgium) in the extruded feed and the period during which it was applied during the production cycle (Table 2). Trials were carried out under standard production protocols in earthen ponds of approximately 5-6,000 m² (Trial site Tra Vinh) and 8,500-12,000 m² (trial site Sa Dec). The ponds were stocked with juveniles with an average size of 15g at a density of 45-50fish/m² in Tra Vinh, and 30g fish were stocked at 34-38 fish/m² in Sa Dec.

<table>
<thead>
<tr>
<th>Fish size (g)</th>
<th>Feed specifications (% crude protein)</th>
<th>TREATMENTS</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CONTROL</td>
</tr>
<tr>
<td>20 - 100</td>
<td>28</td>
<td>-</td>
</tr>
<tr>
<td>100 - 200</td>
<td>28</td>
<td>-</td>
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<tr>
<td>200 - 500</td>
<td>26</td>
<td>-</td>
</tr>
<tr>
<td>&gt; 500</td>
<td>22</td>
<td>-</td>
</tr>
</tbody>
</table>

GAIN FOR THE FARMER: GROWTH, FEED CONVERSION AND PRODUCTION COST

Overall, the results obtained for FCR and individual daily growth rate were excellent compared to the industry average in Vietnam (FCR: 1.6-1.8; growth: 4-5 g/day). The results from both trial locations showed improved growth and food conversion, and a shortening of the production cycle with the application of the feed additive. The improvement on growth performance was modest for the lowest dosage applied only during the initial period (treatment Aquagest 1). However, very significant improvements were obtained for the second treatment (Aquagest 2) compared to the control, including improvements of FCR by 3.3-3.2%, daily weight gain by 10.6-14.8% and a reduction of the culture duration by 5.2-16.4 %. All farm results showed better economics due to the application of the digestibility enhancer. This was due to a combination of the improved feed cost per kg of fish produced (0.2-0.7 % for the lowest application regime and 1.4-2.4 % for the highest application regime) and the significant shortening of the production cycle.
GAIN FOR THE FISH PROCESSOR: FILLET YIELD AND COST PER KG OF FILLET

The fillet ratio is an important criterion for the processor in the Pangasius industry as the main market is sales of fillet. The fillet ratio was determined in the fish processing plant of Hung Vuong Joint stock company after harvesting the ponds.

Pangasius fillets are obtained in three stages, first the total fillet is cut from the fish, secondly the skin is removed from the fillet, and finally the fillet is adjusted to the market demands (less or more fat left depending on the destination country. The first stage “whole fillet” ratio is averages 1.9-2.2 in Vietnam and is reported for the trials in Table 4. Overall, the whole fillet yields obtained in the current trials were excellent in comparison to the industrial average in Vietnam (1.9-2.2). Nevertheless, whole fillet yield improved drastically in all trials because of the addition of the digestibility enhancer, i.e. 2.4 to 4.6 % for the lowest application and 7.5-9.25 % for the highest dosage evaluated (Table 4).

Table 4. Effect of two different application regimes of a digestive aid on fillet ratio (kg whole fish needed for 1 kg of whole fish fillet) of Pangasius catfish in two trial locations in Vietnam (percentage shows difference compared to non-supplemented control) (van Halteren et al., 2009).

<table>
<thead>
<tr>
<th>Treatments (see Table 2)</th>
<th>TRIAL SITE 1: Tra Vinh</th>
<th>TRIAL SITE 2: Sa Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>2.14</td>
<td>2.16</td>
</tr>
<tr>
<td>Aquagest 1</td>
<td>2.09 (-2.4 %)</td>
<td>2.06 (-4.6 %)</td>
</tr>
<tr>
<td>Aquagest 2</td>
<td>1.98 (-7.5 %)</td>
<td>2.00 (-9.25 %)</td>
</tr>
</tbody>
</table>
CONCLUSION

Digestibility enhancing additives have the potential to improve nutrient utilization from cheap ingredients and stimulate the conversion of nutrients into meat gain and less into fat accumulation in muscle and viscera. The current results showed the need for specific product development searching for digestive aids which are compatible with the digestive physiology of each fish species.

The optimized application in the field was illustrated for Pangasius in Vietnam where economic gains were observed both for the farmer (up to 2.4% reduction of feed cost per kg of whole fish produced and 16.4% shortening of the production cycle) as well as for the fish processor (up to 9.25% improvement in fillet yield).

Screening trials for different aquaculture species aims at identifying promising compounds for improving feed utilization and fish performance.

For more information and literature please contact Dr. Peter Coutteau
Asia Pacific’s biggest feed and grain industry event is all set to be even bigger and better than ever before. Taking place March 3 to 5, 2010 at the Queen Sirikit National Convention Centre, Bangkok, Thailand, the biennial event has more scope, more floor space, more exhibitors and more conferences than in previous years.

Victam Asia is growing at such a pace that the organizers have split the trade show into three exhibitions: Victam Asia is the showcase for the world’s foremost suppliers of equipment and technology used in the processing and production of animal feeds, dry petfood and aquafeeds; FIAAP Asia was introduced in 2008 for specialist ingredients, additives and formulation technology and this year, GRAPAS Asia is a new exhibition and conference for grain and flour milling and industrial grain-based food production technology. Also on show will be ancillary equipment used within these processes – bins, silos, weighing & batching, conveyor systems, elevators and buckets, bags & bagging systems, quality control, transportation systems, control and monitoring systems, computer technology and more.

The vast majority of all aquacultured products originate in Asia and the industry is as varied a it is huge: from sophisticated and highly intensive to polyculture and backyard basic; warm-water, cold water, salt and fresh water, carnivorous and herbivorous species—finfish, crustaceans and shellfish—Asia has it all. For Aquafeed producers, ingredients and technology suppliers, it is without doubt the market to be in. No wonder so many exhibitors at Victam Asia focus on the Aquafeed sector. In this issue we showcase a few that have caught our eye. A full list of technology and ingredient exhibitors appears later in this feature.

TRADE SHOW

Safe feed for safe food

Buhler, the global partner for the feed production industry, is expert in all process operations required for transforming raw materials into valuable feeds. At Victam Asia 2010, Buhler is presenting solutions for safe and cost-effective production of high-quality aquafeed.
Pellet Mill and High Speed Mixer set new standards
The Buhler AHHD hygienizing and pelleting system delivers a new standard in the field of feed milling. The pellet mill produces high quality, safe aquafeed pellets. The modular design can be adapted to your specific needs. The revised geometry of the mixer trough and the matching geometry of the flights reduce the mixing time to 1.5 minutes.

Hammer Mill for efficient size reduction
The hammer mill is applied when efficient size reduction is required. The inlet gate feeds the material into the path of the hammers, a series of bars attached to a horizontal shaft that rotates at high speed. The innovative AHZC Hammer Mill saves energy and enables a constant product throughput. The AHZC Hammer Mill operates as a fine grinding mill for a particle size with an edge length of up to 10 mm edge.

COMPACtwin Extruder - powerful, fast, and flexible
High torques, screw speeds and pressures are essential in any state-of-the-art twin-screw extruder for covering a wide range of specific applications. By applying a high degree of modularity, Buhler is in a position to provide the optimum extruder configuration. Easy cleaning requirements and accessibility of all critical zones ensure top sanitation for high quality products.

Efficient, sanitary and uniform drying and cooling
Multi-pass conveyor driers provide efficient, sanitary drying of aquafeed products. The multi-pass driers’ small footprint maximizes the processor’s floor space. The dual plenum airflow distribution and temperature profiling are unmatched when it comes to moisture uniformity in the industry.

Automatic screen exchange

Van Aarsen has developed an automatic screen exchange system for three different screen types. The system is already operational in two feed mills and demand is constantly increasing. The system consists of a cassette unit with three slots to hold the screens, a motorised insertion system and control system.

The control system is with a Siemens S7-300 PLC incl. Multi-panel 277-10” touch-screen. During operation the control system is obsequious to the feed mill control system and automatically selects the screen required for the recipe in question. Communication between the control systems takes place via a Profibus connection. When inspecting or replacing the screens the required actions are indicated step by step on the touch-screen. The PLC can also be used for load control of the hammer mill. The screens are stored
in a cassette system that is suspended above the hammer mill. This construction enables: the surface area required for the hammer mill to remain the same; Easy access, ergonomic working conditions; Use of simple straight screen plates; No extra tools; Sieve exchange during operation; CE protected cassettes; Cassettes to be moved aside when opening the hammer mill doors.

The screen is suspended in a cassette slot by means of a lever with pneumatic cylinder. During insertion the lever pushes the screen down into the mechanism. The insertion mechanism consists of two sets of motor driven wheels that place the screen into the hammer mill. Once in place, a pneumatically operated clamp locks the screen into place and seals the hammer mill. Though this system minimizes dust release from the hammer mill during screen exchange, it can still handle severely damaged sieves.

With this newly developed system a wide range of feed structures can be produced and in combination with frequency control the advantages are numerous: Flexible production; Few production stops; Excellent feed structure for individual recipes.

**Beyond mixing**

Forberg International has for more than 35 years been a considerable supplier to the global feed industry with the Forberg mixing and vacuum coating equipment. Mixing and processing will always be one of the core processes in feed manufacturing. By using Forberg technologies other processes, beyond mixing, can be performed.

Several global companies within the aquafeed industries have invested in vacuum coating technology from Forberg International during the last decade. The Forberg RVC revolutionized this industry. The coated product can absorb up to 40% liquid, such as oil, flavors and other additives and still have an end product with a dry surface. Due to very precise and accurate mixing, even minor ingredients will be evenly spread, and the producer saves considerable costs on expensive additives. All risks of leakages are avoided with Forberg RVC due to one in/outlet.

Besides being a high tech mixer that gives customer a high-end product, the Forberg RVC has close to zero downtime and minimal maintenance.

Globalisation has led to increased awareness of both safety and environmental issues. To secure the production process and always achieve clean and safe feed, there is a correlation between the technology used and the feed result. Due to the fear of bacteria spreading, feed and food safety are focus areas at Forberg International. Forberg technology ensures that what is produced is according to GMP standards. The Quality Management System complies with ISO 9001-2008 standard.
Forberg International focuses on further development of industrial processes in close cooperation with the customers and research institutes.

**Asian made products for Asia**

Andritz Sprout was in April 2009 renamed **Andritz Feed & Biofuel**. The new name now clearly reflecting the target business areas of the division. Andritz F&B continues to grow in the Asian market, and has during the first half of 2009 expanded its manufacturing facilities in PR China. The Andritz Feed & Biofuel engineering and workshops in PR China are part of the Andritz Technology China Industrial parks, in Foshan and Sanhsui, Guangdong Province.

The 2009 expansion has more than doubled the A F&B workshop area with modern manufacturing and assembly facilities. The products from the new plant comprise a range of A F&B pelletmills, extruders, dryers and coolers including the automation systems, as well as pelletmill dies. From its central location, the new plant allows for shorter deliveries to customers in the domestic markets of PR China as well as in the rest of the Asian region.

In parallel to growing manufacturing and engineering capacity, the A F&B sales force in PR China has likewise been increased. The Andritz Feed & Biofuel Vietnam Branch office opened 2008 in Ho Chi Minh City has likewise contributed to further successful growth, especially in the extruded aquafeed segment, where the AFB technology has proven its competitive performance in multiple new plants.

Andritz Feed & Biofuel will exhibit a selection of products from the new plant at VICTAM Asia 2010.
Other exhibitors of interest to Aquafeed manufacturers include Geelen Counterflow. At Victam Asia 2010, the company will exhibit a double deck dryer VD19x19KM-KA MKII for extruded products such as fishfeed and petfood. It saves 20-50% on energy cost compared to horizontal dryers, with superior moisture control, food safety standards and much lower maintenance costs.

Additives and ingredients

FIAAP will bring together feed ingredient and additive companies such as Kemin Industries Inc., represented by Kemin Industries Asia (Singapore). This company is focused on improving the health and nutrition of animals through ensuring the nutritional integrity of feeds. Its TOTAL NUTRITION program is composed of an optimal number of nutrients and nutricines. This program enables animal feed to become functional in its nature and impart both nutritional and health benefits on the animals consuming it, which in turn yields quality production and safe food.

Feed preservation through mold inhibition and oxidation control are fundamental areas of nutrition. Through antimicrobial and mycotoxin control strategies, Kemin ensures the improved health status of the animals. To achieve optimum performance, the Total Nutrition program weighs all factors impacting livestock health and growth. The diverse range of Production Efficiency products provide both supplement and remedy to enable optimum intestinal health and absorption of nutrients. Bio-surfactant products further improve lipid nutrition and nutrient absorption for optimised health status. Managing feeding programs to reduce animal stress, improve nutrient absorption, maintain the integrity of the animal’s gut and enhance the immune system to ward off constant challenges from viruses and bacteria can further enhance animal health.
EXHIBITORS

Information correct at time of press
The 4th Aquafeed Horizons Conference will provide aquafeed producers and the allied industries in the Asia Pacific region with information to help them adapt, improve and innovate in order to stay ahead. It will be held in association with Victam Asia, at the Queen Sirikit National Convention Centre. The conference will deliver an expert level of technical information to meet the needs of the commercial aquafeed industry, particularly in Asia and the Pacific region.

Early registration is strongly advised; walk-ins will only be accepted on a space available basis.

**PROGRAM**

**Chairmen:** Dr. Geoff Allan, Research Leader, Aquaculture, Director, Port Stephens Fisheries Centre, Australia and Dr. Warren G. Dominy, Director Feed & Nutrition, Oceanic Institute, Hawai‘i.

**AQUAFEED AND AQUACULTURE IN THAILAND**

*Dr. Juadee Pongmaneerat, Senior Expert in Fishery Product and Inspection, Thai Department of Fisheries, Bangkok, Thailand*

Thailand is a leading country in aquaculture and aquatic feed development. It boasts 64 feedmills and premix plants for aquafeed, of which 10 are GMP standard and six HACCP certified. The Department of Fisheries (DoF) has developed policies for food safety standards and promotes the CoC and GAP for aquaculture farms, and GMP and HACCP standards for feed manufacturing, over and above basic feed safety and quality control regulations. In 2009 some 1.25 million tonnes of aquafeeds were consumed: 672,000 tonnes shrimp feed and 581,800 tonnes fish feed. The status of economic aquatic species such as marine shrimp, giant freshwater prawn and tilapia will be presented. The DoF regulatory framework for quality control, the inspection and certification system for feed manufacturing and fishery products processing plants will also be discussed.

**REASSURING THE VALUE-CHAIN AS TO THE SUSTAINABILITY AND PURITY OF FISH-MEAL AND FISH OIL**

*Dr. Andrew Jackson, Technical Director, International Fishmeal and Fish Oil Organisation (IFFO), U.K.*

Two of the most important issues facing the fishmeal and fish oil industry in recent years has been the question of the sustainability of the fisheries providing the raw material and the purity of the products arriving at the feedmills. The industry is
therefore looking at ways of reassuring the value-chain on these two critical issues. The best way to do this is using third-party audited schemes and the alternative schemes both developed and in the process of development will be discussed. One scheme that is being initiated to address both these issues is the new IFFO Global Responsible Supply Standard. The development of this scheme will be discussed and how it assesses both fisheries and factories to provide the reassurance required.

**RENDERED PRODUCTS IN AQUAFEEDS**  
*Dr. Geoff Allan, Research Leader, Aquaculture, Director, Port Stephens Fisheries Centre, Australia*

Rendered animal protein sources, such as poultry offal meal, meat and bone meal and blood meal products are excellent protein sources with no carbohydrates and few antinutrients. Approximately 12.5 million tones of rendered animal meals are available globally, roughly twice as much as available fishmeal. Data for digestibility and utilization of rendered animal products fed to a variety of carnivorous and omnivorous aquaculture species will be presented. Data for trout, red sea bream, tilapia and mud crabs from numerous research studies will be summarized and the potential for use of rendered products discussed. The data demonstrate that rendered animal meals can be excellent protein sources for aquaculture species, including carnivorous marine finfish. Substantial replacement of fishmeal is possible, particularly with blends of alternative protein sources based on rendered animal meals.

**HARVESTING THE BENEFITS OF GRAIN APPLICATION IN AQUAFEEDS**  
*David Smith, CSIRO Marine and Atmospheric Research, Australia*

The evaluation of grain protein meals is crucial to their effective application in diets for aquaculture species. Several important knowledge components should be understood to enable the wise use of any particular ingredient in a feed formulation. The four primary knowledge components are: (1) Ingredient characterization, (2) Ingredient digestibilities, (3) Ingredient palatability, and (4) Nutrient utilization and/or interference of utilization. In addition, further details on ingredient functionality, gene and/or protein expression, the influence on immune status and organoleptic qualities are also important considerations. Using this approach a range of feed grain resources have been evaluated in the diets of a range of aquaculture species. While there is no single ideal alternative many of the different feed grain resources offer sound potential when used in the right application. Indeed the judicious use of certain feed grain resources can confer significant nutritional and technical advantages to the feed design and management process.

**STABILIZING FORMULATION COST AND PERFORMANCE OF AQUAFEEDS NEEDS INNOVATIVE APPROACHES**  
*Dr. Peter Coutteau, Business Development Manager Aquaculture, INVE Nutri-Ad, Belgium*

In the livestock industry, a wide variety of feed additives are currently being investigated to improve cost-efficiency of animal nutrition. Organic acids, enzymes,
probiotics, prebiotics, highly available minerals, essential oils and natural plant extracts are some alternatives to antibiotics without causing bacterial resistance that would have at least similar effects on growth and food conversion. This active search for natural growth promoters is starting to extend into fish farming as consumer pressure is likely to ban antibiotics from production in most countries. Although the screening of these compounds for aquaculture has just started, promising results have been obtained with different species. The presentation illustrates the development of a number of innovative feed additives to optimize the utilization efficiency of nutrients from traditional ingredients for aquaculture species.

**TRENDS IN AQUAFEED IN SOUTH EAST ASIA AND CHINA: RELEVANCE AND TECHNICAL SOLUTIONS**  
*Urs Wuest, Head engineering & Fulfillment, Buhler, Switzerland*

Changes throughout the entire aquafeed value chain will impact feed millers in the near future and beyond. Urs Wuest will present the current trends in the aquafeed industry. This will include the changes in raw materials, feed manufacturing, aquaculture, processing of the fish and crustaceans and the demand from customers in total and by fish species. He will explain how changing requirements in the aquafeed industry translate into a demand for specific technical requirements, such as extrusion technology.

**INCREASING THE INGREDIENT POSSIBILITIES FOR FLOATING FEEDS**  
*Will Henry, Director of Technology and Research & Development, Extru-Tech, USA*

The environment in which aquatic feeds being produced in Asia today has changed dramatically from even a few years ago. Now, more than ever, the efficiency of production is critiqued at the same levels as quality and quantity of production. This presentation will focus on the greatest input cost to most aquatic feed production process, and that is raw materials. When reviewing the total cost of production for a specific type of feed, the raw material cost is typically in the range of 80 to 90%. Needless to say, a 10% savings on the raw materials will have a greater impact on production cost efficiency than most likely anywhere else in the process. This strategy of increasing the process’ ingredient flexibility will be addressed from two primary angles. Changes and enhancements in the core pieces of equipment in a typical extrusion process will first be discussed. And secondly, a review of proper/recommended process management directives will be presented.

**IMPROVING PLANT EFFICIENCIES**  
*Galen Rokey, Process Manager, Applications Group, Wenger Manufacturing, USA*

In today’s economic climate, the aquaculture industry is affected by many trends that are affecting plant efficiencies. Industry surveys indicate that energy usage and product safety are the major challenges facing the industry. Sustainability and environmental issues also are impacting aquaculture. Several specific areas will be reviewed that favorably affect plant efficiency and can easily be implemented. Trends in aquaculture that impact plant efficiency: Raw material costs; Market conditions; Energy and water conservation; Supply chain costs reduction; Automation; Labor costs; Food safety; Flexibility; Emissions control; Lean manufacturing. Specific areas to improve plant efficiency: Adjust process to use least cost
energy source; Tighten product moisture variation off dryer; Recycle under-processed material; Extended service programs and line audits; On-line monitoring and control.

EXTRUSION OF MICRO AQUATIC AND SHRIMP FEEDS
Joe Kearns, Aquaculture Process Technology Manager, Wenger Manufacturing, USA

Production methods will be reviewed for manufacturing of microfeeds - or what is commonly referred to as starter feeds. Extrusions cooking in various formats will be discussed with the technology involved for production of these feeds but also the ability to produce at increased production rate. Typical increase levels are in the three to five times range while allowing all the formulation advantages seen in extrusion of shrimp feeds. Topics covered will include: definitions of micro feeds; requirement of fine grinding; review Spherizer Agglomeration System (SAS); direct extrusion review for small diameter feeds; dryer requirements for micro feeds; review of new technologies for high capacity shrimp feed production.

Full details and online registration: www.feedconferences.com

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We could talk all day about our aquatic feed systems.

But we’d rather talk about yours.

Wenger offers you more extruder, dryer, and control choices, and more ways to put together the perfect aquatic feed production system, than anyone in the industry. We’ll custom design your system with a wide range of features and options uniquely configured and expertly engineered to produce optimally for your specific application. We bring unmatched technical expertise to your process requirements, making a Wenger aquatic feed system your Wenger aquatic feed system.

Talk to Wenger today, and surround yourself with unrivaled resources for exceeding your processing goals.
THE FIAAP CONFERENCE

“INGREDIENTS FOR SUCCESS”

March 4, 2010, QSNCC, Bangkok, Thailand

The highly successful FIAAP Conference returns to Bangkok with a focus on ingredients and additives for animal feed production in the Asia Pacific region. It will be held in association with FIAAP 2010, the exhibition for this specialist sector at Victam Asia. The FIAAP Conference will deliver an expert level of technical information to meet the needs of the commercial feed industry, particularly in Asia and the Pacific region. Early registration is strongly advised; walk-ins will only be accepted on a space available basis.

PROGRAM

Chairmen: Dr. Geoff Allan, Research Leader, Aquaculture, Director, Port Stephens Fisheries Centre, Australia and Dr. Warren G. Dominy, Director Feed & Nutrition, Oceanic Institute, Hawai‘i.

THE GLOBAL SUPPLY AND DEMAND FOR FISHMEAL AND FISH OIL

Dr. Andrew Jackson, Technical Director, International Fishmeal and Fish Oil Organisation, U.K.

The presentation will examine the historical production of fishmeal and fish oil by country and discuss the main factors that have affected it right up to present production levels. It will also identify the prospects for future production in the short to medium term. The demand side of the balance will then be analysed, again looking at the historical changes that have occurred between the different market sectors. The key drivers will be identified including price and elasticity of demand for the different sectors for both fishmeal and fish oil. The likely future demand will then be analysed by sector and the future availability of products for the market discussed.

OPTIMIZING USES OF RENDERED PRODUCTS

Dr. Geoff Allen* and Mark A. Booth, NSW Department of Primary Industries, Australia

The cost of ingredients for animal feeds is increasing as global demand for grain outpaces increases in supply. Supplying protein for animal feeds, particularly aquaculture species and those terrestrial animals requiring high quality protein, is a major and increasing cost. Rendered animal products can provide bio-available and cost-effective sources of essential amino acids, minerals and energy. In this presentation, the composition of different rendered animal products will be described and compared with other ingredients. Use of rendered products can be optimized by improving consistency, reducing impurities and ash contents.
BACTERIAL CONTROL IN FEED PRODUCTION AND PROCESSING - WHAT ARE THE OPTIONS AND BENEFITS

Dr. Adam Smith, Dep. Technical Director, Europe, Middle East & Asia Pacific, Anitox, U.K.

Bacterial contamination of animal feed can be a source of infection for food producing animals. Given its importance as a human pathogen, Salmonella is perceived to be the major hazard for animal feed, however, the presence of other bacteria such as E.coli and Clostridium Spp are also of significant importance. This paper will look at the level, type and frequency of bacterial contamination in commonly used feed materials. The adverse effects on livestock consuming such feed will also be considered, along with the benefits achievable through improved bacterial control. As a reduction of bacterial contamination in the feed and prevention of re-contamination typically requires the use of chemical and physical control measures, the options available to help achieve this will be reviewed. The relative advantages and disadvantages of the various methods will be evaluated, both from technological and economic perspectives.

TRACE MINERALS - QUALITY CHALLENGES AND PROTECTING OUR BUSINESS

Tara Jarman, Asia Pacific Quality Assurance Manager, Alltech, USA

For consumers, safety is the most important ingredient. There have been quite a large number of safety scares in recent years with trace mineral sources. Contamination of trace minerals is a global problem, but the sources of contamination are often common and traced back to Asia - mainly China. Risks factors include Dioxins, PCBs and Heavy Metals. It is a company’s responsibility to ensure that their products are safe for use, and tailoring a quality control program to evaluate such risks goes a long way to address this challenge.

SODIUM BENZOATE - A PROMISING ACIDIFIER FOR PIGS

Dr. Li Li, Technical Manager, Kemira Asia Pacific, Singapore

Growing concerns about environmental pollution has forced pig researchers to find reliable and environmentally friendly alternatives. A few short-straight-chained organic acids, such as formic, acetic, propionic, lactic, butyric and citric acid and their salts, have been widely used in the pig industry. Inspired by the outstanding performance of short-straight-chain organic acids in livestock production, animal scientists have been continuously researching the rest of the organic acid family in order to find the next novel generation of animal health and growth promoters. Recently there is a developing interest in sodium benzoate (NaC6H5CO2), the salt form of benzoic acid (C6H5COOH), which is classified as the aromatic carboxylic acid. This paper will focus on the characteristics of sodium benzoate, its potency as an antimicrobial agent and growth promoter in pig nutrition.

RAPID ANALYSIS PREDICTION OF AVAILABLE ENERGY IN FEED GRAINS

John Spragg, AusScan Program Manager, Australian Co-operative Research Centre, Australia

Research work has been completed obtaining data on the available energy content of a range of feed grains fed to different livestock species. Through the use of near infra-
red (NIR) technology, a number of NIR calibrations have been developed and are now being used in Australia to determine available energy content of grains. The technology provides a low cost and rapid analysis method, allowing feed manufacturers to fine tune feed formulations. The technology also enables the marketing of feed grains based upon their energy content. The paper will detail the livestock feeding research that has been completed and the commercial application of the technology for the feed industry. Data will be presented on the variation that naturally occurs in feed grains and how different grains are better suited for each livestock species. The link between grain physical and chemical characteristics and its available energy content will be discussed. The technology has use within the Asia Pacific Region in assessing feed grains utilized in animal feeding applications.

OPTIMIZATION IN THE ROUND - THE BIGGER PICTURE: TAKING ACCOUNT OF NON-NUTRITIONAL PARAMETERS SUCH AS PLANT AND ENERGY CONSTRAINTS WITHIN THE FORMULATION PROCESS

Ian Mealey, Head of Operations, Format International Ltd., U.K.

Whilst achieving the least cost recipes within nutritional specifications is the main purpose of feed formulation software, the decisions made by formulators in these recipes can have unforeseen consequences when it comes to their production; consequences which can have a significant impact on the rest of the process and the true cost of the finished product. These aspects can be hidden from, or even ignored by formulators, but, if taken into account, may have alter ingredient purchasing decisions, plant design, production costs and, ultimately, profitability. This presentation looks at some techniques which can be used in formulation software to incorporate these wider considerations, giving the formulation role a broader perspective and resulting in a better model of the feed manufacturing process.

RAW MATERIAL EVALUATION AND HOW TO EXTRACT THE FULL VALUE FROM IT

Ms. Sheila Heidi M. Ramos, Technical Sales Manager, ASEAN, Evonik Degussa SEA Pte Ltd, Singapore

In any modern livestock operation, the main focus is to optimize cost per unit of product. There have been continuous efforts in improving livestock performance through improvements in breeding/genetics, housing, management, health status and nutrition, among others. Out of these components feed costs often contribute more than 60% of the total production cost. The task for nutritionists is therefore to come up with good quality feeds at the lowest possible cost. In order to achieve such a very challenging task measures need to be taken in order to get the most out of the raw materials that is being purchased. This presentation will focus on how a thorough evaluation of the very variable protein sources meat and bone meal, rice bran and DDGS can affect and improve the value of these raw materials. The evaluation will include the different areas in feed production from raw material purchasing, raw material storage up until feed formulation.
THE GRAPAS CONFERENCE

“QUALITY MATTERS”

March 5, 2010, QSNCC, Bangkok, Thailand

“Quality Matters” is the theme of the first GRAPAS Conference to be held in association with Victam’s newest specialized trade show for the grain industries, GRAPAS Asia 2010. The GRAPAS Conference will reflect the grain quality-related interests of visitors to the Victam Asia trade show, with an emphasis on grain preservation and sanitation, which are crucial issues for both the animal feed and grain-based food industries in the region. Early registration is strongly advised; walk-ins will only be accepted on a space available basis.

PROGRAM

Chairpersons: Peer Hansen and Solvejg Kristensen, Crop-Protector KS, Sweden

GRAIN: QUALITY AND CONDITION, RISKS AND RESPONSIBILITIES
Pamela Kirby Johnson OBE, Director General, The Grain & Feed Trade Association, U.K.

Countries that are successfully integrating into the global trading system face transitional challenges of adaptation and one of the features are logistics; bringing the goods to the export point in a satisfactory quality and good condition for shipping. Trading risks include the goods and shipment as well as documentation. For dry bulk cargoes there may be issues at the load port over the precise quality and quantity of cargo loaded, or over its condition. There may be differences between sampling, analyses tests and measurements from shore scales and a master's draft survey. The need for goods to comply with their contractual quality provisions is highly important.

THE IMPACT OF MYCOTOXINS IN FEED AND THUS ON ANIMAL HEALTH
Dr Hsin-Yi Chen, Technical Product Manager Mycosorb, Alltech, USA

From the mycotoxin survey that Alltech conducted between 2006 and 2009 on ingredients and complete feed sampled in Asian countries, it was found that the prevalence of contamination of mycotoxins is very common, and their levels can be very high. Contamination of several mycotoxins at low levels is also very common in feed ingredients. Animals are exposed to mycotoxins day after day. The long exposure time, synergistic effects from several mycotoxins, and stress from the environment and pathogens may further suppress the immunity of animals, enhance the susceptibility of animals to diseases, and reduce vaccine and drug efficacy. Strategies to protect animals from mycotoxins is essential.
FEED QUALITY AND ANIMAL HEALTH: A REVIEW FROM MYCOTOXIN SURVEY PROGRAM  
Di Ursula Hofsetter, Director of Strategic Business Unit, Biomin, Austria

Since 2005, Biomin has collected raw materials and feed to conduct tests and analyses for the most important mycotoxins in agriculture and animal production; analysis and data were compiled into geographic regions. From 2005 to 2008 the tendency has been towards higher percentage of positive samples in the case of AFB1, ZON, DON and FUM. Only a quarter of the samples showed the presence of a single mycotoxin. The program aims at getting an accurate understanding of the extent of mycotoxin contamination in commonly used feed ingredients. From this feed manufacturers will be able to fine-tune their mycotoxin management strategies.

PROTECTING CONSUMERS FROM MYCOTOXINS AND PARAMETERS TO ASSESS MYCOTOXIN BINDER PERFORMANCE  
Dr. Koh Thong Jin, Kemin Agrifoods Asia, Singapore

The beneficial effect of a mycotoxin binder on performance and health parameters in broilers when fed a diet contaminated with a mixture of mycotoxins (Aflatoxins, Ochratoxin A, T-2 toxin and Citrinin). The current study also addresses all the primary mechanisms affected during mycotoxicosis by studying animal performance, immunology, organ morphology and mycotoxin excretion. Study shows that the inclusion of binder in a broiler diet contaminated with a mixture of four harmful mycotoxins resulted in a complete recovery of zootechnical performance, organ status and immune status. It significantly immobilises mycotoxins in the gut, preventing the absorption in the animal and maintaining the health status of the animal. This reduces transmission of mycotoxins from feed to food and henceforth will improve food safety.

LONG TERM PRESERVATION OF HIGH MOISTURE GRAIN AND MAIZE WITH A NON-CORROSIVE ORGANIC ACID BLEND  
Dr. Christian Lückstädt, R&D Coordinator, Addcon Nordic, Norway

The potential action of organic acids under farm conditions in feed preservation and protecting feed from microbial and fungal destruction is already widely accepted in the agricultural business. Despite this, year on year the agricultural industry faces huge losses due to spoiled grain during storage. Unlimited mould growth causes nutrient losses; mycotoxin contamination can cause acute health problems in animal husbandry, including reduced animal performance and fertility problems. The use of buffered propionic acid com-

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bined with sodium benzoate as a preservative for wet corn storage, even without prior drying, is an interesting option for long term storage and secures the quality of the stored raw material.

**TROPICAL GRAIN STORAGE - CHALLENGES INVOLVED IN MAINTAINING OVERALL GRAIN QUALITY**  
*Steven Goh, DelstAsia, Malaysia*

Mold control starts with moisture control. The challenge is not as simple as using a reputable mold inhibitor to do the job. Mold inhibitors of organic origin are challenged by the need to stay efficacious over the period of storage time required, particularly for tropical grain storage. The various challenges from moisture migration, grain respiration—more aggressive in a tropical storage conditions—and the ensuing water activity that causes both microbial and microflora activity and the subsequent spontaneous heating in the grain mass, results in grain quality degradation and the spoilage we so commonly see in this region: darkened germ, shriveled corn - due to moisture and dry matter loss. We need a chemical program that can effectively manage free water molecules, combined with a long acting mold inhibition property.

**IN-SITÚ MEASUREMENT OF MOISTURE IN STORED COMMODITIES**  
*Peer Hansen, GrainWatch, Sweden*

Commodities must be stored to preserve optimum condition, without infestation. To secure this, it is essential to store the crop at an optimum moisture concentration. Grain moisture concentration is also an essential parameter in preserving value: one percent lost moisture is one percent loss of the value of the stored commodity. A new type of sensor cable provides multi-point measurement of moisture concentration in the silo. This sensor system gives vital information about the moisture concentration in all fractions of the stored grain and shows how this moisture concentration develops over time.

**TECHNOLOGIES TO REDUCE MYCOTOXIN**  
*Stefan Schneider, Buhler, Switzerland*

Grain is particularly susceptible to mycotoxin contamination. Consumers, legislators, bakers, flour and cereal processors increasingly demand higher product safety of grain based finished products. Kernels can be contaminated on the surface or even be completely degraded. As a result, different methods of decontaminations are required. Effective solutions have been developed that set new standards to reduce mycotoxins at various points in the process. These solutions significantly reduce DON levels and range from dust removal, peeling off bran, gravimetric classification to effective color sorting. To ensure a quality standards, not only DON reduction methods are needed but also continuous quality monitoring and assessment in the production process. An automation system with traceability and on-line grain and flour measuring techniques for standard quality parameters is available.

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The European Standing Committee on the Food Chain and Animal Health in August authorized Lallemand Animal Nutrition’s probiotic, Bactocell (lactic acid bacteria strain *Pediococcus acidilactici* CNCM MA18/5M), for use as a zootechnical feed additive in salmonids and shrimp. This made Bactocell the first probiotic authorized for such use in aquaculture in the European Union. This authorization is based on the recognition of the quality and safety (QPS status) as well as the efficacy of Bactocell in beneficially enhancing salmonid and shrimp production.

In salmonids, Bactocell is able to improve the quality of the final fish products by increasing the number of well-conformed fish (prevention of Vertebral Compression Syndrome). This syndrome, which is thought to affect over 20% of rainbow trout harvested constitutes an important economic loss for fish farmers. The use of Bactocell® in the prevention of Vertebral Compression Syndrome in salmonids is the subject of an international patent filed by IFREMER and INRA in 2006.

In shrimp, Bactocell is able to increase survival and growth performance. The trials submitted with the application dossier unequivocally demonstrated beneficial effects in terms of growth enhancement, feed utilization, as well as improved resistance against *Vibrio* sp. infections.

Today, pressure for both sustainable and profitable aquaculture has fuelled the search for acceptable solutions for optimizing production in a natural and environmentally friendly way. Probiotics, which are defined as “live-microorganisms which, when administered in adequate amounts, confer a health benefit on the host”, have been empirically linked to improvements in aquaculture production in certain regions. However until now, the use of micro-organisms for zootechnical improvements in aquaculture had not been unequivocally demonstrated nor authorized in the European Union. This therefore appears to be the first of such authorization in Europe.

Probiotics in animal nutrition are classified in Europe as zootechnical feed additives, and as such are subject to very strict scientific assessments, requirements and regulations. Their assessments, by a panel of scientific experts, include in-depth evaluation of the identity, composition, quality, safety and efficacy of the particular strain on the intended target species. It is therefore a lengthy process demanding important investments by the manufacturer.

The exploratory trials on the possible use of Bactocell in aquaculture started in 2002, with first, feasibility trials on live preys (Gatesoupe, 2002). This was followed by numerous field trials and in-depth studies, on shrimp, salmonids and other marine fishes, some of which will be subject to EU authorization following steeply from this first. The application dossiers for the use of Bactocell in shrimp and salmonids are therefore the fruit of several years of intellectual investment as well as, research and development conducted.
Format boosts worldwide agent network

Format International has recently augmented its worldwide agent network and the Customer Support team, based in the UK Head Office.

Akram Talibov, General Manager of Safeed LLC, has been appointed a Format International agent, covering the Russian market. Mr. Talibov has worked in various senior sales, marketing and project management positions in the agricultural and food sectors and has excellent networks in these areas.

Format’s support team has also been expanded, with Mark Gilooly joining the company. Mr. Gilooly is based in the Woking head office. Born in South Africa, he has a background in the agricultural industry, and relevant IT industry qualifications, thus continuing Format’s commitment to its customers to provide reliable, knowledgeable and approachable customer service.

Fish Peptide Isolate FPI improves feed conversion

Bluewave Marine Ingredients has successfully commissioned its “first of a kind” Fish Peptide Isolate (FPI) production plant in Manta, Ecuador. The $2MM+ project is a joint venture between Marine Protein S.A.C. of Manta, Ecuador and Bluewave Management, Inc. of Panama. The JV is structured whereby Bluewave will manage IP and control product formulations, process development and sales and marketing of the Fish Peptide and Peptone products, while Marine Protein SAC will operate the plant and manage local logistics and raw material contracts.

The sanitary grade facility began commercial scale production of Peptides this summer with Ecuadorian poultry/aquaculture clients being the first to incorporate PerfectDigest™ FPI into their feed formulas. Inclusion rates of 0.5-1.0% during the first 2-4 weeks of feeding has resulted in Feed Conversion Rate (FCR) improvements of several percentage points for poultry. These results have prompted additional local poultry, shrimp, tilapia feed manufacturers and farm operators to initiate trials to determine efficacy in their own applications as well. The ease with which FCR improvements were demonstrated by local poultry producers drove the fast adoption rates in that segment, however aquaculture and swine benefit similarly the company said.

“The Bluewave process is unique in that it utilizes patent protected membrane technology and can produce highly purified peptide isolates (with zero fat content) something which no other company is currently doing in the Americas”, said Mark Rottmann, COO. “Our plants are actually capable of producing human grade protein products as well”.

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The Ecuador site is currently capable of producing about 600 tons/year of the Peptide product with plans to double capacity in the near future and Bluewave’s Pisco, Peru plant with 3,000+ tons of capacity is expected to come on line in the first half of 2010. Discussions for JV sites in Asia & Africa are underway as well. All of the Bluewave plants are based on marine raw materials which qualify as “Sustainable”, as such the products can prove critical to AquaCulture companies needing to reduce the use of wild-catch fishmeal in their feed formulas. For more information visit www.BluewavePeru.com

Canadian, Chilean and Norwegian scientists collaborate to sequence salmon genome

The economically important, environmentally sensitive Atlantic salmon species will have its genome fully sequenced, thanks to an international collaboration involving researchers, funding agencies and industry from Canada, Chile and Norway.

The Cooperation will invest approximately US$6 million in phase one of a multi-phased project to produce a genome sequence that identifies and maps all of the genes in the Atlantic salmon genome and can act as a reference/guide sequence for the genomes of other salmonids (e.g. Pacific salmon, rainbow trout and more distantly related fish such as smelt and pike.)

With salmonid product exports from Norway, Chile and Canada valued at US$3.4 billion, US$2.3 billion and US$0.6 billion, respectively in 2007, the sequenced genome will be an...
important public resource that may lead to better management of wild fish stocks, breeding selection for commercially important traits, and elements of food quality, security and traceability.

In addition, the fully annotated salmon genome will provide important clues about the impact of cultured fish escapees on wild populations, conservation of populations at risk, strategies for combating pathogens, as well as allowing for more accurate assessments of the sustainability of aquatic environments.

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**Nutreco builds new plant in Italy; gets green light to buy Cargill’s Spain and Portugal feed plants**

The European anti-trust authorities have approved Nutreco’s acquisition of the animal nutrition business of Cargill in Spain and Portugal, which includes aquafeed production. The acquisition includes Cargill’s 12 compound feed production facilities, with a production volume of around 700,000 tonnes, annual sales of approximately EUR 240 million. Since 2006 Nutreco has acquired animal nutrition and fish feed businesses in Brazil, Canada, China, Czech Republic, Guatemala, India, Indonesia, Italy, Japan, Mexico, the Netherlands, Poland, Portugal, Russia, Slovakia, Spain, Turkey, United Kingdom and the USA.

Nutreco has also announced that it has opened a state-of-the-art feed specialty plant in Mozzecane, Italy, creating a single site for three brands of Nutreco: Trouw Nutrition and Farmix feed specialties and Skretting fish feeds, which are produced in a plant already located on the Mozzecane site.

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**Revolutionary solvent-free extraction process for krill oil**

Tharos Ltd has recently filed what it expects to be a new and revolutionary way to extract the highest possible quality krill oils. The patented process will significantly reduce production costs and its price to end consumers. Whether the processing takes place within krill’s low-fat capture season or high-fat (or fatty) capture season, the resulting end products are of the highest quality in terms of Omega-3s, phospholipids and natural antioxidant content. By contrast, all actual fishing operations that target krill oil extraction, generally use solvent extraction procedures and are limited to operating at specific parts of each season in order to obtain a raw material to later extract krill oils.

The invention discloses a no-solvent (nor chemicals) extraction principle used to extract the oil. This new process obtains simultaneously phospholipids and neutral lipids enriched krill oils containing DHA and EPA poly-unsaturated fatty acids and astaxanthin. This invention provides two distinctive and selective krill oils and also discloses a krill meal obtained by this modified process that contains low fat content, in all cases these products are used as health products for human application.
All relevant current krill oil extraction methodologies generally use chemicals to extract the oil, which could leave residues on the resulting end product. There are some other companies that also offer krill oil but have not yet disclosed their extraction procedure from which to check their product integrity - suggesting either they infringe existing patents or the resulting end-product is not pure krill oil but rather a mix of several oils, be them marine origin or not. Until such other krill oil offers disclose their production principles, they cannot be properly scrutinized affecting in the long-term end-consumers confidence on it. This invention is a powerful krill-related environment-driven patent as among its direct benefits, it includes:

a) A lower catch-volume requirement to secure the same amount of end product compared to other methods, as there is a higher processing-yield, which allows less captured tonnage per end-product-tonnage output;

b) A significant reduction on processing infrastructure in relation to any other comparable processing method as the amount of catch and equivalent processing capacity is diminished due to higher processing yields;

c) A relevant improvement of the end-product quality in terms of freshness and its molecules quality. The patent avoids phospholipids’ decomposition and/or lipids deterioration during processing and transportation

d) This invention secures lower fishing and processing costs that goes in direct benefit of end-users through a lower end-product selling price. This means that the benefit to the end-user, be it for human health or animal nutrition, will be through the reduction of the market-cost per equivalent high-quality molecule;

e) This invention will also provide a further resource protection as the catch effort will not be focused on a limited catch and processing period rather spread-out the entire krill fishing season.

High-quality cultured pearls from the Queen Conch

For more than 25 years, all attempts at culturing pearls from the queen conch (Strombus gigas) have been unsuccessful—until now. For the first time, novel and proprietary seeding techniques have been developed by scientists from Florida Atlantic University’s Harbor Branch Oceanographic Institute FAU/HBOI.

With less than two years of research and experimentation, Drs. Héctor Acosta-Salmón and Megan Davis, co-inventors, have produced more than 200 cultured pearls using the techniques they developed. This discovery opens up a unique opportunity to introduce a new gem to the industry. This significant accomplishment is comparable to that of the Japanese in the 1920s when they commercially applied the original pearl culture techniques developed for pearl oysters. In their natural form, conch pearls are among the rarest pearls in the world—it takes about 10,000 queen conch to find one conch pearl and only 1 in 100 of those is gem quality.
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