



The **Extru-Technician**

Summer 2017

Extru-TechInc.com



**EXTRUDED AQUAFEED:
A UNIQUE CHALLENGE FOR
FEED MANUFACTURERS**



WELCOME LETTER

MEETING A VARIETY OF AQUAFEED MANUFACTURING DEMANDS

Welcome, and we appreciate your interest in *The Extru-Technician*. As the aquafeed industry continues to grow, we have focused this issue on the unique extrusion-related manufacturing challenges and solutions associated with these formulas. We begin by defining what makes aquafeed different from other types of extruded feed, and then examine the challenges that arise when balancing the physical characteristics in a feed with formulation considerations.

Creating extruded dry aquafeed as functional and durable pellets requires tight control of the extrusion process, which is readily accomplished by using Extru-Tech, Inc. extrusion architecture. The flexibility of our single-screw extrusion solutions provides the ability to create a variety of aquafeeds with a range of functionalities, such

as floating, sinking, or high-protein. This is just another example of how an original investment in an Extru-Tech solution can be utilized to meet changing market demands.

As always, we hope you find this issue of *The Extru-Technician* informative as we share our expertise and experience with our loyal clients and readership.

Please continue to share your comments and thoughts with us; we appreciate the feedback and look forward to offering solutions.

Sincerely,

R. Scott Krebs
Executive V.P., C.O.

The **Extru-Technician** brought to you by **Extru-Tech, Inc.**



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EXTRUDED AQUAFEED: A UNIQUE CHALLENGE FOR FEED MANUFACTURERS

Aquaculture is a growing industry, thanks to its ability to economically produce protein at higher rates and with lower inputs than many other farming methods. But one of the challenges that aquaculture faces is the availability of high-quality feed. Feed performance is particularly important because aquafeed typically accounts for 40 to 70 percent of a farm's costs.

Every type of feed has its own challenges. It should be no surprise that aquafeed presents its own.

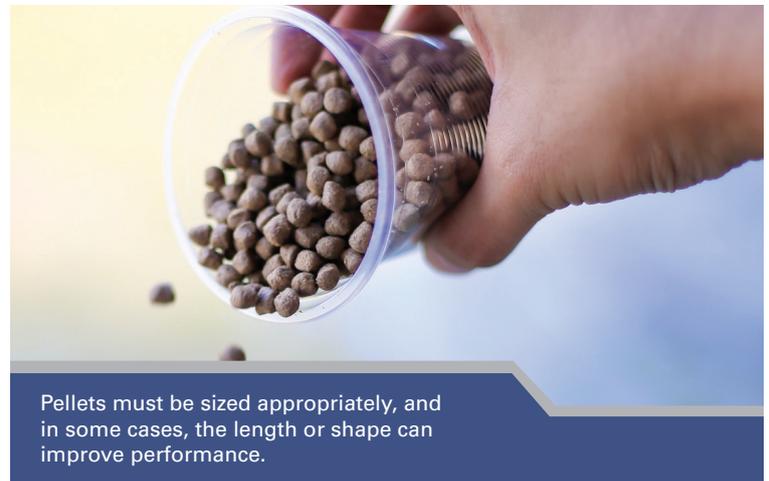
A key thing that distinguishes aquafeed from other types of feed is that it's not given directly to the animal, but instead through a medium (water). Fish live and breathe in the same environment they eat from. Unique complications arise when aquafeed is not manufactured properly.

For example, how a product reacts when being introduced to water influences its performance. This is a feed characteristic that other animal feed or pet food producers would never have to consider. In some cases, aquafeed pellets need to hold together for a long period of time. Any uneaten feed can seriously degrade water quality.

To ensure that feed is durable and accepted by the target species, two factors must be weighed:

- Formulation considerations: The raw ingredients and nutritional factors that make up the feed.
- Physical characteristics: The package in which those nutrients are delivered.

Manufacturers that have experience making feed for land-based animals can transfer some of their knowledge of nutrition and ingredient formulation to aquafeed. However, creating aquafeed with the right physical characteristics presents a much bigger challenge.



Pellets must be sized appropriately, and in some cases, the length or shape can improve performance.

Physical characteristics can make or break aquafeed

While physical characteristics are important with any type of feed, they are critical in aquafeed. Substandard physical characteristics can lead not only to wasted feed, but also major water quality problems that cost the farmer in terms of money, time, labor, and productivity. It is not possible to overemphasize the importance of paying attention to aquafeed's physical characteristics and ensuring that they are consistent within and between batches. The health of aquaculture depends on it.

Physical characteristics to consider include:

- Size: Pellets need to be sized appropriately.
- Shape: In some cases, the length or shape can improve performance.
- Texture: Pellet hardness can be important depending on the species. Surface texture—whether it is smooth or rough—is another important aspect. With juvenile fish, a rough texture can affect acceptability. Finally, the cell structure of the pellet determines how effectively it holds oils and micronutrients added to the feed after extrusion.

- **Density:** Pellet density determines whether the feed floats on the surface of the water or sinks. Some species will only eat feeds that float. Others prefer to feed on pellets as they descend, while still others wait for feed to reach the floor of the pond or pen. Of note, several species are adaptable, accepting floating feeds in some parts of the world while sinking feeds are used in others. Not only does the bulk density need to be in the correct range, but individual pellets need to have uniform density as well.
- **Moisture:** Good control over drying is critical not only to meet storage requirements, but also for economic and formulation considerations.
- **Durability:** Feed needs to be durable enough to meet manufacturing and logistical challenges. Challenges can include not only handling during the manufacturing process, but also during transportation and storage. It is important to understand the effect of durability on the digestive process. In some cases, durability can adversely affect digestibility.

- **Palatability:** Pellets need to have these physical characteristics to ensure acceptability. Taste may affect performance as well.

In addition to all this, feed must be uniform from pellet to pellet. If 99 percent of the batch is perfect, that leaves one percent that the animals may never eat. Put another way, for every 100 pounds of feed added to the water, one pound is pure waste, with little purpose other than to tax filtration systems and provide a medium for pathogens.

During manufacturing, lack of consistency comes about in many ways. These include improper machine settings that lead to variation throughout the batch, or changing conditions at start up and shut down. Even if the process is off spec for just a few moments, the entire batch may be contaminated.

It is also important to understand extrusion equipment is only part of the process. Size reduction (grinding), mixing, dosing, coating, conveying, and packaging equipment all have

How processing affects nutrition

Feed manufacturing can alter the digestibility of ingredients and change nutrient bioavailability. The benefits of cooking and extrusion include reducing pathogens and making it easier for small fish to access foods they otherwise would not be able to consume.

However, there are drawbacks. Heat, grinding, and post-extrusion drying can damage amino acids, vitamins, and carotenoids (the naturally occurring pigments that give fish their color).

Manufacturers can mitigate the drawbacks by:

- Reducing heating and grinding to the minimum needed to form safe, pathogen-free, and digestible feeds.
- Adding heat-sensitive ingredients to the aquafeed after extrusion and drying. Good candidates include oils, probiotics, enzymes, and certain micronutrients. Manufacturers should ensure the pellets have a structure that allows these coatings to adhere throughout storage and transportation. For example, salmon feed manufacturers have developed exceptional control over pellet cell structures that, combined with the use of vacuum infusion, ensure diets will not leach oil.



Feed needs to be sized correctly and durable enough to meet manufacturing and logistical challenges.



A fish's environment affects both nutritional needs and which feed characteristics to prioritize.

the potential to add or subtract value to the process. In some cases, these other steps can have a catastrophic impact. A good example would be extruding small feeds without adequate grinding. No extrusion system has the ability to deal with oversized particles fouling the die.

Extruder configuration, temperature, time in processing, and other factors should be stable from batch to batch and moment to moment to create an end-product with the necessary attributes. This involves getting the extrusion process up and running and on spec as quickly as possible.

Should unstable conditions arise, technicians must know how to recognize pellets that are off spec and be empowered to divert them when necessary. This creates a stable, predictable manufacturing process.

Formulation considerations: Their effect on physical properties

Ingredients influence the physical properties in a variety of ways, but not all of them are easy to predict or account for.

Binders play a critical role in creating the right physical properties for aquafeed. They serve as the “glue” that holds pellets together, contributing to cohesiveness and durability. But they provide their own challenges. The primary binder used in aquafeed is starch, which has great holding power but is prone to expansion during the extrusion process. This means more air in the final product—a useful result when your goal is to reduce density for floating feeds. But starch can make it difficult to achieve the high densities necessary for sinking feeds or the high-protein, high-fat content needed in nutrient-dense diets. (See sidebar on ADT to learn about minimizing expansion in the extrusion process.)

Fish meal is slowly being replaced by other protein sources for sustainability and cost reasons. These proteins behave differently, leading to new challenges.



Advanced Densification Technology creates more dense pellets

Because extruders operate at higher moisture contents and higher temperatures than steam pelleting systems, they offer the potential to more thoroughly cook and plasticize raw materials into very durable pellets that resist disintegration.

Unfortunately, the typical extrusion parameters that influence good water stability also promote expansion. This can be a challenge in producing sinking feeds.

Extru-Tech has developed Advanced Densification Technology (ADT) to address these issues. ADT components are designed to create heat and shear in the initial stage of the extruder, rather than at the die. This allows the final stage at the die to focus on densifying and forming pellets, minimizing expansion.

ADT has three main design features that build on the basic elements of an advanced extrusion system:

- The mid-barrel valve (MBV)
- More efficient, non-conical final screw geometry
- Die designs focused on capacity and densification

In traditional extrusion systems, the die performs two major functions: It restricts flow, which increases cook via mechanical energy (shear and retention), and it facilitates the formation of pellets.

An Extru-Tech ADT-equipped extruder uses the mid-barrel valve to move shear and retention to the initial segments of the extruder, long before it reaches the die.

The mid-barrel valve creates a more substantial contrast between zones than a traditional segmented barrel extruder with steam locks, lobe locks, or interrupted flight elements. Because the die no longer needs to accomplish significant cooking, its open area and hole geometry can be designed for making more dense pellets at increasing open area for much higher rates.

Outside factors affecting formulation

Ingredient availability and physical characteristics are two crucial factors affecting aquafeed formulation, but they are not the only ones. Here are a few of the many factors to consider:

Species

Cold water and carnivorous species tend to require feeds high in proteins and fat, while herbivorous, omnivorous, and warm water species are better able to utilize carbohydrates for growth.

Life stage

Larval stages have completely different needs than adult stages. This applies to both the nutritional profile and physical attributes of finished feed.

The aquaculture environment

Whether the fish are being raised in raceways, ponds, or netted ocean pens affects both their nutritional needs and which

feed characteristics to prioritize. Sinking feed may be preferable in a netted pen so that it does not drift out of the containment area. For species that prefer floating feeds, the float time can vary depending on the environment. In a less-crowded pond situation where the fish are spread out over a large area, floating feeds need to float for a longer period to give fish time to locate the pellets. Floating feeds are also much easier to manage because they can be seen by personnel.

Customer preferences

Different customers have different priorities and preferences. Although aquaculture is a science-based field, it's still small enough that some things can be learned only through experience. One farmer's experience in a particular aquaculture facility may lead to a preference for floating feed, while a farmer raising the same species

in another location may prefer sinking feed, even though the setups appear similar. Customers may demand a specific ingredient or attribute, sending the manufacturer back to the drawing board to dial in new parameters for the extrusion process.

Transport

Aquafeed manufacturing is hyper-specialized in many parts of the world. In some cases, customers hand-feed all of their products. In others, highly automated transport and feed systems are required to deal with the volumes and challenges present. Customers may be hundreds of miles away from their suppliers, which means feed needs to travel long distances and go through multiple handling and transfer points. Feed should be able to stand up to this handling without disintegrating or losing valuable nutrients.

Raw materials can vary from batch to batch. Variations in supplier processes can cause variation in their product.

Changes in commodities markets unfortunately lead to necessary changes in formulations. While least-cost formulation practices offer real value, they can create hurdles to making feed characteristics constant and predictable. Even minor changes to formulations can sometimes create problems.

Solutions for the future of aquafeed

Fortunately, process equipment innovations provide tools to help manufacturers deal with the challenges of balancing necessary formulation changes with the physical attributes required by end users.

More and more options are becoming available for managing the competing priorities involved in manufacturing aquafeeds.

Specializing in a narrow range of products for particular species makes it easier to configure processes that result in feed with the desired characteristics.

Multipurpose production lines are certainly another option. The advantages are straightforward, in that a wider range of products can be developed on the same line. The primary disadvantages revolve around:

- Downtime during equipment configuration changes
- Compromises to ideal configurations to achieve acceptable performance with hybrid configurations

Working with Extru-Tech, manufacturers can determine their production priorities and make the choices that will lead to maximizing value. Many manufacturers have been successful at not only



Floating



Sinking

creating highly efficient specialized lines, but also creating a balance that can accommodate different types of feed. These systems can be designed to minimize downtime and create aquafeeds of different densities, sizes, textures, and formulation characteristics.

Feed manufacturing is most efficient when products do not change significantly, but change often comes despite the measures manufacturers

put in place to ensure consistency. Extru-Tech can help balance numerous priorities so the final product meets customers' needs, expectations, and manufacturing capabilities.

Better feeds with improved physical characteristics are needed to face both current and future challenges to aquaculture. Extru-Tech is committed to developing new innovations that help producers meet the needs of a growing and changing industry.

The Extru-Tech

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