Joseph P. Kearns
Aquaculture Process Engineering Manager
Wenger Manufacturing, Inc.
714 Main Street
Sabetha, Kansas, USA 66534
Tel: 1 (785) 284 2133
Cel: 1 (913) 972 1299
jkearns@wenger.com
www.wenger.com

Dr. Addison L. Lawrence
AgriLife Research Mariculture Laboratory
1300 Port Street
Port Aransas, TX 78343
Phone: 361-749-4625
smpall@yahoo.com

Venue: **Aquafeed Horizons Asia 2010**
Feed & Grain Conferences at Victam Asia
Bangkok, Thailand
March 3-5, 2010

Title: **"Extrusion of Micro Aquatic and Shrimp Feeds"**

Outline:

- 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

Abstract:

Production methods are reviewed for manufacturing of micro or what is commonly referred to as starter feeds. Extrusion cooking in various formats are reviewed with the technology involved for production of these feeds. Also discussed is the ability to produce small diameter feeds at increased production rates. Typical increase levels are in the 3 to 5 times range while allowing all the formulation advantages seen in extrusion of shrimp feeds.

Presentation:

Micro-aquatic feeds are considered to be between 0.3 to 1.2 mm in diameter. These feeds can be produced by a number of methods including large pellet production followed by crumbling; a Spherizer Agglomeration System or simply directly off the extrusion process. The common critical points to be concerned with when producing micro feeds are the raw material preparation, drying, conveying and particle sizing before packing. Special attention is taken to avoiding particles which could potentially plug the die causing disruption during production.

Raw materials for these processes need to be free of large particles and consistent in particle size. Typically flours are used with special care to insure the fishmeal and animal proteins used are ground properly. Oils and other liquids as well as steam must also be filtered to remove particles from possible line build up. As in any feed processing operation mixing requires a review of the coefficient of mixing and when making small feeds this becomes more critical to ensure the same formulation is in each feed particle. Possible mixer contamination should be eliminated by having a dedicated mixer for a micro feed line and having the mixer properly sized for the capacity are also considerations.

Grinding of formulas for micro feeds in general require a pulverizer style grinder. They yield a consistent finely ground formula while developing low heat levels to prevent nutrient degradation. It is believed that screening after grinding is essential to insure particle size is correct for continuous operation. Over sized particles are recycled to maintain formulation consistency and the use of self cleaning screens also allow for longer production runs. The charts below show how important screening is with regards to particle size.

Sample #1B4	
Pulverized	
Micron Size	% Through
450	99.8%
350	99.2%
250	98.6%
149	97.8%
75	77.7%

Sample #1B4	
Pulverized & Sifted	
Micron Size	% Through
450	100.0%
350	100.0%
250	100.0%
149	99.8%
75	80.8%

The pulverized only sample yielded 99.2% through a 350 micron screen which is good but not quite what is needed if the extrusion die holes are 300 micron. The pulverized and sifter sample would result in a longer production run due to the 100% through a 250 micron sieve. Hammer milling typically yield grind sizes of about 0.8 mm and air swept pulverizers in the 420 to 177 micron ranges. It is recommended that all ground materials must be sifted for micro feeds prior to extrusion.

Direct extrusion of micro feeds or producing feeds with the desired diameter are typically limited to feeds of 0.8 mm or larger for twin screw extruders and 1.2 mm for single screw extrusion. Some producers are making 0.6mm feeds with attention paid to the above referenced critical points. Advantages of direct extrusion production methods are pasteurized feeds with high yields after post extrusion sifting. Typically oil if required is added internally while producing excellent appearing pellets with good water durability and either sinking or floating qualities. Disadvantages include the need for a dedicated line and pellet sizes. The historic disadvantages of high cost per unit and low production rates have vanished due to the development of methods of achieving higher rates per hour which will be discussed. Capacities vary greatly between extruder diameters for both single and twin screw extruders but in general capacities have increased by 3 to 5 times for feeds under 3.0 mm in diameter. Smaller extruders both single and twins were in the 100 to 350 kg/hr capacity ranges and larger extruders in the 1500 to 2600 kg/hr range. 1.5 mm feeds can now approach 5,000 kg/hr 10,000 or even 15,000 kg/hr for small diameter shrimp feeds or floating tilapia feeds as examples.

The recommended flow for direct extrusion of micro feeds begin with pulverized dry raw materials passing 100% through a 250 micron screen followed by sifting through a 300 micron screen. Extrusion with all fluid streams to the extruder being filtered as well through a 250 micron screen. Pneumatic conveying occurs from the extruder to a dryer with a screen size of less the 250 micron or a fluid bed dryer being preferred. Finally sifting for final sizing and to packaging.

Starter feed production with a Spherizer Agglomeration System (SAS) is a low shear & low temperature extrusion of a uniform and pulverized formulation into agglomerated strands. These strands, by cyclonic motion, are then rounded into nutritionally homogenous pellets. The typical flow of this system is similar in the raw material preparation area covered above. The actual extrusion system is a specialized machine beginning with a Dual Conditioning Cylinder providing inline dynamic mixing, injection of oils and other fluids. The first in first out conditioning process with consistent and manageable retention times, temperatures and gelatinization levels feed the specialized extruder barrel. In the extruder barrel the feed is compressed and densified instead of cooked and expanded as in normal extrusion cooking with the end result densities approaching 720 g/l.

The agglomerated strands from the extruder are conveyed to the Sphere-izer™ which breaks the strands into small individual agglomerations. Each pellet is simultaneously shaped into spherical particles with use of variable retention time control and cascade designs are available for higher capacities. The spheres are conveyed to and pass through a fluid bed dryer/cooler where excess moisture is removed and the product is cooled. Spheres finally pass through a screener for size classification with the SAS™ process providing on-size yields as high as 95%.

The advantages of this production method are oil can be added internally while processing at moderately low temperatures for pellet sizes approaching 0.150 mm with 95% yield after post-production sifting. These pellets are excellent in appearance and the system is perfect for making medicated and elevated vitamin inclusion micro feeds. Disadvantages include sinking feeds only with low pasteurization levels can be produced with relatively low production rates. A dedicated line is also recommended. New preconditioning technology is available for elevated gelatinization levels if desired. Capacities are between 100 kg/hr for 0.15mm pellets to almost 3,000 kg/hr for 1.5 mm products. It is advisable to consider installing the extruder portion of the SAS system in a wash down area for complete sanitation.

As mentioned above, high capacity micro aquatic feed production is now possible with the use of specialized cone screw developed for both single and twin screw extruders. Historically limitations existed for aquatic feeds smaller then 3 mm in diameter. These limitations were due to the final die open area and their location at the end of the extruder. Flare out adapters also were known for limiting the expansion rates when producing floating feeds used in attempts to increase die open area. These same flare out adapters also disrupted product flow on sinking products with results of non uniform product sizes.

Benefits of this new technology for micro floating feed production is that the die can be properly located for maximum capacity and feed expansion. Larger correctly positioned dies allow for increased die hole population and increased production rates. In addition to the new cone screw technology special tube die extensions yield retention time and flow characteristics for densities of sinking feeds in the 650 gm/l range as well as 3 to 5 times traditional capacities. Benefits of the combination of the advanced cone screw technology and tube dies allow for 3 times the die hole population as well as resulting in increased cook and decrease expansion through pressure drop and retention time designs for sinking feeds. The adjusted tube diameters allow for uniform cross-sectional flow with the desired results of higher rates, uniform size pellets and heavier density products.

The Impact of Advanced Cone Screw Technology
on a 165 mm Single Screw Extruder Throughput

Product	Prior Art Rates	New Technology
1.5mm Sinking	1000-1500 kg/hr	3750-5000 kg/hr
1.8 mm Floating	1500-2000 kg/hr	3750-5000 kg/hr

Similar effects are seen on twin screw extruders with capacity increases of 3 to 5 times on both floating and sinking feed production. This is accomplished by conversion of the twin screw design into a single screw design at the critical end of the extruder barrel, the discharge. This technology allows for the same advantages described above to be utilized, higher die hole population and adjusted die location for maximum benefits for both floating and sinking feeds.

Reviewing results of shrimp feed work recently with regards to grow out of shrimp on extruded feeds. This is mentioned as extrusion is again at the forefront for consideration as a profitable production method for shrimp feeds as single screw extruders of about 165 mm in diameter can now do 5 tons per hour while 215 mm extruders can do 10,000 kg/hr and 235 mm extruders are in the 15,000 kg/hr ranges. When you consider the fact that extruders need less starch, do not require binders, allow for a wide ingredient selection, easily handle elevated vegetable protein sources all while producing excellent water stable feeds justify their use from a total cost perspective. The main advantage was always the ability to use lower cost formulations which is the highest cost for any aquatic feed product coupled with the newly developed devices for increased capacity which easily allows for overall feed production costs for shrimp feeds to be reduced.

Feed trials conducted at Texas A&M with Dr. Addison Lawrence were preformed with the following criteria:

-Feeding studies conducted with 5 shrimp per tank with 100 tanks utilized.
-Shrimp of .26 grams initial weight used
-Water filtered recirculated and exchanged
-Water checked for salinity, temperature and dissolved oxygen daily
-Ammonia, nitrite, nitrate, and pH measured weekly
-Light regimen: 12 hours dark and 12 hours dim daily
-35 days trial
-Feeding was 15 times per day
-Unconsumed feed removed daily
-Water recirculation: 4,193% daily
-Clean water system (no natural productivity)
-150 shrimp/m3
-temperature range: 29 to 31oC

-oxygen levels: always above 5 ppm
-pH: between 8.0 and 8.2
-ammonia, nitrite and nitrate: very acceptable low levels and not limiting
-salinity: between 25 and 37 ppt

The results of the trials at Texas A&M were reported as Estimated Growth Rate/Week. It was noted that the % survival for all treatments was over 90%

WEEK	SIZE	CHANGE IN WEIGHT
0	0.26 Gms initial weight	
1	0.65	0.39
2	1.30	0.65
3	2.60	1.60
4	4.30	1.70
5	6.00 final wt	1.70

The trials were continued until the linear growth phase was achieved which settled out to be 1.7 grams of growth per week on average for all trials. This equates to about 30 shrimp per kilo in 16 to 18 weeks.

Conclusions:

The production of micro feeds has been reviewed and the advancing technology now allows for micro feeds of very small diameters, down to 0.15mm with the SAS system as well as direct extruded feeds down near 0.6mm. The level of gelatinization as well as the microbe destruction level in the feeds can be engineered into the system. Production capacities are up to standard large diameter pellet rates on extrusion cookers on small diameter feeds less then 3 mm in diameter with 5, 10 or even 15 tons per hour possible. These capacities justified trials preformed by Dr. Lawrence showing that extruded shrimp feeds provide excellent growth rates.