Oceanic Institute
Biofuels Co-Products Workshop

Extrusion Process for Aquatic Feeds

Joseph P. Kearns, Wenger, USA
Aquatic Feeds Made by Extrusion
Floating: Catfish, Carp, Tilapia
Coated and Uncoated Salmon and Trout Feeds
# SALMON FEED

## DENSITY BEFORE COATING

<table>
<thead>
<tr>
<th>Density (g/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>654</td>
</tr>
<tr>
<td>628</td>
</tr>
<tr>
<td>530</td>
</tr>
<tr>
<td>504</td>
</tr>
<tr>
<td>420</td>
</tr>
<tr>
<td>392</td>
</tr>
</tbody>
</table>

## DENSITY AFTER COATING and TOTAL FAT %

<table>
<thead>
<tr>
<th>Density (g/l)</th>
<th>Fat (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>679</td>
<td>16.2</td>
</tr>
<tr>
<td>690</td>
<td>19.5</td>
</tr>
<tr>
<td>672</td>
<td>23.8</td>
</tr>
<tr>
<td>640</td>
<td>28.4</td>
</tr>
<tr>
<td>617</td>
<td>37.8</td>
</tr>
<tr>
<td>626</td>
<td>40.5</td>
</tr>
</tbody>
</table>
EFFECT OF SME ON CELL STRUCTURE SIZE
(SME Units = kWh/t)

SME is expressed as a ratio to the control
Small Diameters

- 0.6 mm SINKING
- 0.8 mm SINKING
- 1.2 mm SINKING
- 0.8 mm FLOATING
- 1.2 mm FLOATING

WENGER DIRECT EXTRUSION
Micro Feeds

300 MICRON

500 MICRON

750 MICRON

1.0 mm

1.2 mm

EXTRU-TECH
SPHERE-IZER AGGLOMERATION SYSTEM™
Big Fish Feeds
Semi Moist Feeds

WENGER SEA URCHIN FEED
Abalone Semi Moist Feed
Abalone Style Feeds
Shrimp Feeds
Sea Bass Sea Bream Feeds
Sinking medium fat content
SINKING AQUATIC

SHRIMP  YELLOW TAIL  SALMON
FLOUNDER  SEA BREAM  TILAPIA
COD  SEA BASS  EEL
HALIBUT  TROUT  CATFISH
MAIMAI  MOI  MILKFISH

FLOATING AQUATIC

TURBOT
Diversity in Aquatic Feeds

<table>
<thead>
<tr>
<th>Pellet Characteristic</th>
<th>In sea water @ 20°C (3% salinity)</th>
<th>In fresh water @ 20°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast sinking</td>
<td>&gt; 640 g/l</td>
<td>&gt; 600 g/l</td>
</tr>
<tr>
<td>Slow sinking</td>
<td>580-600 g/l</td>
<td>540-560 g/l</td>
</tr>
<tr>
<td>Neutral buoyancy</td>
<td>520-540 g/l</td>
<td>480-520 g/l</td>
</tr>
<tr>
<td>Floating</td>
<td>&lt; 480 g/l</td>
<td>&lt; 440 g/l</td>
</tr>
</tbody>
</table>
Four Main Areas To Evaluate/Organize an Aquatic Feed Extrusion Project

1) **Raw Materials**
2) System Configuration (Hardware)
3) Processing Conditions (Software)
4) **Final Product Specifications**
Former Limitations for Products Smaller than 3mm Diameter

1) Final die open area was the limiting factor in production capacity of micro-aquatic feeds and other products smaller than 3mm diameter
Twin Screw, Floating
Value of this Technology for Floating and Sinking Products

The major advantages of the diverging cone screw are:

3-5 times the rates over what we have been able to do in the past due to overcoming die limitations in open area.

Smaller diameter floating products have a higher % of floating due to the close proximity of the die to the cone screw.

Smaller diameter for sinking is increased capacity.

VFD on main extruder drive required.
Initial Floating Product: 5 times normally expected capacity
Initial Sinking product, notice product uniformity also at 5 times normally expected rates
Sanitary X-165 With HIP Conditioner
Application of High Intensity Preconditioner

Sample off preconditioner:
- 50% fresh meat slurry
- 11.5% steam
- 3.4 minutes retention time
- 35% moisture
Comparison of particle size off preconditioners with 75% fresh meat slurry

New High Intensity Preconditioner

Original DDC Preconditioner
Recent Testing

Made a product with die opening of 0.8 mm at high rates on a Single Screw Extruder
0.4mm Sinking via Extrusion
Why Fluid Bed or Rotary Dryer?
Indigenous Ingredients

As ingredients come forward we have seen additional or better preconditioning is required. SBM requires additional moisture at elevated levels. Same for other vegetable proteins.
Fishmeal Replacement Blend
Via Extrusion Cooking

Work has advanced by Stuart Romes of Agronomic Trading of Cyprus, Wenger Mfg. and Dr. Addison Lawrence of TA&M. An engineered liquid solution containing limiting Amino Acids when compared to fish meal is used in conjunction with a Wenger extruder to improve the AA profile of vegetable proteins.
Plant Proteins – Fish Protein Replacement

Problem: Essential Amino Acids (EAA) not optimal in Plant Proteins

Problem: Optimization of EAA using crystalline amino acids limited

Solution: Chemically bind EAA to plant protein

Problem: Process to bind EEA to plant protein is expensive and not cost effective

Dr. Addison Lawrence, Texas A&M University
Plant Proteins – Fish Protein Replacement

Solution: Exciting new technology utilizing proprietary chemical mixture with desire mixture of EAA and extruding with any plant protein in a feed grade ingredient

Result:
Increase digestibility of plant protein
3 to 10 fold fortification of one or more EAAs of choice
3. >99% of EAA bound

Dr. Addison Lawrence, Texas A&M University
Plant Proteins – Fish Protein Replacement

Test results:

1. Crystalline methionine bound to soybean protein in 44% soybean meal

Methionine level in 44% soybean meal increase a minimum of three-fold (times)

Greater than 99% of methionine bound

Growth rate of bound methionine equal to that of crystalline methionine with L. vannamei

Dr. Addison Lawrence, Texas A&M University