ADVANCEMENTS IN MICRO AQUA FEED EXTRUSION

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Wide range of aquatic species to be fed
Aquatic Feeds

Floating
- Catfish
- Carp

Slow Sinking
- Salmon
- Trout

Fast Sinking
- Shrimp

Aquarium
- Flakes

Product Properties:
1) Piece size
2) Buoyance
3) Water stability
Aquatic Feeds

Sizes Range From 0.5 mm to 60 mm Diameter
Three phases of Aqua Farming

In-door Hatchery

In-door Nursery

Out-door Grow-out Ponds
Hatchery Feeds

Sizes Range From < 50 micron to < 450 micron
Micro-Aquatic Feeds

• 1) Large pellet extrusion followed by crumbling
• 2) Spherizer process (SAS)
• 3) Direct extrusion
Micro Aquatic Feeds

Sizes Range From 0.5mm to 1.2mm
Why we need Micro Aquatic Feeds

1) Historically the baby shrimp or fish were produced in the hatchery and later stocked in Out-door nurseries / grow-out ponds.

2) In the initial days of grow-out they were fed crumbled feed.

3) Now increasingly the Nursery phase has been moved In-doors for the following benefits:
   - Higher survival rates in Intensive systems – production predictability
   - Biosecurity
   - Mitigate Disease threats
   - More optimal Production Conditions – to ensure faster growth
   - Utilize the benefits of compensatory growth
Intensive In-door Aqua farming

Stacked Raceway system from Dr. Addisson Lee Lawrence
Steam Pelleting Vs Extruded Micro Aquatic Feeds

Nursery Feed Priorities are: Quality First: Make up less than 10% of total feed used

BENEFITS OF EXTRUSION:
1. Entire pellets – not crumbled – have a smooth surface, less fines (fines pollute the water)
2. Uniform Size: both Pellet Dia & Length
3. Formulation flexibility: can produce nutrient dense feeds
4. Better Cook: Better Digestibility
5. Based on requirement can produce: Floating or Slow sinking Vs sinking only
6. Better suited for use on Auto feeders
Micro Aquatic Feeds: Bottleneck Review

- Mixing and Grinding Capacities?
- Conveying Capacities?
- Extrusion Capacities?
- Drying Capacities?
- Sifting and dust control?
- Pneumatic system Changes?
- Sanitation and HACCP requirements?
- Is it a dedicated line?
Fundamentals of Extrusion Processing

- Raw Material Characteristics
- System Configuration
- Processing Conditions
- Final Product Specifications
Client Specified RAW MATERIALS

PROCESSING HARDWARE

PROCESSING CONDITIONS AND CONTROL

Client Specified FINAL PRODUCT CHARACTERISTICS
Raw Material Preparation

• Raw Material Choices
  • Flours
  • Deboned fish meal / animal proteins

• Oil
  • Must be screened / sieved
  • Oil needs to be added internally

• Water and Steam
  • Must be filtered to remove any line build-up
Raw Material Preparation

- **Hammer Mill**
  - Limited to 2/64” (0.8mm) Grind Size

- **Air Swept Pulverizer**
  - 40 mesh (420 microns)
  - 80 mesh (177 microns)

Note: Ground Materials must be sifted “IMMEDIATELY” prior to extrusion!!!
Grinding Considerations

- Pulverizer for Grinding
  - Consistent, Fine Grinding
  - Low Heat Grinding to Prevent Nutrient Degradation

- Ground Material Sifting
  - Essential to ensure continuous operation
  - Recycle over-sized material
  - Self Cleaning Screens
Guidelines for Grind of Recipe

The thumb rule:
• Maximum particle size = 1/3 die opening
• Not to exceed 1.2 mm

• Recommended grind size for feed size 0.5mm to 1.2mm: 95% < 125 micron
• Recipe to contain adequate starch level: 20 - 25% for floating & 10-15% for sinking feeds
Proper Grinding & sifting is important

1) Improved product appearance
2) Reduced incidence of die orifices plugging
3) Ease of cooking
4) Reduced product breakage and fines
5) Increased water stability
6) Improved retention of liquid coatings due to small cell structure
Extrusion System Process Flow

- Live bin
- Feed system
- Preconditioner
- Extruder barrel
Live Bin and Feeders

Loss in Weight – critical for advanced control systems
Preconditioning

A vital component in the extrusion process
Hydration & Heating

• Moisture Addition
  - Steam
  - Water

• Slurry Addition
  - Water-based
  - Oil-based
Factors Which Affect Preconditioner Performance or Efficiency

• Ingredient size, shape, and density
• Sequence and ratio of ingredient additions
• Preconditioner fill (beater configuration)
• Preconditioner design
• Beater design and contacts/time (speed)
• Retention time and residence time distribution
• Mixing energy (power and duration)
• Component wear
• Feed rate
Latest Conditioner: HIP

Can include up to 50% Wet Ingredients
New HIP Shaft/Beater Design

Hygienic design without threaded beaters
Comparison of particle size of preconditioners with 75% fresh meat slurry

New High Intensity Preconditioner

DDC Preconditioner
## HIP Preconditioner

### Average Cook and Coefficient of Variation for Moisture Content of Various Preconditioner Designs

<table>
<thead>
<tr>
<th>Preconditioner Design</th>
<th>CV (%)</th>
<th>Cook (%)</th>
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<tbody>
<tr>
<td>HIP (80% MI)</td>
<td>2.65</td>
<td>30.0</td>
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<tr>
<td>DDC</td>
<td>4.96</td>
<td>25.9</td>
</tr>
<tr>
<td>DC (Double Cylinder)</td>
<td>6.66</td>
<td>20.4</td>
</tr>
<tr>
<td>SC (Single Cylinder)</td>
<td>9.36</td>
<td>15.7</td>
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</table>
## Effect of Preconditioning on Microbial Populations

<table>
<thead>
<tr>
<th>Microbe</th>
<th>Raw Recipe</th>
<th>After DDC Preconditioner</th>
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<tbody>
<tr>
<td>TPC (CFU/g)</td>
<td>240,00</td>
<td>9,300</td>
</tr>
<tr>
<td>Coliform</td>
<td>22,600</td>
<td>&lt;10</td>
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<tr>
<td>Mold count</td>
<td>54,540</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Clostridium</td>
<td>16,000</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Listeria</td>
<td>positive</td>
<td>negative</td>
</tr>
<tr>
<td>Salmonella</td>
<td>negative</td>
<td>negative</td>
</tr>
</tbody>
</table>
Steam – Water Mixing Injection System (SMI)

Single point injection of Steam and Water into Pre-conditioner
Extruder Types

Twin Screw

Single Screw

Conical Co Rotating Twin Screw
TWIN SCREW EXTRUSION

Is the process of choice when:

Ultra high levels of internal fat (above 17%)
Ultra high levels of fresh meat (above 35%)
Very uniform size and shape (portioned feeds)

Ultra small product sizes (less than 1.5 mm dia.)

Greater ingredient flexibility is required
Twin Screw Rotating Elements

- Fully intermeshing
- Self-wiping
Extrusion of Pasteurized Products
Critical Control Point – Product Temperature
Special Dual Die Components: to increase capacity

0.6mm Extruded Feed
Back Pressure Valve to Control Cook
BACK PRESSURE VALVE

Operation / Adjustable Orifice Controls:

✓ Extruder barrel pressure independent of open area in die.
✓ SME Input
✓ Piece density
✓ Bulk density
✓ Compensates for material variations.
✓ Safer die changes for operators
Hygienic Pneumatic Conveying Systems

1) HEPA filter air intake
2) Burn-out sanitizing mode
3) Strategically located temperature sensors
4) Positive pressure at die/knife area
5) Positive pressure at sampling port
Critical Control Point
Extruder Temperature Validation

95°C

125°C
Automated controls:

Ensures smooth operation
Product monitors and on-line devices to De-couple personnel from direct product contact

1) On-line measurement of product technical qualities
2) Remote digital imaging
On-line Product Measurements

1) Bulk density
2) Moisture
3) Temperature
4) Photographic recognition
5) Proximate analysis
6) Presence of contaminants
Process Flow for Direct Extruded Feeds

- Mixing
- Pulverizing
- Extrusion
- Sifting
- Drying / Cooling
- Sizing
- Recycle or waste
- Packaging

WENGER®
RECOMMENDED FLOW FOR DIRECT-EXTRUDED MICRO-AQUATIC FEEDS

- Pulverizer (100% through 250 microns)
- Rotary sifter (300 micron screen)
- Twin Screw Extruder (with oil, steam, and water injection streams screened through 250 microns)
- Pneumatic conveying system
- Dryer (screen size as per product size requirement)
- Sifter for sizing final product
- Packaging
Questions?

Email: ramesh@wenger.com
Thank You

WENGER TECHNICAL CENTER – Sabetha, Kansas, USA