Comparison of two commercial diets for the production of marketable *Litopenaeus vannamei* in super-intensive, biofloc-dominated, zero-exchange raceways

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Introduction

- Recent advances in super-intensive, limited-discharge, biofloc systems for the culture of *Litopenaeus vannamei*, suggest that these systems can be profitable when used to produce live or fresh (never frozen) shrimp for niche markets.

- Researchers, supported in part by the United States Marine Shrimp Farming Program have been working to improve system efficiency and make this technology economically viable.
Introduction

- These systems offer improved biosecurity with reduced risk of crop losses to viral diseases
- Furthermore, operating these systems with no water exchange minimizes the negative effluent impact on receiving waters
Objectives

- To study the performance of *Litopenaeus vannamei* juveniles fed two commercial diets under high density and no water exchange
- To study the changes in selected WQ indicators in RWs stocked with these shrimp
- To study the benefit of using the YSI 5500 DO monitoring system as a management tool for a super-intensive, zero-exchange shrimp production system
Materials & Methods

- Six 40 m³ EPDM-lined RWs (Firestone Specialty Products, Indianapolis, IN) filled with a mixture of seawater (22 m³), and biofloc-rich water (18 m³) used in an earlier nursery trial
- Salinity was adjusted to 30 ppt
- RWs were stocked at 500/m³ with juveniles (2.66 g) from a cross between Taura Resistant and Fast-Growth genetic lines (Shrimp Improvement Systems, Islamorada, FL)
Materials & Methods

- Each RW had eighteen 5.1 cm airlifts, six 1 m long air diffusers (AeroTube, Colorite Division, Tekni-Plex, Austin, TX) and a center longitudinal partition over a 5.1 cm PVC pipe with spray nozzles fed by a Venturi injector operated by a 2 hp pump.

- Raceways were operated with no water exchange.

- Evaporation was weekly compensated by adding chlorinated municipal freshwater.
Materials & Methods

- Three RWs were fed HI-35 ($1.75/kg) while three others received SI-35 ($0.99/kg) feed (Zeigler Bros., Gardners, PA)
- Feed was distributed continuously 7 days a week using belt feeders
- Rations were initially determined using an assumed FCR of 1.4, growth of 1.5 g/wk, and mortality of 0.5%/wk, and were adjusted according to twice a week growth samples
Materials & Methods

- Each RW optical DO monitoring systems (YSI 5500, YSI Inc., Yellow Springs, OH) for continuous DO monitoring
- Water temperature, salinity, DO, and pH were monitored twice daily; ammonia-N, nitrite-N, nitrate-N, alkalinity, settleable solids, turbidity, TSS, VSS, and cBOD$_5$ were monitored once a week
- Alkalinity was adjusted to 150-200 mg/L (as CaCO$_3$) using sodium bicarbonate
Materials & Methods

- All RWs were outfitted each with a small commercial Foam Fractionator (VL 65 Aquatic Eco Systems, Apopka, FL) and a settling tank.

- FFs & ST were used to control particulate matter and dissolved organics, originally targeting TSS and SS levels in the ranges of 200-300 mg/L and 10-14 mL/L, respectively.
Results

- The optical DO monitoring probe (YSI 5500, Yellow Springs Instruments, OH) of the monitoring system worked very well.
- The use of this system enabled better scheduling of the feeding and minimized DO fluctuations.
- TSS, turbidity and VSS levels remained significantly higher in the SI-35 treatment.
- These results may be related to the higher levels of non-digestible components contained in the SI-35 than HI-35.
- Fiber: 2.69% vs. 1.61%
- Ash: 11.11% vs. 9.55%
## Daily WQ Data

<table>
<thead>
<tr>
<th></th>
<th>HI-35</th>
<th>SI-35</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Min - Max</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a.m.</td>
<td>29.6</td>
<td>27.5-30.7</td>
</tr>
<tr>
<td>p.m.</td>
<td>30.5</td>
<td>28.2-31.6</td>
</tr>
<tr>
<td>DO (mg/L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a.m.</td>
<td>5.9</td>
<td>4.6-7.0</td>
</tr>
<tr>
<td>p.m.</td>
<td>5.5</td>
<td>4.7-6.6</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a.m.</td>
<td>7.1</td>
<td>6.6-7.5</td>
</tr>
<tr>
<td>p.m.</td>
<td>7.1</td>
<td>6.2-7.6</td>
</tr>
<tr>
<td>Salinity (ppt)</td>
<td>28.3</td>
<td>24.4-36.5</td>
</tr>
</tbody>
</table>
Results

- Ammonia and nitrite levels stayed low (< 0.5 and 1.22 mg/L, respectively) in all six raceways throughout the trial.
- Nitrate increased from about 40 mg/L at the study initiation to a maximum of 359 mg/L at the end of the trial.
## Weekly Solids and Alkalinity Data

<table>
<thead>
<tr>
<th></th>
<th>HI-35</th>
<th></th>
<th>SI-35</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Min-Max</td>
<td>Mean</td>
<td>Min-Max</td>
</tr>
<tr>
<td>ALK (mg/L)</td>
<td>208&lt;sup&gt;a&lt;/sup&gt;</td>
<td>123-274</td>
<td>171&lt;sup&gt;b&lt;/sup&gt;</td>
<td>102-230</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>223&lt;sup&gt;a&lt;/sup&gt;</td>
<td>115-552</td>
<td>278&lt;sup&gt;b&lt;/sup&gt;</td>
<td>155-460</td>
</tr>
<tr>
<td>VSS (mg/L)</td>
<td>161&lt;sup&gt;a&lt;/sup&gt;</td>
<td>92-435</td>
<td>205&lt;sup&gt;b&lt;/sup&gt;</td>
<td>117-288</td>
</tr>
<tr>
<td>SS (mL/L)</td>
<td>8</td>
<td>2-21</td>
<td>11</td>
<td>2.5-27</td>
</tr>
<tr>
<td>Turb. (NTU)</td>
<td>90&lt;sup&gt;a&lt;/sup&gt;</td>
<td>46-132</td>
<td>125&lt;sup&gt;b&lt;/sup&gt;</td>
<td>68-246</td>
</tr>
</tbody>
</table>
Results

- Sodium bicarbonate was initially added to RWs equivalent to ~20% of the feed to target 160 mg/L CaCO$_3$
- The HI feed did not reduce the alkalinity at the same rate experienced with the SI-35 feed
- This quickly led to a separation in alkalinity between treatments due to the initial overcompensation in the HI-35 treatment
- By Week 5 the alkalinity levels in the two treatments were similar
## Results

<table>
<thead>
<tr>
<th></th>
<th>HI-35</th>
<th>SI-35</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water use (L/kg shrimp)</td>
<td>124.7</td>
<td>138.3</td>
</tr>
<tr>
<td>Bicarbonate (kg)</td>
<td>41.6</td>
<td>53.6</td>
</tr>
<tr>
<td>Molasses (L)</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Foam fractionator (h)</td>
<td>812</td>
<td>1,253</td>
</tr>
<tr>
<td>Settling tank (h)</td>
<td>87</td>
<td>391</td>
</tr>
</tbody>
</table>
Growth Performance

\[ y = 1.1463x + 1.4894 \]
\[ R^2 = 0.9954 \]

\[ y = 1.0621x + 1.3139 \]
\[ R^2 = 0.9917 \]

- HI-35 Av (g)
- SI-35 Av (g)
- Linear (HI-35 Av (g))
- Linear (SI-35 Av (g))

\[ P = 0.62 \]
Performance of shrimp fed HI-35 & SI-35 diets in a high-density 67-d in biofloc dominated system

<table>
<thead>
<tr>
<th></th>
<th>HI-35</th>
<th>SI-35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Weight (g)</td>
<td>22.12 ± 11.35&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.74 ± 8.28&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Growth (g/wk)</td>
<td>2.03 ± 0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.76 ± 0.10&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Total Biomass (kg)</td>
<td>389.8 ± 1.77&lt;sup&gt;a&lt;/sup&gt;</td>
<td>348.5 ± 9.21&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Yield (kg/m³)</td>
<td>9.74 ± 0.04&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.71 ± 0.22&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>FCR</td>
<td>1.25 ± 0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.43 ± 0.04&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Survival (%)</td>
<td>87.4 ± 0.52&lt;sup&gt;a&lt;/sup&gt;</td>
<td>88.3 ± 4.18&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

* Although the cost difference between the HI & SI feeds is significant ($1.75/kg vs. $0.99/kg), a preliminary economic analysis indicates that both feeds would be commercially viable with the profit advantage in favor of the HI feed.
Issues to address

- Operating year round
- Disease
- PL Supply
- Marketing
- Feed cost
- FCR
- Growth
- Survival
- Energy & Temperature control
- Zero exchange vs. Recirculating
Opportunities for the Future

- Improved technology continues to increase growth and production rates while reducing variable costs
- Continued genetic selection should favor higher yields over time
- Financial analyses are focusing research to sharpen competitiveness
- Marketing opportunities
  - Consistent fresh never frozen product
  - Improved image as a domestic producer of healthy food in eco-friendly systems
Acknowledgements

- National Institute of Food & Agriculture (NIFA) USDA, AgriLife Research, The National Academy of Sciences USAID and CAPES, CNPq, FURG of Brazil for funding
- Zeigler Bros. for the feed
- Shrimp Improvement Systems for the PL
- YSI for the DO monitoring systems
- Aquatic Eco-Systems for the foam fractionators
- Colorite Plastics for the air diffusers
- Firestone Specialty Products for the EPDM liner