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On the cover:
Responsible aquaculture provides healthy food and important employment opportunities around the world. The Global Aquaculture Alliance has been proud to share this news through the *Global Aquaculture Advocate* magazine. Please continue to read the new *Advocate* online. Photo by Noppharat_th.

DEPARTMENTS

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Density Ups Feeding Response In Grouper
Contrary to common perceptions, grouper stocked at high density had greater feed intake and better feed conversion.

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Enhanced AHPND Detection
A study found that shrimp allowed to decompose prior to processing reflected improved PCR detection of AHPND.

innovation

Indoor-Raised Shrimp Find Potential Market In Kentucky State University Test

The tank at KSU raised shrimp to over 24 g in 98 days.

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Summary:
By raising shrimp in a closed building, producers can increase biosecurity, produce shrimp more consistently, grow shrimp year-round and locate production centers near markets. Shrimp raised in an indoor recirculating system in Kentucky, USA, grew well with efficient feed conversion. Chefs and consumers were very accepting of the whole fresh shrimp offered at a farmers market. Their survey responses indicated they would pay attractive prices for fresh shrimp, which may be profitable despite the varied costs associated with indoor culture.

Indoor shrimp production is growing in popularity in some parts of the world, including the United States. By growing shrimp in a closed building, producers can dramatically increase biosecurity, produce shrimp more consistently, grow shrimp year-round and locate production centers near markets.

Biosecurity is enhanced through restricted access and controlled inputs. Indoor systems experience minimal water quality variations in temperature, dissolved-oxygen or pH levels. Furthermore, if a consistently productive system can be developed, it may be sited nearly anywhere and sized for the markets it supplies. This may fit well with local foods movements, allow live animal distribution and reduce transportation costs, allowing farmers to receive substantial prices for their products.

In an effort to support industry involvement in this growing field, researchers at Kentucky State University (KSU) are exploring production and marketing aspects of indoor shrimp production.

RAS Culture

This work was conducted inside the newly equipped Aquaculture Production Technologies Laboratory at KSU. The 1,300-m^2 lab building houses a variety of recirculating aquaculture systems. The air temperature of the building is maintained at approximately 23° C year-round using electric boilers.

A 3.1-m^3 rectangular raceway was used as a nursery and outfitted with an external 190-L settling chamber and a 190-L biological filter filled with plastic biomedia. Ten-day-old postlarvae of Pacific white shrimp, *Litopenaeus vannamei*, were obtained from a hatchery in Florida, USA, and stocked into the nursery at a density of 2,500/m^3.

After the nursery phase, 5,250 shrimp weighing an average of 0.55 g each were stocked in a 20-m^3 fiberglass growout raceway with water containing artificial sea salt at a salinity of 20 ppt.

The raceway was equipped with a 1-hp pump, which delivered water to three aeration nozzles distributed around the raceway and one nozzle that fed a foam fractionator.

The nozzles inside the raceway drew air in through snorkels extending above the water surface and directed water around a central wall. The fractionator nozzle delivered finely aerated water into the foam fractionator, which was used as needed to maintain turbidity at approximately 40 nephelometric turbidity units.

Two 3,000-watt submersible heaters in the growout raceway maintained a water temperature of approximately 28.5° C. A dry shrimp probiotic was initially added to the water over a two-week period, and 3 L of biomedia from the nursery was placed in a mesh bag and submerged in the water to help establish a bacterial community.

Results

The growout tank was managed as a biofloc system, with the only external filtration being the foam fractionator to remove dissolved and suspended solids. There was a 1.3 mg/L spike of total ammonia nitrogen one week after stocking shrimp, and a 3.5 mg/L spike in nitrite-nitrogen concentration one month later. Neither spike resulted in noticeable mortality. Sodium bicarbonate was used to maintain pH, which got as low as 7.0. The aeration system was effective at maintaining dissolved-oxygen levels above 6.5 mg/L.

There was 15 cm of tank freeboard above the water surface and 46 cm of vertical netting surrounding the tank. Regardless, 457 shrimp jumped out of the growout tank during this project, mostly on two occasions. Netting was then placed tightly over the top of the tank, which prevented shrimp from escaping. Lights turned on and off in the building may have startled the shrimp, resulting in much of the jumping.

Shrimp were grown in the growout tank for 98 days. Shrimp weighed 24.3 g at harvest and there were 91.8 kg harvested. Survival was 69.1%, although adding the shrimp that jumped out of the tank would have made the survival 80%. The feed-conversion rate was 1.3:1, and the growth rate was 1.7 g/week. The shrimp performance is summarized in Table 1.

Harvested shrimp were sold at a farmers market in Frankfort, Kentucky, USA, where farmers are able to sell a variety of products directly to consumers. Frankfort has a population of approximately 27,500 residents, who had a mean annual per-capita income in 2013 of U.S. $24,100. The shrimp were sold fresh on ice at $26.40/kg. A total of 37.2 kg were sold at this market in only an hour and a half. Also, samples of shrimp were cooked and offered to patrons at the market.

Table 1. Shrimp performance during the first production trial.

Parameter	Value
Final weight (g)	24.3
Growth rate (g/week)	1.7
Biomass (kg/m^3)	4.6
Feed-conversion ratio	1.3
Survival (%)	69.1

Recirculating aquaculture techniques are being developed at the KSU Aquaculture Production Technologies Laboratory.

Shrimp were dispersed to chefs in Louisville, Kentucky, through two distribution centers. Shrimp were also given to two chef/restaurant owners and a grocery store in Lexington, Kentucky.

Survey

Consumers and chefs who tried the shrimp were given a questionnaire. In total, five chefs and 27 consumers completed questionnaires. Their responses are outlined in Table 2.

The questions asked participants their opinions of the Kentucky-grown shrimp regarding taste, texture, freshness, size, overall and appearance. For each topic, the respondents could select: 1 = loved it, 2 = liked it, 3 = it's okay, 4 = disliked it or 5 = hated it.

Respondents were also asked what price they would expect to pay for the fresh whole shrimp, as well as the most they would pay for them. Their options were "will not buy," U.S. $17.60/kg or less, $19.80/kg, $22.00/kg, $24.20/kg, $26.40/kg, $28.60/kg, $30.80/kg, $33.00/kg, $35.20/kg, $37.40/kg, $39.60/kg, $41.80/kg and $44.00/kg or more.

Table 2. Mean responses from chefs and consumers who tasted the shrimp.

Question Topic	Chefs	Consumers
What is your opinion of the shrimp for:		
Taste	2.0 ± 0	1.3 ± 0.1
Texture	2.2 ± 0.5	1.3 ± 0.1
Freshness	1.0 ± 0	1.0 ± 0
Size	2.2 ± 0.2	1.3 ± 0.1
Overall	2.2 ± 0.2	1.1 ± 0.1
Appearance	1.8 ± 0.2	1.1 ± 0.1
What price would you expect to pay? (U.S. $/kg)	21.6 ± 2.4	25.9 ± 2.3
What is the maximum you would pay? (U.S. $/kg)	26.0 ± 2.5	28.6 ± 1.5

Responses were rated 1 to 5, with 1 the best rating.

Costs

The recurring costs of nursery and growout production for this project were approximately U.S. $12.10/kg. Calculated at $0.04/kWh, electricity fees accounted for 25% of production costs. Labor at $10.00/hour accounted for 28%, while feed reflected 29% of the total costs. Postlarvae at 16% and other consumables at 2% made up the remainder of the total.

If 14 growout tanks were used, one tank could be harvested weekly all year. If more tanks were used, an economy of scale effect should be realized, bringing down costs. Other cost considerations include heating the air, infrastructure, taxes and distribution. These should be considered carefully and vary depending on a farmer's circumstances.

Perspectives

Shrimp grew very well during this project. They had an efficient feed conversion, and a substantial amount of the mortality that occurred could easily be prevented. Survey respondents were very accepting of the product and scored it highly. Consumers appeared willing to pay more than chefs, possibly because chefs are motivated more by the profitability of their restaurants.

The highest-scoring attribute was freshness of the product, a quality that cannot easily be achieved without year-round, indoor, local shrimp production. A direct-to-consumer approach for shrimp sales could prove to be profitable. At a sale price of U.S. $26.40/kg, there appears to be room for profit, and according to survey responses, a higher price may be acceptable to consumers.

Future efforts at KSU will focus on increasing shrimp stocking density and survival to enhance production output and augment the potential profitability of this approach. The sale of live shrimp will also be explored.