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Comparison of Tilapia Production in 1-m^3 and 4-m^3 LVHD Cages with a Soy-Based Feed

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INTRODUCTION

A feeding trial was jointly conducted by the American Soybean Association International Marketing (ASA-IM) program and the Beijing Municipal Fishery Extension Center to compare production of tilapia in 1-m^3 and 4-m^3 cages using a soy-based feed and the ASA-IM Low Volume High Density (LVHD) cage technology. The feeding trial was conducted in Ding Rong Reservoir near Wenchang, Hainan Province, China. The reservoir is under the jurisdiction of the Hainan Fish Breeding Center of the Beijing Municipal Fishery Extension Center.

LVHD CAGES

ASA-IM has conducted successful feeding trials with a variety of fish species in 1-m^3 and 4-m^3 LVHD cages over many years. While it has been generally agreed that there is no difference in fish performance in 1-m^3 and 4-m^3 cages, a comparison study has not been conducted by the ASA-IM/China program to verify this. To clarify the consensus that there are no differences in fish production between the two LVHD cage sizes, a 2006 feeding trial was conducted to evaluate tilapia production performance and economic return with the ASA-IM 32/6 feed[1] in the two LVHD cage sizes that are used by the ASA-IM program, i.e. 1-m^3 and 4-m^3.

The trial was conducted over a 4-month period. Data on fish survival, gross and net production, average fish weight, and feed conversion efficiency were obtained at harvest for all cages. All fish from each cage were counted and weighed at harvest to obtain this data. Data on production input costs was recorded throughout the trial to determine the economic return of the cage sizes.

[1] The numerical component of the feed description refers to the percentage of protein and fat, respectively, in the ration, i.e. 32/6 indicates 32% crude protein and 6% crude fat.

FEEDING TRIAL PROTOCOLS

Three, 1-m^3 LVHD cages and three, 4-m^3 LVHD cages were used in the feeding trial to assess the impact of cage size on tilapia production. Tilapia in all cages were fed to satiation twice daily with the ASA-IM 32/6 growout feed (Tables 1-3). Fish in all cages received the same amount of feed per unit of cage volume at each feeding. All feed was fed in extruded, floating pellet form.

Monosex, all-male GIFT strain tilapia previously obtained from the Philippines were used for the trial. The monosex tilapia were produced at the Hainan Fish Breeding Center Fish Farm. Tilapia were stocked in all six LVHD cages at a density of 400 fish per m^3 of cage volume. Mean weight of the tilapia in all cages at stocking was 50 g. Tilapia were stocked in the six trial cages on 13 June 2006 and fed for 117 days. The target harvest size for tilapia in all cages was 500 g, representing a fish biomass at harvest of 200 kg/m^3 of cage volume.

FEEDING TRIAL RESULTS

There was no difference in the average weight of individual tilapia in the 1-m^3 and 4-m^3 cages at harvest. There were significant differences in fish production per unit of cage volume, feed conversion ratio (FCR), fish survival, net economic return and return on investment (ROI) that favored the 1-m^3 cages (Table 4).

Tilapia in each cage received a total of 257.6 kg of feed per m^3 of cage volume during the 117 days of feeding. Tilapia grew from 50 g to an average weight of 628 g in both the 1-m^3 and 4-m^3 LVHD cages (Table 4). Fish survival rate and feed conversion efficiency were significantly better, however, in the 1-m^3 cages than in the 4-m^3 cages. Average fish survival in the 1-m^3 cages was 96%, compared to 83% in the 4-m^3 cages. Average FCR for fish in the three 1-m^3 cages was 1.16:1, in comparison to 1.37:1 for fish in the 4-m^3 cages. The difference in FCR between the 1-m^3 and 4-m^3 cages was the result of lower fish survival in the 4-m^3 cages, rather than poorer feed utilization efficiency.

Tilapia production per unit of cage volume averaged 241 kg/m^3 in the 1-m^3 cages, and 208 kg/m^3 in the 4-m^3 cages (Table 4). Net income averaged RMB 487/m^3 (\$61.65/m^3) for the three 1-m^3 LVHD cages, and RMB 262/m^3 (\$33.14/m^3) for the three 4-m^3 cages (Table 4). Average ROI was 42.3% for the 1-m^3 cages and 22.7% for the 4-m^3 cages. Differences in production per unit of cage volume, net income and ROI were also the result of differences in fish survival between the two cage sizes.

SUMMARY AND CONCLUSIONS

Tilapia grew rapidly and efficiently on the ASA-IM 32/6 soy-based feed in both LVHD cage sizes. Fish in both cage sizes exceeded the 500-g target harvest weight by 26% in just 117 days of feeding. There was no difference in average fish weight at harvest for the two cage sizes. Results of the comparison of overall productivity between 1-m^3 and 4-m^3 cages were deemed inconclusive, however, due to water quality conditions. Poorer fish performance and economic return from the 4-m^3 LVHD cages than the 1-m^3 cages

were determined to be primarily the result of the impact of declining water quality on fish health in Ding Rong Reservoir near the end of the trial.

The surface area of Ding Rong Reservoir is 1,700 mu (113 ha). This water area is sufficient for sustainable cage production of 35-40 mt of fish. At an average fish biomass of 200 kg/m^3 in LVHD cages, Ding Rong Reservoir can support the operation of 175-200 m^3 of LVHD cages, or approximately 50, 4-m^3 LVHD cages. In 2006, fish farmers operated 1,760 m^3 of LVHD cages (440 cages of size 4-m^3 per cage) in Ding Rong Reservoir, which was approximately nine times the sustainable level. Fish biomass at the end of the production season was estimated to be in excess of 250 mt, or seven to eight times the 35-40 mt carrying capacity of Ding Rong Reservoir. The excessive number of cages and fish, and the resulting excessive feed input, had a significant impact on water quality. The net effect was a decline in water quality that became worse as the fish grew larger and the feed input increased. The impact of declining water quality was greatest near the end of the production cycle when fish biomass and feed input were highest, and resulted in higher fish mortality in the 4-m^3 cages than in the 1-m^3 cages. The situation was exacerbated by intensive duck culture in the reservoir that contributed an additional nutrient load to the water.

ASA-IM strongly encourages the cage fish farmers in Ding Rong Reservoir to decrease the number of cages in the reservoir to a sustainable level. Decreasing the number of cages, and subsequently the feed input, is the only way to prevent excessive organic matter accumulation that leads to low dissolved oxygen and reservoir turnovers that cause catastrophic fish losses.

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Table 1. Formula for the ASA-IM 32/6 soy-based feed used in the 2006 tilapia LVHD cage feeding trial in Ding Rong Reservoir, Hainan Province, China. The feed was fed in extruded, floating pellet form. The feed was produced as a least-cost formulation by Techbank Feed Mill, Shanghai, under supervision of ASA-IM. Individual batches of feed produced over the trial duration may have varied in ingredient composition due to differences in specific ingredient nutrient profiles and ingredient availability.

Ingredient	Percent of total
Soybean Meal 46%	51.00
Wheat Middlings 14%	14.00
Wheat Flour 11%	12.00
DDGS, 27/10	11.50
Fish Meal, 65/8	3.00
Ca Phosphate Mono 21%	2.00
Soy Oil	1.50
Soy Lecithin	1.50
Corn Gluten Meal 60%	1.50
Fish Oil	1.20
Vit PMX F-2	0.50
Min PMX F-1	0.25
Stay C – 35%	0.03
Ethoxyquin, SQ mixture 6	0.02
TOTAL	100.00

Table 2. Calculated nutritional profile of the ASA-IM 32/6 soy-based feed used in the 2006 tilapia LVHD cage feeding trial in Ding Rong Reservoir, Hainan Province, China. The feed was produced in extruded, floating pellet form.

Nutrient	Value, As Fed
DE Fish (extruded)	2369.68
NFE	39.83
Starch	17.89
Protein, crude	32.74
Protein, digestible	29.82
Fish Protein	1.95
Soy Protein	23.46
Fat	6.07
W-3 (omega 3 fatty acid)	0.57
W-6 (omega 6 fatty acid)	2.08
Ash	6.06
Calcium	0.60
Phosphorus, available	0.61
Choline	2469.93
Vitamin C	105.00
Ethoxyquin	134.50
Arginine	2.06
Isoleucine	1.63
Lysine	1.85
Methionine	0.50
Methionine + Cystine	1.00

Table 3. Vitamin and mineral premix formulations included in the ASA-IM 32/6 soy-based feed used in the 2006 tilapia LVHD cage feeding trial in Ding Rong Reservoir, Hainan Province, China. Quantities of vitamins and minerals are per kilogram of premix.

Ingredient	Unit	Amount
Vitamin Premix F-2		
Vitamin A	IU/kg	1,200,000
Vitamin D3	IU/kg	200,000
Vitamin E	IU/kg	20,000
Vitamin K	mg/kg	0
Vitamin C	mg/kg	0
Biotin	mg/kg	40
Choline	mg/kg	0
Folic Acid	mg/kg	1,800
Inositol	mg/kg	0
Niacin	mg/kg	40,000
Pantothenate	mg/kg	20,000
Pyridoxine (B6)	mg/kg	5,000
Riboflavin (B2)	mg/kg	8,000
Thiamin (B1)	mg/kg	8,000
Vitamin B12	mcg/kg	2,000
Ethoxyquin	mg/kg	500
Mineral Premix F-1		
Iron	ppm	40,000
Manganese	ppm	10,000
Copper	ppm	4,000
Zinc	ppm	40,000
Iodine	ppm	1,800
Cobalt	ppm	20
Selenium	ppm	200

Table 4. Results of the 2006 ASA-IM aquaculture trial in Ding Rong Reservoir, Hainan that compared fingerling to market growth performance of monosex tilapia in 1-m^3 and 4-m^3 LVHD cages when fed the ASA-IM 32/6 soy-based feed.

Cage No.	Cage size	Stocking size (g)	Stocking rate (fish/m^3)	No. days fed	Harvest wt (g/fish)	P_G[1] (kg/m^3)	Survival (%)	FCR feed only	Net income (RMB/m^3)[2]	ROI (%)
1	1-m^3	50	400	117	592.0	234.5	99.0	1.20	442	38.3
2	1-m^3	50	400	117	666.4	247.9	93.0	1.13	533	46.2
3	1-m^3	50	400	117	628.7	241.2	96.0	1.16	487	42.3
Mean		50	400	117	628.8	241.2	96.0	1.16	487	42.3
4	4-m^3	50	400	117	643.2	198.1	77.1	1.45	195	16.9
5	4-m^3	50	400	117	622.5	212.5	85.4	1.34	292	25.3
6	4-m^3	50	400	117	618.0	213.5	86.4	1.33	299	25.9
Mean		50	400	117	627.9	208.0	83.0	1.37	262	22.7

[1]P_G = Gross Production

[2]RMB exchange rate: RMB 7.9 = $1.00