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# **Soy Protein Concentrate as a Replacement for Fishmeal in the Fingerling Diet for Common Carp, Grass Carp, Tilapia and Channel Catfish**

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## **INTRODUCTION**

A series of feeding trials was conducted cooperatively by the American Soybean Association International Marketing (ASA-IM) program, the Heilongjiang Provincial Fishery Extension Center, the Taixing Fish Stock Farm of Jiangsu Province, the Jiangxi Provincial Fishery Extension Center, the Hainan Fish Breeding Center of the Beijing Municipal Fishery Extension Center, and the Aquaculture Nutrition and Feed Lab of the Feed Research Institute of the Chinese Academy of Agricultural Sciences to evaluate a soy protein fingerling feed for key cultured freshwater fish species in China. The soy protein fingerling feed used soy protein concentrate (SPC) as a replacement for fishmeal in the ASA-IM 36/7<sup>1</sup> fingerling feed. Feeding trials comparing the standard ASA-IM 36/7 feed with fishmeal (36/7 FM) and the soy protein 36/7 feed with SPC (36/7 SPC) were conducted during the 2007 aquaculture production season at five locations in China with common carp, grass carp, tilapia and channel catfish. The objectives of replacing fishmeal with SPC in the fingerling feed were: 1) to provide feed millers with an option to fishmeal as a means to reduce feed cost associated with the rising price of fishmeal; and 2) to improve industry sustainability by providing a fingerling feed in which the majority of protein is supplied from renewable plant sources.

## **2007 FEEDING TRIAL PROTOCOLS AND RESULTS**

### **Common Carp**

Production of common carp fingerlings with the 36/7 FM and 36/7 SPC feeds was evaluated in a pond trial at the extension demonstration fish farm of the Heilongjiang Provincial Fishery Extension Center in Harbin using the Songpu carp strain. Advanced common carp fry of size 0.5-g were stocked in six ponds at a density of 4,000 fish per mu

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<sup>1</sup>The numerical component of the feed description refers to the percentage of protein and fat, respectively, in the ration, i.e. 36/7 indicates 36% crude protein and 7% crude fat.

(60,000 fish/ha), together with 1,000 silver carp fry per mu (15,000/ha), in mid June 2007. Common carp in all six ponds were fed the ASA-IM 41/11 fry feed from size 0.5-g to size 2-3 g, at which time the fish were weaned to either the 36/7 FM or 36/7 SPC diet. Common carp in three of the ponds were fed the 36/7 FM feed for 69 days, while common carp in the other three ponds were fed the 36/7 SPC feed for the same duration. The 36/7 FM feed contained 13.5% fishmeal (Table 1), while the 36/7 SPC feed replaced fishmeal with 65% crude protein animal grade SPC (Table 2). The animal grade SPC was produced by ADM in China under the trade name Soycomil. Supplemental methionine (MHA 84%) was included in the 36/7 SPC feed to make it methionine equivalent to the 36/7 FM diet. The 36/7 FM and 36/7 SPC feeds were formulated to be nutritionally equivalent (Table 3).

The two 36/7 feeds were fed in extruded, floating pellet form, with an initial feed pellet size of 1.5-mm. Common carp in all ponds were fed to satiation twice daily using the ASA-IM 90% average satiation feeding technique, with fish in the three replicate ponds of each feed treatment receiving an identical amount of feed each day and at each feeding. All feeds were produced by the Ningbo Techbank Feed Mill in China. Pond management was based on the ASA-IM 80:20 model.

There was no difference in common carp performance with the two fingerling diets. Common carp fed the 36/7 SPC feed grew from 0.5 g to an average weight of 135.5 g per fish during the 69-day trial, while common carp fed the 36/7 FM feed grew from 0.5 g to an average weight of 132.0 g (Table 4). Fish biomass at harvest averaged 434.9 kg/mu (6,524 kg/ha) for common carp fed the 36/7 SPC feed and 446.6 kg/mu (6,699 kg/ha) for common carp fed the 36/7 FM feed. An additional 54.7 kg/mu (821 kg/ha) and 52.2 kg/mu (783 kg/ha) of silver carp were produced in each of the 36/7 SPC and 36/7 FM fed ponds, respectively. The average feed conversion ratio (FCR) for common carp fed the 36/7 SPC feed was 1.13:1. Average FCR for common carp fed the 36/7 FM feed was 1.10:1. The average survival rate for common carp was 80.5% in the 36/7 SPC ponds and 84.6% in the 36/7 FM ponds. There were no significant differences ( $P>0.05$ ) in common carp fingerling growth, harvest biomass, FCR or survival with the two feeds.

### **Grass Carp**

Production of grass carp fingerlings with the 36/7 FM and 36/7 SPC feeds was evaluated in a pond trial at the Taixing Fish Stock Farm in Taixing, Jiangsu Province. Grass carp fry of size 0.6-g were stocked in six ponds at a density of 5,000 fish per mu (75,000 fish/ha), together with 1,000 silver carp fry per mu (15,000/ha), in early June 2007. Grass carp in all six ponds were fed the ASA-IM 41/11 fry feed from size 0.5-g to size 2-3 g, at which time the fish were weaned to either the 36/7 FM or 36/7 SPC diet. Grass carp in three of the ponds were fed the 36/7 FM feed for 141 days, while grass carp in the other three ponds were fed the 36/7 SPC feed for the same duration.

The two 36/7 feeds were fed in extruded, floating pellet form, with an initial feed pellet size of 1.5-mm. Grass carp in all ponds were fed to satiation twice daily using the ASA-IM 90% average satiation feeding technique, with fish in the three replicate ponds of each feed treatment receiving an identical amount of feed each day and at each feeding. All

feeds were produced by the Ningbo Techbank Feed Mill in China. Pond management was based on the ASA-IM 80:20 model.

There was no difference in grass carp performance with the two fingerling diets. Grass carp fed the 36/7 SPC feed grew from 0.6 g to an average weight of 67.2 g per fish, while grass carp fed the 36/7 FM feed grew from 0.6 g to an average weight of 59.9 g (Table 5). Fish biomass at harvest averaged 240.8 kg/mu (3,612 kg/ha) for grass carp fed the 36/7 SPC feed and 236.3 kg/mu (3,545 kg/ha) for grass carp fed the 36/7 FM feed. An additional 75.9 kg/mu (1,139 kg/ha) and 66.4 kg/mu (996 kg/ha) of silver carp were produced in each of the 36/7 SPC and 36/7 FM fed ponds, respectively. The average feed conversion ratio (FCR) for grass carp fed the 36/7 SPC feed was 1.06:1. Average FCR for grass carp fed the 36/7 FM feed was 1.08:1. The average survival rate for grass carp was 72% in the 36/7 SPC ponds and 79% in the 36/7 FM ponds. There were no significant differences ( $P>0.05$ ) in grass carp fingerling growth, harvest biomass, FCR or survival with the two feeds.

### **Tilapia**

Production of tilapia fingerlings with the 36/7 FM and 36/7 SPC feeds was evaluated in a LVHD cage trial at Wenchang Reservoir in Wenchang, Haikou, Hainan Province. This trial was conducted in cooperation with the Hainan Fish Breeding Center of the Beijing Municipal Fishery Extension Center. Tilapia were monosex GIFT strain tilapia produced at the Hainan Fish Breeding Center. Tilapia of size 3 g were stocked into twelve 4-m<sup>3</sup> LVHD cages at a density of 12,000 fish per cage in late May 2007.

The two 36/7 feeds were fed in extruded, floating pellet form, with an initial feed pellet size of 1.5-mm. Tilapia in all cages were fed to satiation using the ASA-IM 90% average satiation feeding technique. Tilapia in four of the cages were fed the 36/7 FM feed twice daily for 79 days. Tilapia in another four cages were fed the 36/7 SPC feed twice daily for 79 days. Tilapia in the final four cages were fed the 36/7 SPC feed six times daily for 79 days. Tilapia fed twice daily were fed at 0800 and 1800 hours, and tilapia fed six times daily were fed at two hours intervals throughout the day beginning at 0800. Tilapia in the four replicate cages of each feed treatment received an identical amount of feed each day and at each feeding. All feeds were produced by the Ningbo Techbank Feed Mill in China.

There was no difference in tilapia performance with the two fingerling diets or feeding frequencies. Tilapia fed the 36/7 FM twice daily feed grew from 3 g to an average weight of 60.2 g per fish in 79 days (Table 6). Tilapia fed the 36/7 SPC feed twice daily grew from 3 g to an average weight of 61.3 g in the same period, while tilapia fed the 36/7 SPC feed six times daily grew from 3 g to an average weight of 61.3 g. Average FCR was 1.13:1 for the 36/7 FM feed fed twice daily, 1.17:1 for the 36/7 SPC feed fed twice daily, and 1.18:1 for the 36/7 SPC feed fed six times daily. The average survival rate for tilapia in all cages was 50-53%. Low survival was the result of disease. There were no significant differences ( $P>0.05$ ) in tilapia fingerling growth, harvest biomass, FCR or survival with the two feeds or the two and six feedings per day. Results were deemed inconclusive, however, due to the low survival rate of tilapia in all twelve test cages. The study will be repeated in 2008 to verify the results.

### **Tilapia Protein Retention and Utilization**

A parallel study to the tilapia LVHD cage fingerling study in Hainan was conducted at the Aquaculture Nutrition and Feed Lab of the Feed Research Institute of the Chinese Academy of Agricultural Sciences (CAAS) in Beijing using the same tilapia stock as the Hainan trial. The purpose of the parallel Beijing study was to identify if there were differences in protein utilization and deposition efficiencies with the fishmeal and SPC-based feeds. The CAAS study evaluated tilapia growth, feed utilization and body composition with the 36/7 FM feed fed twice daily (FM2), the 36/7 SPC feed with supplemental methionine fed twice daily (SPCM2), the 36/7 SPC feed with supplemental methionine fed six times daily (SPCM6), and the 36/7 SPC feed without supplemental methionine fed six times daily (SPC6). Evaluations were made of tilapia feed intake, specific growth rate (SGR), feed conversion ratio (FCR), survival rate (SR), nitrogen retention efficiency (NRE), protein efficiency ratio (PER), condition factor (CF), hepatosomatic index (HSI), and visceral somatic index (VSI).

The CAAS study was conducted in indoor 260 liter fiberglass tanks with a recirculating flowing water system. Tilapia were hand fed the test diets to apparent satiation daily for eight weeks. Tilapia in the feed treatments fed twice daily were fed at 0900 and 1600 daily. Tilapia in the feed treatments fed six times daily were fed at two hour intervals beginning at 0700. Fish fed twice daily were given access to the feed for one hour, after which uneaten feed was collected, dried and weighed for calculating feed consumption. The same procedure was followed for fish fed six times daily, except that access to the feed was restricted to 40 minutes.

Best overall results were obtained with the FM2 and SPCM6 feed treatments (Table 7). There was no significant difference ( $P>0.05$ ) between the FM2 and SPCM6 feed treatments for all factors except PER. PER was significantly better for the FM2 diet. Both the FM2 and SPCM6 feed treatments yielded significantly ( $P<0.05$ ) better FCR than the SPCM2 and SPC6 feed treatments. Other factors varied by significance between the four feed treatments (Table 8). There were no significant differences in CF and VSI among all the treatments ( $P>0.05$ ).

### **Channel Catfish**

Production of channel catfish fingerlings with the 36/7 FM and 36/7 SPC feeds was evaluated in a pond trial at the Wanan Fishery Bureau Demonstration Fish Farm in Wanan County, Jiangxi Province. Channel catfish of size 2 g were stocked in six ponds at a density of 9,000 fish per mu (135,000 fish/ha), together with 1,000 silver carp fry per mu (15,000/ha), in July 2007. Channel catfish in three of the ponds were fed the 36/7 FM feed for 122 days, while channel catfish in the other three ponds were fed the 36/7 SPC feed for the same duration.

The two 36/7 feeds were fed in extruded, floating pellet form, with an initial feed pellet size of 1.5-mm. Channel catfish in all ponds were fed to satiation twice daily using the ASA-IM 90% average satiation feeding technique, with fish in the three replicate ponds of each feed treatment receiving an identical amount of feed each day and at each feeding.

All feeds were produced by the Ningbo Techbank Feed Mill in China. Pond management was based on the ASA-IM 80:20 model.

Channel catfish performance was better with the 36/7 FM diet than the 36/7 SPC diet. Channel catfish fed the 36/7 SPC feed grew from 2 g to an average weight of 52.3 g per fish, while channel catfish fed the 36/7 FM feed grew from 2 g to an average weight of 61.5 g (Table 8). Fish biomass at harvest averaged 413 kg/mu (6,195 kg/ha) for channel catfish fed the 36/7 SPC feed and 465 kg/mu (6,975 kg/ha) for channel catfish fed the 36/7 FM feed. An additional 109.7 kg/mu (1,646 kg/ha) and 107.3 kg/mu (1,610 kg/ha) of silver carp were produced in each of the 36/7 SPC and 36/7 FM fed ponds, respectively. The average feed conversion ratio (FCR) for channel catfish fed the 36/7 SPC feed was 1.21:1. Average FCR for channel catfish fed the 36/7 FM feed was 1.07:1. The average survival rate for channel catfish was 87.9% in the 36/7 SPC ponds and 84.2% in the 36/7 FM ponds. Catfish growth, production and FCR were all better with the 36/7 FM feed. There was no difference in fish survival with the two feeds.

## **SUMMARY AND CONCLUSIONS**

Results of the five studies indicate that soy protein concentrate can be substituted for fishmeal in the fingerling diet for common carp, grass carp, tilapia and channel when these species are produced in ponds and cages. No differences in fish growth, harvest biomass, FCR or survival were found with common carp, grass carp and tilapia fed the fingerling feed in which soy protein concentrate replaced fishmeal. Channel catfish yielded better growth and FCR with the 36/7 FM diet than with the 36/7 SPC diet, but both catfish growth (2 g to 52 g in 122 days) and FCR (1.2:1) were acceptable with the 36/7 SPC feed. Results of the study with tilapia in closed, recirculating tanks in Beijing indicate value in increasing the number of daily feedings in tank cultures when feeding the 36/7 SPC feed with supplemental methionine.

The collective results indicate that SPC supplemented with methionine can be used as a substitute for fishmeal in the ASA-IM 36/7 feed to formulate a soy protein feed for key freshwater fish species cultured in ponds and cages. Feed mills are encouraged to incorporate animal grade SPC 65% in their fingerling feed formulations when it is cost effective to do so. Use of SPC as a fishmeal replacement in the fingerling diet of freshwater fish species cultured in China can reduce demand on the limited supply of fishmeal, help stabilize feed prices, and provide feed millers and fish producers with a renewable plant protein option to fishmeal that will better ensure industry sustainability.

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the Feed Research Institute of the Chinese Academy of Agricultural Sciences, and Yihai Group Goldensea Food Industry Co. Ltd. and Archer Daniels Midland Co. (ADM) for the significant time, facilities and SPC product contributed to conduct the studies detailed in this report.

Table 1. Formula for the 36/7 FM fingerling feed containing fishmeal used in the 2007 ASA-IM common carp, grass carp, tilapia and channel catfish fingerling pond feeding trials in China. The 36/7 FM feed is the standard fingerling feed used by ASA-IM to produce fingerlings of carp, tilapia and catfish stocks from fish size 2-3 g to fish size 50-100 g. .

Ingredient	Percent of total
Soybean Meal 46%	42.00
Wheat Flour 11.7%	20.90
Fish Meal, Anchovy 65/7.5	13.50
DDGS 24/12	10.00
Corn Gluten Meal 60%	5.00
Soy Lecithin/Corn Blend	3.00
Fish Oil (imported)	2.60
Ca Phosphate Mono 21%	1.60
Soy Oil	0.50
Vit PMX F-2	0.50
Min PMX F-1	0.25
Mold Inhibitor	0.10
Stay C 35%	0.03
Ethoxyquin, Liquid, 60%	0.02
TOTAL	100.00

Table 2. Formula for the 36/7 SPC fingerling used in the 2007 ASA-IM common carp, grass carp, tilapia and channel catfish fingerling pond feeding trials in China. The 36/7 SPC feed is formulated to be nutritionally equivalent to the 36/7 FM feed, but replaces fishmeal with soy protein concentrate.

Ingredient	Percent of total
Soybean Meal 46%	30.00
Wheat Middlings 14%	18.50
Soy Protein Concentrate 65% cn	16.00
Wheat Flour 11.7%	14.00
Corn Gluten Meal 60%	5.00
Blood Meal SD 90/0.5	5.00
Soy Lecithin/Corn Blend	3.00
Fish Oil (imported)	3.00
Ca Phosphate Mono 21%	2.70
Soy Oil	1.50
Vit PMX F-2	0.50
Min PMX F-1	0.25
Choline Chloride 50%	0.21
MHA (methionine) 84%	0.19
Mold Inhibitor	0.10
Stay C 35%	0.03
Ethoxyquin, Liquid, 60%	0.02
TOTAL	100.00

Table 3. Calculated nutritional profiles of the ASA-IM 36/7 FM and 36/7 SPC fingerling diets tested in feeding trials with common carp, grass carp, tilapia and channel catfish in China in 2007.

Nutrient	Value, As Fed	
	36/7 FM	36/7 SPC
DE Fish (extruded)	2828	2841
NFE	34.78	35.59
Starch	18.05	19.52
Protein, crude	36.08	36.13
Protein, digestible	33.29	33.72
Fish Protein	8.78	0.00
Soy Protein	19.32	24.20
Fat	7.12	6.95
W-3 (omega 3 fatty acid)	1.01	0.99
W-6 (omega 6 fatty acid)	1.62	1.81
Fiber	3.49	4.00
Ash	6.99	6.62
Calcium	0.93	0.63
Phosphorus, available	0.70	0.70
Choline	2472	2501
Vitamin C	105	105
Ethoxyquin	147	149
Arginine	2.18	2.23
Lysine	2.11	2.22
Methionine	0.69	0.69
Methionine + Cystine	1.20	1.24
Threonine	1.43	1.43
Tryptophan	0.40	0.41

Table 4. Results of the 2007 ASA-IM aquaculture trial in Harbin that compared common carp fingerling production in ponds with the standard ASA-IM 36/7 fingerling feed with fishmeal (36/7 FM) and a nutritionally equivalent feed in which the fishmeal was replaced with soy protein concentrate (36/7 SPC).

Feed treatment	CoC <sup>1</sup> stocking size (g)	Stocking rate (fish/mu)	No. days fed	Harvest wt. (g)		P <sub>G</sub> <sup>3</sup> (kg/mu)		Survival (%)		FCR
				CoC	SiC <sup>2</sup>	CoC	SiC	CoC	SiC	
36/7 FM	0.5	4,000	69	130	58	432.9	51.7	83.3	89.9	1.13
36/7 FM	0.5	4,000	69	126	59	431.7	52.7	85.7	89.1	1.14
36/7 FM	0.5	4,000	69	140	58	475.2	52.1	84.9	89.4	1.03
Mean	0.5	4,000	69	132	58	446.6	52.2	84.6	89.5	1.10
36/7 SPC	0.5	4,000	69	142	62	440.3	55.3	77.5	89.3	1.11
36/7 SPC	0.5	4,000	69	144	62	457.0	56.0	79.4	90.1	1.07
36/7 SPC	0.5	4,000	69	121	59	407.3	52.7	84.5	89.7	1.21
Mean	0.5	4,000	69	136	61	434.9	54.7	80.5	98.7	1.13

<sup>1</sup>CoC = Common Carp

<sup>2</sup>SiC = Silver Carp

<sup>3</sup>P<sub>G</sub> = Gross Production

Table 5. Results of the 2007 ASA-IM aquaculture trial in Taixing that compared grass carp fingerling production in ponds with the standard ASA-IM 36/7 fingerling feed with fishmeal (36/7 FM) and a nutritionally equivalent feed in which the fishmeal was replaced with soy protein concentrate (36/7 SPC).

Feed treatment	GrC <sup>1</sup> stocking size (g)	Stocking rate (fish/mu)	No. days fed	Harvest wt. (g)		P <sub>G</sub> <sup>3</sup> (kg/mu)		Survival (%)		FCR
				GrC	SiC <sup>2</sup>	GrC	SiC	GrC	SiC	
36/7 FM	0.6	5,000	141	60.3	69	240.0	64.1	79.6	93.5	1.06
36/7 FM	0.6	5,000	141	59.2	69	238.9	65.9	80.7	95.1	1.07
36/7 FM	0.6	5,000	141	60.1	74	230.0	69.1	76.5	94.0	1.11
Mean	0.6	5,000	141	59.9	70	236.3	66.4	78.9	94.2	1.08
36/7 SPC	0.6	5,000	141	71.7	83	241.4	82.7	67.3	92.1	1.06
36/7 SPC	0.6	5,000	141	69.3	74	245.0	73.1	70.7	90.9	1.04
36/7 SPC	0.6	5,000	141	60.6	71	235.9	70.4	77.9	93.2	1.08
Mean	0.6	5,000	141	67.2	76	240.8	75.4	72.0	92.0	1.06

<sup>1</sup>CoC = Common Carp

<sup>2</sup>SiC = Silver Carp

<sup>3</sup>P<sub>G</sub> = Gross Production

Table 6. Results of the 2007 ASA-IM aquaculture trial in Haikou, Hainan, that compared tilapia fingerling production in 4-m<sup>3</sup> LVHD cages with the standard ASA-IM 36/7 fingerling feed with fishmeal (36/7 FM) fed twice daily and a nutritionally equivalent feed in which the fishmeal was replaced with soy protein concentrate fed either two (36/7 SPC2) or six times daily (36/7 SPC6).

Feed treatment	Fish stocking size (g)	Stocking rate (fish/cage)	No. days fed	Harvest wt. (g)	Production (kg/m <sup>3</sup> )	Survival (%)	FCR
36/7 FM	3	12,000	79	60.2	101.5	56.2	1.06
36/7 FM	3	12,000	79	60.6	96.9	53.3	1.11
36/7 FM	3	12,000	79	60.6	95.7	52.6	1.13
36/7 FM	3	12,000	79	59.6	89.9	50.2	1.21
Mean	3	12,000	79	60.2	96.0	53.1	1.13
36/7 SPC2	3	12,000	79	63.1	94.9	50.1	1.14
36/7 SPC2	3	12,000	79	61.0	91.9	50.2	1.18
36/7 SPC2	3	12,000	79	60.6	91.0	50.1	1.19
36/7 SPC2	3	12,000	79	60.3	92.1	50.9	1.18
Mean	3	12,000	79	61.3	92.5	50.3	1.17
36/7 SPC6	3	12,000	79	63.7	97.3	45.6	1.25
36/7 SPC6	3	12,000	79	60.1	95.3	52.9	1.13
36/7 SPC6	3	12,000	79	61.2	96.1	52.3	1.13
36/7 SPC6	3	12,000	79	60.3	90.8	50.2	1.20
Mean	3	12,000	79	61.3	92.3	50.3	1.18

Table 7. Results of the CAAS/Beijing study that evaluated tilapia growth, feed utilization and body composition with the 36/7 FM feed fed twice daily (FM2), the 36/7 SPC feed with supplemental methionine fed twice daily (SPCM2), the 36/7 SPC feed with supplemental methionine fed six times daily (SPCM6), and the 36/7 SPC feed without supplemental methionine fed six times daily (SPC6).

Factor	FM2	SPCM2	SPCM6	SPC6
Initial weight (g)	1.57±0.00	1.57±0.00	1.57±0.00	1.57±0.00
Final weight (g)	53.16±3.68 <sup>bc</sup>	44.40±1.14 <sup>a</sup>	55.53±1.38 <sup>c</sup>	47.35±2.16 <sup>ab</sup>
Specific Growth Rate	6.27±0.12 <sup>bc</sup>	5.97±0.05 <sup>a</sup>	6.37±0.04 <sup>c</sup>	6.07±0.08 <sup>ab</sup>
Feed Intake	3.21±0.04 <sup>a</sup>	3.36±0.04 <sup>bc</sup>	3.29±0.02 <sup>ab</sup>	3.42±0.03 <sup>c</sup>
FCR	0.95±0.01 <sup>a</sup>	1.01±0.01 <sup>b</sup>	0.97±0.00 <sup>a</sup>	1.02±0.01 <sup>b</sup>
Nitrogen Retention Efficiency	42.67±0.42 <sup>a</sup>	40.52±0.75 <sup>b</sup>	41.07±0.86 <sup>ab</sup>	40.42±0.38 <sup>b</sup>
Protein Efficiency Ratio	2.76±0.02 <sup>a</sup>	2.56±0.03 <sup>c</sup>	2.65±0.01 <sup>b</sup>	2.57±0.02 <sup>c</sup>
Condition Factor	2.07±0.05	2.15±0.02	2.15±0.02	2.11±0.02
Hepatosomatic Index	1.47±0.08 <sup>ab</sup>	1.58±0.12 <sup>ab</sup>	1.28±0.05 <sup>a</sup>	1.78±0.16 <sup>b</sup>
Visceral Somatic Index	8.85±0.61	8.46±0.14	8.00±0.22	8.90±0.24
Whole Body Composition				
Moisture	72.1±0.5	72.4±0.5	72.7±0.4	71.9±0.4
Crude Protein*	15.4±0.2	15.7±0.1	15.4±0.3	15.6±0.1

Values in the same row with different superscripts are statistically different (P<0.05)

\*Crude protein is expressed on a wet weight basis

Table 8. Results of the 2007 ASA-IM aquaculture trial in Wanan, Jiangxi Province, that compared channel catfish fingerling production in ponds with the standard ASA-IM 36/7 fingerling feed with fishmeal (36/7 FM) and a nutritionally equivalent feed in which the fishmeal was replaced with soy protein concentrate (36/7 SPC).

Feed treatment	ChC <sup>1</sup> stocking size (g)	Stocking rate (ChC/mu)	No. days fed	Harvest wt. (g)		P <sub>G</sub> <sup>3</sup> (kg/mu)		Survival (%)		FCR
				ChC	SiC <sup>2</sup>	ChC	SiC	ChC	SiC	
36/7 FM	2.16	9,000	122	65.8	105	476.7	104.8	80.5	99.5	1.04
36/7 FM	2.16	9,000	122	60.7	107	447.5	105.5	81.9	99.0	1.11
36/7 FM	2.16	9,000	122	58.1	112	471.7	111.5	90.2	99.3	1.05
Mean	2.16	9,000	122	61.5	108	465.3	107.3	84.2	99.3	1.07
36/7 SPC	2.16	9,000	122	51.4	105	415.2	104.7	89.8	99.8	1.20
36/7 SPC	2.16	9,000	122	54.5	106	434.9	105.1	88.6	99.2	1.14
36/7 SPC	2.16	9,000	122	50.9	120	389.7	119.4	85.2	99.5	1.28
Mean	2.16	9,000	122	52.3	110	413.3	109.7	87.9	99.5	1.21

<sup>1</sup>ChC = Channel Catfish

<sup>2</sup>SiC = Silver Carp

<sup>3</sup>P<sub>G</sub> = Gross Production