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Soy Protein Concentrate as a Substitute for Fishmeal in the Feed for Black Carp

Results of the 2008 Beijing Feeding Trial

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INTRODUCTION

A pond feeding trial was conducted by the American Soybean Association International Marketing (ASA-IM) program, in cooperation with the China National Fisheries Technology Extension Center (NEC) and the Beijing Municipal Fishery Technology Extension Center (BFTEC), to demonstrate the value of soy protein concentrate (SPC) as a substitute for fishmeal in the growout feed for black carp. Three previous ASA-IM feeding trials conducted in 2006 and 2007 had demonstrated the value of the ASA-IM 36/7¹ soy-based feed for culturing black carp. In two trials in 2006, black carp grew from 250 g to 855 g in 113 days with an FCR of 1.08:1, and from 51 g to 693 g in 131 days with an average FCR of 1.32:1 with the 36/7 feed. In a 2007 trial, black carp grew from 600 g to 2.24 kg in 113 days with an FCR of 1.39:1 with the 36/7 feed. The feed in both the 2006 and 2007 trials contained an average of 43% dehulled soybean meal and 13.25% fish meal.

The 2008 black carp feeding trial compared black carp performance with the standard 36/7 feed containing fishmeal that was used in the 2006 and 2007 black carp feeding trials, and a nutritionally equivalent 36/7 feed in which fishmeal was replaced by SPC. The objective was to demonstrate to fish farmers and feed millers that SPC could be used as a substitute for fishmeal to provide a renewable, all-plant protein feed that would allow for greater feed formulation flexibility and improved industry sustainability.

2008 FEEDING TRIAL PROTOCOLS

The 2008 black carp feeding trial was conducted at the NEC Demonstration Fish Farm in Beijing, China. Black carp were stocked in six, 2.0-mu (0.13 ha) ponds at a density of 600 fish per mu (9,000/ha), together with 100 silver carp fingerlings per mu (1,500/ha).

¹ 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.

Average sizes of the black and silver carp at stocking were 178 g and 275 g , respectively. Target harvest size for the black carp was 750 g. Pond management was based on the ASA-IM 80:20 model.

Black carp were stocked in the three trial ponds on 23 May 2008. Feeding commenced the day of stocking and continued through 12 October 2008. Black carp were fed to satiation twice daily during this period using the ASA-IM 90% average satiation feeding technique. Black carp in three of the ponds were fed the standard ASA-IM 36/7 fingerling feed (36/7 FM) containing 20% fish meal, while black carp in the other three ponds were fed a nutritionally equivalent 36/7 feed in which SPC replaced all fishmeal (36/7 SPC) (Tables 1, 2 and 3). The 36/7 SPC feed was fortified with supplemental methionine, in the form of MHA 84, to make it methionine equivalent to the 36/7 FM feed.² All feed was fed in extruded, floating pellet form. The feed was manufactured by the Ningbo Techbank Feed Mill in China. SPC for the 36/7 SPC feed was produced in China and donated to ASA-IM by Archer Daniels Midland Company (ADM).

The six trial ponds were harvested between 12 and 14 October 2008. All fish from each of the trial ponds were weighed to obtain data on gross and net production and feed conversion efficiency for each individual pond. Sub-samples of fish were obtained from each pond to determine estimated fish survival and average fish weights for black and silver carp.

2008 FEEDING TRIAL RESULTS

The average weight for black carp at harvest exceeded the target market size of 750 g with both feeds, but black carp grew larger and yielded a higher harvest biomass with the 36/7 SPC feed than with the 36/7 FM feed. Black carp grew from 178 g to average weights of 1,297 g and 1,033 g with the 36/7 SPC and 36/7 FM feeds, respectively (Table 4). Black carp biomass at harvest averaged 507.6 kg/mu (7,614 kg/ha) in the 36/7 SPC ponds and 441.8 kg/mu (6,627 kg/ha) in the 36/7 FM ponds.

Silver carp grew from 280 g to 1,833 g in the 36/7 SPC ponds, and from 270 g to 1,650 g in the 36/7 FM ponds (Table 4). Black carp and silver carp represented 74% and 26%, respectively, of the total harvest biomass of 687 kg/mu (10,305 kg/ha) from the 36/7 SPC ponds, and 73% and 27%, respectively, of the harvest biomass of 605 kg/mu (9,074 kg/ha) from the 36/7 FM ponds.

The average survival rates for black carp and silver carp were 65.4% and 98%, respectively, in the 36/7 SPC feed ponds, and 71.5% and 99%, respectively, in the 36/7 FM feed ponds. The feed conversion ratio (FCR) for black carp with the soy-based 36/7 SPC feed averaged 1.57:1 for the three trial ponds. Average FCR with the fishmeal inclusion 36/7 FM feed was 1.87:1 for the three trial ponds.

² MHA 84 is a supplemental methionine product of NOVUS Co., and contains 84% methionine activity.

Average net economic return was a negative RMB 443/mu for the three 36/7 FM ponds, and a positive RMB 1,401 for the three 36/7 SPC ponds. However, the feed cost for the 36/7 SPC feed (RMB 4.5/kg) was 29% lower than the cost for the 36/7 FM feed (RMB 5.8/kg) because the SPC for the 36/7 SPC feed was donated to ASA-IM without charge by ADM. The economic return for the 36/7 SPC ponds at the equivalent feed cost of the 36/7 FM feed was a positive RMB 587/mu.

SUMMARY AND CONCLUSIONS

Results from the feeding trial indicate that black carp do not have a dietary requirement for fishmeal, and that in a properly formulated feed SPC can be used to replace fishmeal in the growout diet for black carp. Average FCR with the SPC diet was 16% better than with the 20% fishmeal inclusion diet, indicating a high level of acceptance by black carp of the all-plant protein, soy-based feed, both in terms of palatability and digestibility. FCR with both diets, however, was poorer in the 2008 trial than in the 2006 and 2007 black carp trials with the 36/7 FM feed. This may have reflected differences in pond conditions and/or fish stock quality between the test sites.

No drugs or chemicals were used in the ASA-IM black carp trial, allowing the harvest of high quality, uncontaminated fish that met the standard for a “green” product. Pond water quality remained good throughout the 2008 trial, with no observed incidences of water quality deterioration. Fish survival was lower than expected, with some fish mortality attributed by the cooperator to disease. However, neither the causative disease organisms nor a remedial treated were identified.

The three-year series of ASA-IM trials conducted with black carp have demonstrated that the ASA-IM soy-based 36/7 feed is a superior growout feed for black carp at all life stages, including first year fingerling, second year sub-market, and third year market growout to >2 kg. In addition, the 2008 trial demonstrated that SPC can fully substitute for fishmeal in the black carp growout diet, yielding as good or better growth and feed conversion efficiency as a diet with up to 20% fishmeal inclusion. Fish farmers and feed millers are encouraged to use the ASA-IM soy-based 36/7 feed for sustainable and economically viable feed-based production of black carp, and to utilize SPC as a substitute for fish meal in the diet for black carp when it is cost effective to do so.

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Table 1. Formulas for the ASA-IM fishmeal (36/7 FM) and soy protein concentrate (36/7 SPC) feeds used in the 2008 black carp feeding trial conducted at the National Fisheries Extension Technology Center Demonstration Fish Farm in Beijing. The 36/7 SPC feed is formulated to replace fishmeal with low antigen, animal grade SPC. Figures are expressed as a percentage of the as fed diet.

Ingredient	<u>36/7 FM</u>	<u>36/7 SPC</u>
Soybean Meal 46.5%	42.60	22.50
Wheat Middlings 16.5%	-----	16.40
Fishmeal, Anchovy 64.5%	20.00	-----
Soy Protein Concentrate 65% cn	-----	20.00
Wheat, Feed Flour 11.5%	30.00	20.00
Corn Gluten Meal 60%	-----	5.00
Blood Meal spr. 90/0.5	-----	5.00
Fish Oil, anchovy	1.00	2.70
Soy Oil	2.40	2.00
Soy Lecithin/Corn Blend	2.00	2.00
Ca Phosphate Mono 21%	1.10	3.05
Vit PMX F-2	0.50	0.50
Min PMX F-1	0.25	0.25
Choline Chloride 50%	-----	0.24
MHA (methionine) 84%	-----	0.21
Mold Inhibitor	0.10	0.10
Stay C 35%	0.03	0.03
Ethoxyquin, SQ Mixture 6	0.02	0.02
TOTAL	100.00	100.00

Table 2. Calculated nutritional profiles of the ASA-IM 36/7 FM and 36/7 SPC feeds evaluated in the 2008 black carp 80:20 pond feeding trial in Beijing, China.

Nutrient	Value, As Fed	
	36/7 FM	36/7 SPC
DE Fish (extruded)	2959	2943
NFE	35.35	35.85
Starch	22.61	22.56
Protein, crude	36.26	36.41
Protein, digestible	33.98	34.49
Fish Protein	12.90	0.00
Soy Protein	19.81	23.46
Fat	7.08	7.01
W-3 (omega 3 fatty acid)	1.16	1.10
W-6 (omega 6 fatty acid)	2.04	2.15
Fiber	2.38	3.29
Ash	7.28	6.93
Calcium	1.10	0.69
Phosphorus, available	0.70	0.76
Choline	2560	2489
Vitamin C	105	105
Ethoxyquin	135	135
Arginine	2.29	2.28
Lysine	2.37	2.14
Methionine	0.70	0.71
Methionine + Cystine	1.20	1.24
Threonine	1.46	1.44
Tryptophan	0.44	0.42

Table 3. Vitamin and mineral premix formulations for the ASA-IM 36/7 FM and 36/7 SPC feeds used in the 2008 black carp feeding trial. Quantities of vitamins and minerals are per kilogram of premix. Both premixes were produced at the Phoenix Feed Mill premix plant in Chengdu, Sichuan Province.

Ingredient	Unit	Amount
<u>Vitamin Premix F-2</u>		
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
<u>Mineral Premix F-1</u>		
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 2008 ASA-IM aquaculture trial in Beijing that compared the growth performance of black carp in ponds using ASA-IM fishmeal (36/7 FM) and soy protein concentrate (36/7 SPC) feeds.

Feed	Stocking rate (fish/mu)		Stocking size (g)		Harvest wt (g/fish)		P _G ³ (kg/mu)		Survival (%)		FCR
	BkC ¹	SiC ²	BkC ¹	SiC ²	BkC ¹	SiC ²	BkC ¹	SiC ²	BkC ¹	SiC ²	
36/7 SPC	600	100	178	280	1,150	1,700	478.4	170	69.3	100	1.68
36/7 SPC	600	100	178	280	1,450	1,900	545.2	181	62.5	95	1.43
36/7 SPC	<u>600</u>	<u>100</u>	<u>178</u>	<u>280</u>	<u>1,290</u>	<u>1,900</u>	<u>499.2</u>	<u>186</u>	<u>64.5</u>	<u>98</u>	<u>1.59</u>
Mean	600	100	178	280	1,297	1,833	507.6	179	65.4	98	1.57
36/7 FM	600	100	178	270	950	1,600	430.4	158	75.5	99	1.93
36/7 FM	600	100	178	270	1,050	1,900	450.4	186	71.5	98	1.82
36/7 FM	<u>600</u>	<u>100</u>	<u>178</u>	<u>280</u>	<u>1,100</u>	<u>1,450</u>	<u>444.4</u>	<u>145</u>	<u>67.3</u>	<u>100</u>	<u>1.85</u>
Mean	600	100	178	273	1,033	1,650	441.8	163	71.5	99	1.87

¹BkC = Black Carp

²SiC = Silver Carp

³P_G = Gross Production