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Total replacement of fish meal by soy bean meal, with various percentages of supplemental L-methionine, in diets for blue catfish, *Ictalurus furcatus* (Lesueur)

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Abstract

A 12-week feeding trial was conducted in aquaria with juvenile (8.9 g) blue catfish, *Ictalurus furcatus* (Lesueur), to examine effects of totally replacing fish meal with a high (65%) percentage of soy bean meal (SBM) in prepared diets. Five isonitrogenous (35% protein) and isocaloric (10.5 kJ digestible energy g^{-1} of diet) diets were formulated. Diet 1 was similar to a high-quality commercial channel catfish diet, containing 15% fish meal and 42% SBM. Diets 2–5 contained 0% fish meal and 70% SBM with various amounts (0.0%, 0.3%, 0.6% and 0.9%) of L-methionine added. After 12 weeks, individual weight, weight gain, survival, specific growth rate, feed conversion ratio, protein efficiency ratio and food intake were not significantly different ($P > 0.05$) among treatments and averaged 36 g, 302%, 100%, 1.6% day^{-1}, 2.4, 1.3, and 3.4% body weight, respectively. Whole-body compositions of fish were not significantly different ($P > 0.05$) among treatments and averaged 75%, 61% and 27% for percentage moisture, protein and fat, respectively. These data suggest that a diet with an all-plant protein source (SBM) can totally replace fish meal in a diet for blue catfish, without adverse affects on weight gain or body composition, when the dietary protein level is 35% and fish are fed to satiation.

Introduction

Fish meal is one of the most expensive ingredients in prepared fish diets. Fish nutritionists have tried to use less expensive plant protein sources to partially or totally replace fish meal. Soy bean meal (SBM) is considered to be one of the most nutritious of all plant protein feedstuffs (Lovell 1988). However, growth has often been reduced in fish fed diets with SBM replacing all the fish meal (Cowey, Pope, Blair & Shanks 1974; Lovell, Prather, Tres-Dick & Chhorn 1974; Murai, Ogata, Kosutarak & Arai 1986; Shiau, Chuang & Sun 1987; Reigh & Ellis 1992). One possible reason may be the activity of protease (trypsin) inhibitors in crude or inadequately heated SBM (Dabrowski & Kozak 1979; Wilson & Poe 1985). However, this may not be of practical importance since commercially available SBM usually has little trypsin inhibitor activity if adequately processed (Webster, Yancey & Tidwell 1992a). A second possible reason may be suboptimal amino acid balance of SBM (Dabrowski, Poczyczynski, Kock & Berger 1989). It has been reported that addition of supplemental methionine improved growth in common carp, *Cyprinus carpio* L., fed diets with soy flour (Murai, Ogata & Nose 1982; Murai *et al.* 1986). A third possible explanation may be that the energy content of SBM is lower than that of fish meal in diets for fish (Viola, Mokady & Arieli 1983; Hilton & Slinger 1986). Lastly, SBM may have reduced digestibilities of minerals, especially phosphorus, compared with fish meal (Liebowitz 1981).

Blue catfish, *Ictalurus furcatus* (Lesueur), possess several attributes that could make them a desirable culture species in temperate regions of the USA. They have a higher dressing percentage than channel catfish, *I. punctatus* (Rafinesque) (Dunham, Ben-chakan, Smitherman & Chappell 1983), may have a lower optimum growing temperature than channel catfish, are easier to seine (Chappell 1979), and may have higher weight gains in temperate regions than some strains of channel catfish (Tidwell & Mims 1990).

Webster *et al.* (1992a) reported that juvenile blue catfish fed a diet containing 13% fish meal had higher weight gains than fish fed diets with lower percentages of fish meal, possibly due to a higher methionine content of the diet with 13% fish meal. The purpose of the present study was to evaluate commercially available soybean meal as a total replacement for fish meal in diets and effects of supplementation with various percentages of L-methionine for blue catfish.

Materials and methods

Experimental diets

Five experimental diets were formulated. Diet 1, with 42% hexane-extracted SBM (International Feed No. 5-04-604) and 15% Atlantic menhaden fish meal (International Feed No. 5-02-009) was formulated to be similar to a high-quality commercial channel catfish diet. The other four diets (diets 2–5) contained 0% fish meal, 65% SBM, and various percentages (0.0, 0.3, 0.6, 0.9%) of supplemental crystalline L-methionine (Sigma Chemical Co., St Louis, Missouri) (Table 1). Amino acid compositions of the diets were calculated from tabular values provided for diet ingredients (NRC 1983). All diets were formulated to be isonitrogenous (35% protein) and isocaloric (10.5 kJ digestible energy g^{-1} of diet).

In preparing the diets, dry ingredients were first ground to a small particle size (approximately 250 μm) in a Wiley mill. Ingredients were thoroughly mixed and water added to obtain a 30% moisture level. Diets were passed through a mincer with die into 0.4-mm diameter 'spaghetti-like' strands and were dried (20°C) for 16 h using a convection oven. After drying, the diets were broken up and sieved into appropriate pellet sizes. Cod liver oil was sprayed onto the dried pellets immediately prior to storage (–20°C). Marine

Table 1 Composition of a diet similar to a high-quality commercial catfish diet (with fish meal) and experimental diets (without fish meal) fed to juvenile blue catfish. All diets without fish meal contained various percentages of supplemental L-methionine

	Diet				
	1	2	3	4	5
Ingredient					
Menhaden fish meal (67%)	15.00	0.00	0.00	0.00	0.00
Soybean meal (47%)	42.00	65.00	64.70	64.40	64.10
Ground corn	35.50	23.00	23.00	23.00	23.00
Cod liver oil[1]	2.00	5.00	5.00	5.00	5.00
Premix[2]	3.00	3.00	3.00	3.00	3.00
Dicalcium phosphate	0.50	2.00	2.00	2.00	2.00
CMC[3]	2.00	2.00	2.00	2.00	2.00
L-methionine	0.00	0.00	0.30	0.60	0.90
Nutrient composition					
Moisture (%)	11.39	7.75	7.91	10.90	9.19
Protein (%)[4]	34.76	34.83	35.02	34.92	34.93
Fat (%)[4]	7.16	8.79	8.87	8.62	8.43
DE[5]	10.17	10.79	10.75	10.71	10.67
P:E[6]	34.2	32.3	32.6	32.6	32.7

[1] Ethoxyquin was added at 0.02% of lipid.
[2] Premix supplied the following vitamins and minerals (mg or IU/kg of diet): A, 5280 IU; D_3, 2640 IU; E, 660 IU; cyanocobalamine (B_{12}), 0.011 mg; K, 13.2 mg; riboflavin, 15.8 mg; pantothenic acid, 42.2 mg; thiamine, 13.2 mg; niacin, 105.6 mg; pyrodoxine (B_6), 13.2 mg; folic acid, 2.6 mg; choline, 580 mg; ascorbic acid, 935 mg; zinc, 207 mg; iron, 72 mg; manganese, 216 mg; copper, 9 mg; iodine, 4.5 mg; cobalt, 1.8 mg; selenium, 0.3 mg; KCl, 3474 mg; NaH_2PO_4, 1932 mg.
[3] CMC =carboxymethylcellulose.
[4] Moisture-free basis.
[5] DE=digestible energy in kJ g^{-1} of diet; based on estimated values of diet ingredients for channel catfish (NRC 1983).
[6] P:E =protein to energy ratio (as mg protein kJ^{-1} of DE).

Table 2 Amino acid composition (excluding tryptophan) of experimental diets fed to juvenile blue catfish (amino acids expressed as percentage of diet)[1]

		Diet				
Amino acid	Required[2]	1	2	3	4	5
Alanine		1.70	1.52	1.52	1.33	1.37
Arginine	1.55	2.15	2.37	2.40	2.14	2.32
Aspartic acid		3.42	3.87	3.81	3.38	3.47
Cystine	–	0.34	0.41	0.41	0.39	0.45
Glycine		1.71	1.47	1.47	1.30	1.31
Glutamic acid		4.50	5.04	5.00	5.27	5.47
Histidine	0.54	1.03	1.09	1.10	1.00	1.08
Isoleucine	0.94	1.44	1.58	1.54	1.37	1.38
Leucine	1.26	2.50	2.64	2.60	2.33	2.38
Lysine (total)	1.84	1.88	1.82	1.84	1.65	1.68
Methionine[3]	0.83	0.60	0.52	0.74	1.09	1.30
Phenylalanine[4]	1.80	1.51	1.69	1.67	1.48	1.51
Proline		1.79	1.81	1.76	1.63	1.69
Serine		1.47	1.66	1.72	1.53	1.43
Threonine	0.72	1.31	1.33	1.36	1.11	1.17
Tyrosine	–	0.95	0.99	0.96	0.80	0.81
Valine	1.08	1.65	1.67	1.67	1.52	1.55

[1] Values are means of two replications.
[2] Essential amino acid requirement (% of diet) of channel catfish based on a 36%-protein diet (NRC 1983).
[3] Approximately 60% of cystine can substitute for methionine (Lovell 1989).
[4] Approximately 50% of tyrosine can substitute for phenylalanine (Lovell 1989).

fish oil was used to supply essential n–3 fatty acids that may be required. Percentage protein of the diets was determined by macro-Kjeldahl, percentage fat was determined by the acid-hydrolysis method, and moisture was determined by drying (100°C) until constant weight (AOAC 1990). Digestible energy (DE) was estimated from the diet ingredients as established for channel catfish (NRC 1983). Diets were also analysed for amino acid composition by a commercial analytical laboratory (Woodson–Tenent Lab, Dayton, OH) (Table 2). Samples were prepared for analysis by method 982.30, d & e (AOAC 1990) and measured using a Dionex ion-exchange chromatograph.

Experimental system and animals

The feeding trial was conducted in 15 37.5-l acrylic aquaria. Water was recirculated through biological and mechanical filters. The recirculating system consisted of a 2000-l vertical screen filter system utilizing high-density polyester screens (Red Ewald, Inc., Karnes City, TX) and a drum filter system comprising plastic 'bio-balls' and fibrous polyester material. These two filter systems removed particulate material and provided substrate for *Nitrosomonas* and *Nitrobacter* bacteria. Continuous aeration was provided by a blower and airstones. Water exchange rate for the system was approximately 3% of total volume day^{-1}. Chloride levels were maintained at approximately 600 mg l^{-1}, by addition of food-grade NaCl, to minimize potential adverse effects of nitrite to fish health (Perrone & Meade 1977). Each aquarium was supplied with water at a rate of 2.0 l min^{-1} and siphoned daily to remove uneaten feed and faeces. Black plastic covered the back and sides of all aquaria to minimize disturbances resulting when personnel were present in the laboratory. Continuous illumination was supplied by fluorescent ceiling lights.

Water temperature and dissolved oxygen were measured every other day using a YSI Model 58 oxygen meter (YSI Industries, Yellow Springs, OH). Total ammonia and nitrite were measured twice weekly using a DREL 2000 spectrophotometer (Hach Co., Loveland, CO). Total alkalinity and chloride were monitored twice weekly using the titration method of the DREL 2000; pH was monitored twice weekly using an electronic pH meter (pH pen; Fisher Scientific, Cincinnati, OH). Over the duration of the study, these water-quality parameters averaged (±SD): water

Table 3 Length, weight, percentage weight gain, survival, specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), food intake, and whole-body composition of juvenile blue catfish fed a diet containing fishmeal (diet 1) and four diets without fish meal and containing various percentages of supplemental L-methionine as shown in Table 1. Values are means ± SE of three replications. Means in the same row, having different superscript letters, are significantly different ($P < 0.05$)

	Diet				
	1	2	3	4	5
Total length (mm)	155.2 ± 2.2[b]	170.9 ± 2.8[ab]	171.0 ± 6.9[ab]	169.3 ± 7.9[ab]	173.7 ± 4.7[a]
Final indiv. wt (g)	28.89 ± 1.44[a]	36.06 ± 1.26[a]	37.74 ± 3.71[a]	36.83 ± 5.07[a]	39.16 ± 3.12[a]
Weight gain (%)	257.3 ± 13.7[a]	302.0 ± 10.9[a]	319.3 ± 31.3[a]	308.8 ± 32.3[a]	324.4 ± 18.4[a]
Survival (%)	100.0 ± 0.0[a]	100.0 ± 0.0[a]	100.0 ± 0.0[a]	100.0 ± 0.0[a]	100.0 ± 0.0[a]
SGR (% day^{-1})	1.46 ± 0.10[a]	1.65 ± 0.03[a]	1.70 ± 0.09[a]	1.67 ± 0.09[a]	1.72 ± 0.05[a]
FCR	2.79 ± 0.25[a]	2.34 ± 0.08[a]	2.19 ± 0.22[a]	2.29 ± 0.27[a]	2.21 ± 0.20[a]
PER	1.05 ± 0.09[a]	1.24 ± 0.03[a]	1.33 ± 0.12[a]	1.29 ± 0.17[a]	1.32 ± 0.13[a]
Food intake (% body wt)	3.88 ± 0.31[a]	3.30 ± 0.04[a]	3.15 ± 0.17[a]	3.26 ± 0.29[a]	3.21 ± 0.23[a]
Whole-body composition					
Moisture (%)	76.09 ± 0.34[a]	74.43 ± 0.85[a]	74.00 ± 0.52[a]	74.50 ± 0.47[a]	73.51 ± 1.25[a]
Protein (%)[1]	62.23 ± 0.99[a]	59.73 ± 0.80[a]	58.77 ± 0.44[a]	62.39 ± 1.94[a]	60.39 ± 1.33[a]
Fat (%)[1]	25.53 ± 1.20[a]	28.89 ± 0.17[a]	28.04 ± 1.27[a]	26.77 ± 1.30[a]	27.52 ± 0.18[a]

[1]Moisture-free basis.

temperature, 27.4 ± 0.8°C; dissolved oxygen, 6.7 ± 0.5 mg l^{-1}; total ammonia, 0.21 ± 0.16 mg l^{-1}; nitrite, 0.07 ± 0.05 mg l^{-1}; total alkalinity, 181 ± 46 mg l^{-1}; chlorides, 575 ± 154 mg l^{-1}; pH, 8.4 ± 0.1.

Juvenile blue catfish (single spawn of broodstock from the Kentucky River; average weight 8.9 ± 1.2 g) were used for the feeding trial. Six fish were randomly stocked into each aquarium with three replications per treatment. After stocking, to minimize stress of handling, fish from each aquarium were weighed after 6 weeks and at the conclusion of the feeding trial. Total length of each fish was measured at the conclusion of the experiment. All fish were fed all they could consume in 40 min twice daily (0800 and 1600 h) for 12 weeks. At the start and conclusion of the feeding trial, a number of fish were killed by decapitation (15 at stocking and six fish per aquarium at conclusion), homogenized in a blender, stored in polyethylene bags, and frozen for subsequent protein, fat, and moisture analysis. Protein was determined by macro-Kjeldahl, fat was determined by ether extraction, and moisture was determined by placing a 10-g sample in an oven (100°C for 24 h) to be dried until constant weight (AOAC 1990).

Growth performance and feed conversion were measured in terms of final individual fish weight (g), total length (mm), survival (%), specific growth rate (SGR, % day^{-1}), feed conversion ratio (FCR), protein efficiency ratio (PER), and food intake (% body weight). Growth response parameters were calculated as follows: SGR (% day^{-1}) = ([ln W_t–ln W_i] / T) × 100, where W_t is the weight of fish at time t, W_i is the weight of fish at time 0, and T is the culture period in days; FCR = total dry feed fed (g) / total wet weight gain (g); PER = wet weight gain (g) / amount of protein fed (g); food intake = (DFI × 100) / ([W_{t+1} + W_t] / 2), where DFI is mean daily dry food intake per fish (t, t+1) and W_t, W_t+1 are the averaged wet weights at the start (t) and conclusion (t+1) of the experimental period (Richardson, Higgs, Beames & McBride 1985).

Statistical analysis

Data were analysed by analysis of variance (ANOVA) using the SAS ANOVA procedure (Statistical Analysis Systems 1988). Duncan's multiple-range test was used to compare differences among individual means. Treatment effects were considered significant at $P <$ 0.05. All percentage and ratio data were transformed to arcsin values prior to analysis (Zar 1984).

Results and discussion

Fish fed diet 5 were significantly ($P < 0.05$) longer (174 mm) than fish fed diet 1 (155 mm); however, fish fed diets 2–4 were not significantly different ($P > 0.05$) compared with fish fed diet 1 or diet 5 (Table 3). No significant difference ($P > 0.05$) in final weight of blue catfish fed diet 1 (42% SBM and 15% fish meal) and fish fed diets containing 0% fish meal (diets 2–5) was found, and final weight averaged 35.8 g among treatments (Table 3). Percentage weight gain, survival, specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), and food intake were not significantly different ($P > 0.05$) among treatments and averaged 302%, 100%, 1.6% day^{-1}, 2.36, 1.25, and 3.36% body weight, respectively.

These data indicate that growth of blue catfish may not be adversely affected by feeding a diet containing a high percentage of soy bean meal (SBM) (65%) and 0% fish meal. This is in contrast to some studies on common carp (Nandeesha, Basavaraja, Keshavanath, Varghese, Shetty & Srikanth 1989), tilapia, *Oreochromis niloticus* × *O. aureus* (Shiau, Lin, Yu, Lin & Kwok 1990), channel catfish (Mohsen & Lovell 1990), and blue catfish (Webster *et al.* 1992a).

Results of the present study are in agreement with other studies (Davis & Stickney 1978; Webster, Tidwell, Goodgame, Yancey & Mackey 1992b; E.H. Robinson, Delta Branch Experiment Station, Stoneville, Mississippi, personal communication). Channel catfish fed diets containing 0% fish meal and 60–70% SBM had similar growth rates compared with fish fed commercial catfish diets containing fish meal (E.H. Robinson, personal communication). No differences in weight gains were reported in blue tilapia, *Oreochromis aureus* (Steindachner), fed diets containing 0% fish meal and 74% SBM (36% protein) compared with fish fed a 36% protein diet containing fish meal (Davis & Stickney 1978). When protein level was below 30%, fish fed diets containing fish meal had higher weight gains compared with fish fed diets without fish meal. Since the essential amino acid levels in the 36% protein diets exceeded the requirements of other fishes, it may be that the amino acid profiles of the lower-protein diets were not adequate when SBM totally replaced fish meal. In the present study, percentage dietary protein was 35%.

Although final weights and weight gains were not significantly different among treatments, fish fed diet 1 (containing 15% fish meal and 42% SBM) had numerically smaller values compared with fish fed diets 2–5. This is unexplained since diet 1 was similar to a diet known to provide for good growth in blue catfish (Webster *et al.* 1992a). All essential amino acid requirements for channel catfish were met or exceeded by diet 1, except methionine (Table 2). Diet 1 contained 0.80% methionine (methionine plus 60% of cystine), whereas the requirement of channel catfish is 0.83% (NRC 1983). This discrepancy does not appear large, but may be a factor in the somewhat reduced growth of fish fed diet 1. Fish meal quality may have been less than optimal; however, a commercial source of Atlantic menhaden fish meal was used and this meal was identical to that used in previous studies (Webster *et al.* 1992a,b).

Feed conversion ratio (FCR), PER, and food intake were not significantly different ($P > 0.05$) among treatments (Table 3). Food intake and PER values were similar to values reported in Webster *et al.* (1992a). Feed conversion values in the present study are somewhat higher than reported in the literature; however, they are consistent with FCR values found in other studies (Andrews & Stickney 1972; Webster *et al.* 1992a,b). The higher FCR values tend to be due to the use of small (37.5-l) aquaria and the relatively slow feeding habits of blue catfish (Webster *et al.* 1992a). Agitation of the water during feeding tends to rapidly break diet pellets into smaller pieces. Small particles of diet could then be removed through the standpipe, skewing the FCR values upward. Further, the colour of the diets (light brown) sometimes made them difficult to see against the brown aquarium bottoms and may have resulted in overfeeding. This may have been especially true for diet 1, resulting in a higher numerical, but not statistically different ($P > 0.05$), value. However, feed supply must not be limiting in nutrition experiments and overfeeding is more desirable than underfeeding (Tacon & Cowey 1985).

Whole-body proximate composition at the conclusion of the feeding trial resulted in no significant differences ($P > 0.05$) in percentage moisture, protein, and fat among fish fed the five diets, and averaged 74.5%, 60.7% and 27.3%, respectively (Table 3). All diets were formulated to be similar in percentage protein and energy content.

Replacement of fish meal with SBM has had variable success. In those studies in which growth is reduced, several hypotheses have been suggested to explain the results: 1. suboptimal amino acid balance; 2. inadequate levels of phosphorus in SBM; 3. presence of antinutritional factors (including trypsin inhibitors); and 4. inadequate levels of energy in SBM. SBM has one of the best amino acid profiles of any plant protein feedstuff and the composition meets the essential amino acid requirements of channel catfish (Lovell 1988). Amino acid analyses indicated that all diets met the amino acid requirements of channel catfish (NRC 1983). However, the biological value of amino acids from SBM may be less than indicated. Dabrowski *et al.* (1989) stated that methionine availability may be reduced when SBM comprises a large percentage (> 50%) of the diet. However, practical diets for channel catfish have percentages of SBM higher than 50% without adverse effects on growth (Reis, Reutebuch & Lovell 1989; Li & Lovell 1992; Robinson & Robinette 1994).

Addition of supplemental methionine in fish diets has had variable success. Tacon, Webster & Martinez (1984) stated that addition of 0.2% L-methionine to a diet deficient in methionine for rainbow trout, *Oncorhynchus mykiss* (Walbaum), did not improve growth. However, Shiau *et al.* (1987) reported that addition of supplemental methionine improved growth in tilapia. Murai *et al.* (1986) reported that nutritional value of soy flour was improved by addition of 0.4% crystalline L-methionine. This is in contrast to Andrews & Page (1974), who reported no improvement in weight gains when supplemental methionine was added to channel catfish diets. These conflicting data may be due to the higher level of sulphur amino acids in the basal diet fed by Andrews & Page (1974). It has been stated that crystalline methionine is rapidly absorbed in fish and degraded into methionine sulphoxide (Thebault 1985; Murai *et al.* 1986).

While it has been stated that diets containing high percentages of SBM may be deficient in methionine for blue catfish (Webster *et al.* 1992a), it is not known with certainty whether diets were deficient in methionine. Quantitative essential amino acid requirements of blue catfish have not been established. However, diets used in the present study met the essential amino acid requirements of channel catfish (NRC 1983). Strict comparison of the results reported in the present study and of Webster *et al.* (1992a) may be misleading since different genetic groups of blue catfish were used in the two studies.

Fish have a high requirement for phosphorus; however, SBM is deficient in available phosphorus. Although SBM contains approximately 0.7% phosphorus, only about one-third to one-half is biologically available to fish (Lovell 1988). Diets used in the present study contained supplemental phosphorus and all diets contained > 0.50% available phosphorus, while the requirement for available phosphorus for channel catfish is 0.45% (Lovell 1978). It has been reported that SBM could mostly replace fish meal in a diet for channel catfish if supplemental phosphorus was added (Liebowitz 1981). Reinitz (1980) stated that weight gain in rainbow trout was positively correlated with the percentage of dietary phosphorus.

It is known that antinutritional factors in raw or inadequately heated SBM can adversely affect growth (Smith, Peterson & Allred 1980; Robinson, Wilson, Poe & Grizzle 1981; Viola *et al.* 1983). Webster *et al.* (1992a) reported that use of heated SBM in diets did not increase growth of blue catfish, probably because of the already low level of trypsin inhibitor in the commercial SBM used. However, Wee & Shu (1989) reported higher growth in Nile tilapia, *Oreochromis niloticus* (L.), fed diets containing boiled SBM compared with fish fed diets containing fish meal or raw SBM. This was due to inactivation of the high trypsin inhibitor activity in the SBM used and increasing digestibility of diets containing boiled SBM compared with raw SBM.

Some fish, such as red drum, *Sciaenops ocellatus* L., find SBM unpalatable and will not consume diets that have 0% fish meal (Reigh & Ellis 1992). Mohsen & Lovell (1990) reported that addition of animal by-products to an SBM-based diet improved palatability. However, fish adapted to an SBM diet may have similar consumption rates to those of fish fed diets containing animal protein sources. In the present study, blue catfish appeared to consume diets containing 65% SBM and 0% fish meal and did not find them unpalatable. Diets wihtout fish meal did have a higher percentage (5%) of cod liver oil top-dressed onto the diets, compared with the diet containing fish meal (diet 1; 2%), and this may have increased palatability.

The variable success of researchers in using SBM as a total replacement for fish meal indicates the wide variation possible in the nutritive value of SBM for various fish species and the influence of diet formulation on growth. The data from the present study indicate that a diet in which SBM totally replaces fish meal, without supplemental L-methionine, may be fed to juvenile blue catfish without adverse effects on growth and body composition when the fish are fed to satiation, and the diet contains 35% protein, cod liver oil, and 2% supplemental dicalcium phosphate. Further evaluation of a soy bean meal-based diet on growth of blue catfish in production trials of longer duration should be conducted.

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