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[Article]

Pond Production and Fatty Acid Profiles of the Fillets of Channel Catfish Reared on Diets with Different Protein Sources

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Abstract.—Three protein sources were evaluated as supplements to grow-out feeds for mixed-sized channel catfish *Ictalurus punctatus* stocked at 16,750 fish/ha in 0.04-ha earthen ponds. Three practical diets were tested: (1) meat, bone, and blood meal (MBM), (2) fish meal containing menhaden *Brevoortia* spp., and (3) soybean meal and wheat (lysine added). The fish were fed to satiation once daily for 133 d. For total fish harvested, dietary protein did not affect the weight gain, hepatosomatic index, percent survival, harvest yield, protein efficiency ratio, percentage of intraperitoneal fat, or dress-out percentage. Feed consumption and the feed conversion ratio were significantly higher in fish fed the MBM diet. This diet also produced a significantly lower percentage of lipids in the fillets. Significant differences were shown for fatty acids found in the fillets of large fish and small fish fed all diets. A size-related significant difference was found for the total saturated fatty acids, where values for the fillets of small fish were lower than those of large fish. Conversely, a size-related significant difference was found for the total monounsaturated fatty acids in the fillets, where the large fish had lower levels than those of the small fish. When the fatty acids found in the fillets were classified as total polyunsaturated fatty acids (total omega-3 fatty acids or total omega-6 fatty acids), no significant differences in concentrations as a result of diet were found. This suggests that all three protein sources performed similarly and that the all-vegetable diet supplemented with lysine is a suitable alternative to diets containing animal and fish protein sources for channel catfish grown under pond production conditions.

Feed is the largest cost input for the intensive production of channel catfish *Ictalurus punctatus* (Engle and Kouka 1996), and protein is the most expensive major component of feeds. Animal proteins are generally believed to be of higher quality and more palatable to channel catfish than plant protein (Lovell 1989); however, because of the high cost of animal proteins, the substitution of animal protein with plant protein may provide economic benefits to producers. Although some researchers have concluded that young channel catfish require animal protein for maximum growth (Mohsen and Lovell 1990), there is evidence that animal protein is not an essential ingredient for maximum growth by channel catfish reared in ponds from fingerlings to market size (Robinson and Li 1994, 1998, 1999; Robinson et al. 2000). Efforts to reduce feed costs have resulted in increased use of plant protein supplements in diet formulations as replacements for expensive animal ingredients (Reigh 1999). However, the constant need for minimizing costs should not be overshadowed by the need for a high-quality final product that could offer human health benefits.

One of the primary health benefits of eating fish originates from the oils in fish flesh that contain omega-3 polyunsaturated fatty acids. These fatty acids have been shown to have positive effects on the cardiovascular system and help to maintain and increase brain function. These fatty acids have also been shown to help reduce myocardial infarction, thrombosis, cardiac arrhythmias, high blood pressure, hypertension, and depression (Horrocks and Yeo 1999; Holm et al. 2001).

The inclusion of animal proteins in fish diets is a topic of extensive research. The objective of this study was to evaluate the benefits of three sources of protein in nutritionally balanced diets on the production performance, dress-out, and fat indices of mixed-sized channel catfish fed to apparent satiation in ponds.

Methods

Experimental diets.—Diets were manufactured by Alabama Catfish Feed Mill (Union Town, Alabama) and were formulated to be isocaloric based on digestible energy levels. Three diets (Table 1) were formulated to contain three dietary protein supplements originating from fish meal (FM), meat, bone, and blood meal (MBM), or all-vegetable (AV) sources. The FM diet contained fish meal made from menhaden *Brevoortia* spp. (8

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TABLE 1.—Composition of catfish production diets (g/100 g as fed) containing either fish meal (FM); meat, blood, and bone meal (MBM); or vegetables (AV), as well as ingredient costs for fall 2000 (period 1) and fall 2003 (period 2).

Ingredient	FM	MBM	AV	Cost ($/ton)	
				Period 1	Period 2
Menhaden fish meal	8.0			335	530
MBM		8.0		310	314
Soybean meal	35.0	35.0	49.0	201	191
Cottonseed meal	15.0	15.0	15.0	140	153
Wheat middlings	15.0	15.0	7.15	76	87
Corn	23.8	23.8	23.8	102	112
Dicalcium phosphate	1.0	1.0	1.8	230	240
Trace minerals	0.1	0.1	0.1	390	390
Vitamin mix[a]	0.1	0.1	0.1	4,400	3,800
Catfish and menhaden oil (1:1)	2.0	2.0	3.0	300	315
Lysine			0.05	1,900	1,900

[a] Vitamin and mineral premix (Roche Vitamins, Inc., Parsippany, New Jersey).

g/100 g as fed; Omega Protein, Inc., Houston, Texas); the majority of the remaining dietary protein originated from soybean meal (35 g/100 g as fed) and cottonseed meal (15 g/100 g as fed). The MBM diet was identical to the previous diet, except meat and bone meal with blood meal (Mid-South Milling Company, Inc., Memphis, Tennessee) replaced the menhaden fish meal. The AV diet was an all-vegetable diet containing additional solvent-extracted soybean meal (49%) and lysine (0.05%) and reduced wheat middling (7.15%). All three diets had adequate levels of nonprotein energy and recommended minimum concentrations of lysine- and sulfur-containing amino acids (NRC 1993). After manufacturing, the feeds were bagged and stored in a temperature- and moisture-controlled feed shed. Subsamples were taken from multiple bags and pooled by treatment for subsequent proximate analyses. The experimental diets were formulated to contain similar proportions of total dietary protein (30.5–31.8%), lysine (5.4–5.5% protein), methionine plus cystine (2.9–3.1% protein), phosphorus (0.9–1.0%), and calcium (1.7–1.9%). The crude protein content of the diets was 31.70% (FM), 30.50% (MBM), and 31.80% protein (AV) as determined by the micro-Kjeldahl method (Ma and Zuazago 1942).

Stocking, feeding, and harvesting.—This study was conducted in 0.04-ha ponds at the North Auburn Fisheries Research Unit in Auburn, Alabama, from May to September 2000. Before stocking, all ponds were treated with agricultural lime at a rate of 2 metric tons/ha on 12 April. Two weeks after filling, chelated copper was applied to the ponds at a rate of 2 mg/L to control aquatic plant growth. On 5 May, mixed-sized channel catfish were stocked into 18 ponds at a combined density equivalent to 16,750/ha and a 9:1 ratio of 8-g fingerlings (7–13 cm) and 470-g submarket (30–35 cm) fish. During the first 2 weeks of the study, observed mortalities were removed, weighed, and replaced with a fish of similar size. Thereafter, mortalities were removed, weighed, and counted but not replaced.

Fish in each pond were fed once daily to apparent satiation, which was determined by the quantity of feed consumed within 15 min. If 0–5% of the ration remained after 15 min, the fish were considered ‘‘underfed’’ and the ration was increased the following day. If 5–10% of the ration was unconsumed after 15 min, the fish were considered to be ‘‘satiated’’ and the same amount of ration was given the following day. If more than 10% of the feed was unconsumed after 15 min, the fish were considered to be ‘‘overfed’’ and the ration was lowered the following day. On the days when fish were ‘‘overfed,’’ all or nearly all of the feed was usually consumed within 2 h. During the first 5 weeks of the study, fish were fed in the afternoon, but when afternoon water temperatures rose to 30°C, the fish were fed in the morning (0900 hours).

Water temperature and dissolved oxygen (DO) concentrations were measured twice daily at approximately 0600 and 2200 hours with a DO meter (Yellow Springs Instrument Company, Inc., Yellow Springs, Ohio; Model 55). To maintain DO above 3 mg/L, 0.5-hp (37 kW) pump sprayer aerators were used. Initially, aeration was applied if the nighttime DO was less than 9 mg/L. When water temperatures rose to 30°C in midsummer, nightly aeration was applied to all ponds.

Fish were harvested on 15–17 September by seining and draining the ponds. All fish were separated into size-groups (‘‘small’’ subpopulation was <45 cm; ‘‘large’’ subpopulation was >45 cm)

TABLE 2.—Production response of mixed-sized channel catfish (9:1 ratio of small fish stocked as 8-g fingerlings and large fish stocked at an average weight of 470 g with a total density of 16,750 fish/ha) fed daily to satiation on three experimental diets containing either fish meal (FM); meat, bone, and blood meal (MBM); or vegetables (AV). Within rows, values with different letters are significantly different based on Fisher's protected least significant difference test.

Variable	FM	MBM	AV	*P*-value
Survival (%)				
Small	63.6	66.5	66.1	0.86
Large	95.7	96.6	99.1	0.14
Total	67.0	69.7	69.5	0.86
Average final weight (g)				
Small	214	231	232	0.45
Large	1,316	1,298	1,219	0.11
Average weight gain (g)				
Small	207	214	225	0.59
Large	845	805	742	0.14
Small:large	0.24 y	0.27 zy	0.30 z	0.04
Harvest (kg/ha)				
Small	2,043	2,293	2,298	0.40
Large	2,201	2,219	2,094	0.31
Total	4,244	4,512	4,392	0.60
Net yield (kg/ha)				
Small	1,948	2,217	2,195	0.36
Large	1,405	1,426	1,283	0.12
Total	3,354	3,642	3,478	0.61
Small:total	0.58	0.61	0.63	0.10
Feed utilization[a]				
Feed consumption (kg/ha)	5,688 y	6,775 z	5,999 zy	0.04
Feed conversion ratio[a]	1.70 y	1.87 z	1.73 y	0.04
Protein efficiency ratio[b]	1.9	1.8	1.8	0.52

[a] (Weight of feed offered × 100)/weight gain of the fish.

[b] Weight gain of the fish/weight of protein fed.

and weighed. From each pond, 4 fish were randomly collected from the large group as well as the small group (8 fish total), euthanatized, and frozen at −20°C for later analyses. At the conclusion of the production trial, total fish production, feed inputs, feed conversion ratio (FCR; weight of feed fed × 100/weight of fish gain), and protein efficiency ratios (PER; weight of fish gain × 100/weight of protein fed) were determined. The following body condition indices were determined: hepatosomatic index (HSI; liver weight × 100/fish weight), intraperitoneal fat ratio (IPF; intraperitoneal weight × 100/fish weight), and skin-on dress-out percentage (weight after removal of head and viscera/wet weight of fish). Muscle samples were taken from the fillet and stored at −20°C for proximate analysis. Lipid content of the fillet was determined by chloroform–methanol extraction (Folch et al. 1957). The fatty acid methyl esters were analyzed with a gas chromatograph (Shimadzu Scientific Instruments, Inc., Columbia, Maryland; Model GC-17A) equipped with a flame ionization detector and Omegawax 530 capillary column (30 m × 0.53 mm; Supelco, Bellefonte, Pennsylvania). Fatty acids were identified by comparison of retention times with those of known standards and expressed as a percentage of total identified fatty acids.

Pond data were analyzed by one- and two-way analysis of variance (ANOVA) with Statview 5.0 (Caldarola et al. 1998) to determine significant ($P < 0.10$) differences among treatment means, and Fishers protected least significant difference test was used to distinguish significant differences between treatment means. The fatty acid data were analyzed with SAS 6.1 (Statistical Analysis Systems 1994) by one- and two-way ANOVAs to determine significant ($P < 0.05$) differences among treatment means, and Duncan's multiple-range test was used to distinguish significant differences between treatment means.

Results

The results of this study are summarized in Tables 2–5. Two ponds were eliminated from the analyses because of mass mortality caused by

TABLE 3.—Characteristics of small channel catfish stocked as 8-g fingerlings and large channel catfish stocked at an average weight of 470 g fed daily to satiation on three experimental diets containing either fish meal (FM); meat, bone, and blood meal (MBM); or vegetables (AV). Dress-out, hepatosomatic index, and percent lipid content of the fillets of large fish, as well as intraperitoneal fat content of both large and small fish are presented. Within rows, values with different letters are significantly different based on Fisher's protected least significant difference test.

Variable	FM	MBM	AV	*P*-value
Percent dress-out	64.7	65.8	67.2	0.13
Percent intraperitoneal fat				
Small	2.4	2.9	2.6	0.18
Large	4.1	4.4	3.7	0.36
Hepatosomatic index	1.37	1.26	1.25	0.47
Percent lipid (g/100 g dry weight)	8.64 z	5.87 y	7.87 z	0.003

electrical failures, resulting in six replicates in the FM treatment and five in the MBM and AV treatments. No significant differences among treatments were observed in overall survival. Survival of the small fish was similar for all diets, but the large fish fed the AV diet had a numerically higher survival than fish offered the FM and MBM diets. At harvest, there were no significant differences in mean weights of the small fish as a result of dietary treatment ($P = 0.45$). Although not significant, mean harvest weight of the large fish subgroup was highest for fish fed the FM and MBM diets ($P = 0.11$). Mean relative weight gain by small fish, expressed as a ratio (small fish weight gain : large fish weight gain), was significantly greater for fish offered the AV diet compared with fish fed the FM and MBM diets ($P = 0.04$). Net yield of small fish was similar in all treatments ($P = 0.61$), but yield of large fish fed the AV diet was lower than that of fish fed the FM and MBM diets. Net yield of small fish, expressed as a percentage of total net yield, receiving the AV diet was similar to fish fed the MBM diet but higher than fish fed the FM diet ($P = 0.10$).

Feed consumption by fish offered the FM diet was similar to consumption by fish fed the AV diet but inferior to feed consumption of fish fed the MBM diet ($P = 0.04$). The FCR of fish fed the FM diet was similar to fish fed the AV diet and superior to fish fed the MBM diet ($P = 0.04$). However, the MBM diet contained slightly less protein than the other two diets (31 versus 32%), resulting in similar PERs for all diets ($P = 0.52$). Dress-out percentages for the small and large fish ($P > 0.1$) were similar. Overall, there was no strong indication that dress-out changed as a function of the diet ($P = 0.13$). Dress-out of fish fed the MBM diet was intermediate and not statistically different from dress-out of fish fed the FM or AV diets. Although not significant, fish fed the AV diet had a higher dress-out than fish fed the FM diet.

Intraperitoneal fat, expressed as a percentage of live weight, was proportionally higher in big fish than in small fish ($P < 0.01$). The mean IPF value was highest for fish fed the MBM diet and lowest for fish fed the AV diet, but there was no statistical evidence that visceral fat content was related to diet ($P > 0.10$). The HSI did not show a significant difference among treatment diets, but did show a significant difference between size-groups.

Fillet lipid and fatty acid composition of small fish stocked as 8-g fingerlings and large fish stocked at an average weight of 470 g are presented in Tables 3 and 4. Lipid content of the fillets ranged from 5.9% to 8.6%. Fatty acid profiles of the fillets indicated significant size-related differences ($P = 0.01$). Total saturated fatty acid levels (Table 5) indicated the smaller fish had a lower amount compared with the large fish. Conversely, significant differences as a result of size ($P = 0.03$) were found for the total monounsaturated fatty acids, in which fillets from large fish had lower levels of this fatty acid than fillets from the small fish. No significant differences were shown for total polyunsaturated fatty acids, total omega-3 fatty acids, or total omega-6 fatty acids.

With reference to the large fish, significant differences were shown for fatty acid contents in fillets among the treatments. The large fish showed a significant difference ($P = 0.05$) in fillet content of myristic acid (14:0). Large fish fed the AV diet produced lower levels of myristic acid in the fillets than fish fed the MBM and FM diets. There was also a significant difference ($P = 0.01$) for 16:1(n-7)[1] concentrations in fillets. Again, the

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[1] In this nomenclature, 16 is the number of carbon atoms, 1 is the number of double bonds, and 7 is the position of the first double bond from the methyl end.

TABLE 4.—Fatty acid profiles of small channel catfish stocked as 8-g fingerlings and large channel catfish stocked at an average weight of 470 g fed daily to satiation on three experimental diets containing fish meal (FM); meat, bone, and blood meal (MBM); or vegetables (AV). Means within the same row with different letters are significantly different based on Duncan's multiple-range test. See footnote 1 in the text for an explanation of fatty acid nomenclature.

	Small fish				Large fish			
Fatty acid	FM	MBM	AV	*P*-value	FM	MBM	AV	*P*-value
14:0	1.27	1.15	1.12	0.193	1.13 z	1.07 zy	1.04 y	0.047
16:0	20.54	19.92	20.67	0.346	19.43	19.41	17.36	0.285
16:1(n-7)	3.15 z	2.62 y	3.09 z	0.016	2.66 z	2.43 zy	2.21 y	0.011
16:2(n-4)	0.01	0.06	0.12	0.153	0.01 y	0.07 z	0.03 zy	0.056
16:3(n-4)	0.12	0.11	0.13	0.824	0.12	0.14	0.1	0.627
18:0	6.7	6.9	6.85	0.662	6.8	6.77	6.75	0.985
18:1(n-9)	43.53	44.41	45.15	0.321	48.71	47.1	45.86	0.113
18:1(n-7)	1.53	1.97	1.57	0.539	1.13	1.2	0.8	0.736
18:2(n-6)	15.05	14.4	14.17	0.127	14.42	14.27	14.11	0.803
18:3(n-4)	0.11	0.07	0.1	0.395	0.1	0.12	0.07	0.42
18:3(n-3)	1.05	1.01	1.1	0.684	1.11 y	1.10 y	1.71 z	0.058
18:4(n-3)	0.05	0.04	0.05	0.968	0.06	0.06	0.06	0.979
20:1(n-9)	1.54	1.6	1.4	0.264	1.62	1.6	1.55	0.672
20:2	1.07	1.14	1.16	0.100	1.01	0.92	1.03	0.299
20:3(n-6)	1.01	1.22	1.00	0.114	1.06	1.03	1.10	0.797
20:4(n-6)	0.75	0.92	0.63	0.120	0.84	0.82	0.85	0.981
20:4(n-3)	0.13	0.10	0.11	0.346	0.12	0.11	0.10	0.853
20:5(n-3)	0.39 z	0.36 zy	0.27 y	0.037	0.39	0.35	0.30	0.144
22:1(n-9)	0.11	0.12	0.14	0.913	0.11	0.14	0.12	0.881
22:5(n-3)	0.43 z	0.43 z	0.30 y	0.031	0.40	0.39	0.35	0.637
22:6(n-3)	1.46	1.43	0.95	0.059	1.63	1.53	1.21	0.262

fish fed the AV diet showed lower levels of fatty acids in the fillets when compared with the fillets of fish fed the MBM and FM diets. Significant differences ($P = 0.05$) were also found in 16:2(n-4) content of the fillets, where the fish fed the FM diet had less 16:2(n-4) in fillets than fish maintained on the other diets. A significant difference was shown in levels of linolenic acid (18:3[n-3]) in fillets; fish fed the FM and MBM diets were similar but had lower levels of linolenic acid in the fillets compared with fish fed the AV diet. There were no other significant differences among the fatty acid profiles in fillets of the large fish.

TABLE 5.—Pooled data of small channel catfish stocked as 8-g fingerlings and large channel catfish stocked at an average weight of 470 g fed daily to satiation on three experimental diets and their fillet content of saturated, monounsaturated, polyunsaturated, omega-3, and omega-6 fatty acids and analyzed for the effects of fish size and diet.

	P-value	
Fatty acids	Size	Diet
Saturated	0.0091	0.1228
Monounsaturated	0.0265	0.1583
Polyunsaturated	0.9278	0.3729
Omega-3	0.100	0.5171
Omega-6	0.5171	0.2314

The fillets of small fish also exhibited significant differences in their fatty acid profile. A significant difference ($P = 0.02$) was found for 16:1(n-7); the fillets of fish fed the MBM diet had a lower mean than the fillets of fish fed the AV and FM diets. There were significant differences ($P = 0.04$) for eicosapentanoic acid (EPA; 20:5[n-3]), where means were lower in the fillets of fish fed the AV diet than in the fillets of fish fed the MBM and FM diets. Finally, no significant differences ($P = 0.06$) for docahexaenoic acid (DHA; 22:6[n-3]) were indicated in the fillets. There were no other significant differences among the fatty acid profiles of the fillets of small fish.

Discussion

Choosing a production diet is possibly one of the most important decisions made on the farm. The diet should be economical or ''the best diet for the price paid.'' The diet must also promote good survival, fast growth, high dress-out percentage, and an economical FCR. Furthermore, the flesh must have a good taste and positive health benefits for the consumer.

Production performance of the fish maintained on all diets used in this study was satisfactory; net yields ranged from 3,354–3,642 kg/ha. Protein source in production diets did not influence channel catfish survival, final weight, weight gain, total harvest weight, or net yield. However, there was a significant difference in the ratio of the weight gain of small to large fish, the FM diet producing a significantly lower ratio (Table 2). This was because fish fed the FM diet were larger in the large size-class and smaller in the small size-class than large and small fish fed the MBM and AV diets, thus resulting in a different ratio. Results of this study are similar to those of Robinson and Li (1999), who showed that inclusion of animal proteins in channel catfish feeds had no significant effect on harvest weight.

Significant differences for feed consumption and FCR among fish fed the experimental diets were found. This is contrary to the findings of Robinson et al. (2000), who reported a significant improvement in the FCR of fish fed animal protein compared with fish fed an all-vegetable diet. However, Reigh (1999) demonstrated no statistical difference in FCR of fish fed diets containing animal protein compared with fish fed diets containing vegetable protein.

When fed to satiation, fish offered the MBM diet consumed more feed and had a poorer FCR than fish fed the other diets. These differences in feed consumption and FCR could be a result of natural variation or a slightly lower availability of nutrients in the MBM diet. Since there were no indications of differences in PER for fish maintained on the three diets, one could conclude that the utilization and deposition of protein among the three diets was similar and that the poor FCR was a result of natural variation. The various sources of protein did not have any effect on dress-out percentage. This could be because the protein: energy ratio and percent lipids were similar among the diets. An increase in fattiness, which has an inverse relationship to dress-out, would typically be observed as the dietary digestible-energy-to-protein ratio is increased in the diet, the amount of fat is increased in the diet, or both (Robinson and Li 1999; Robinson et al. 2000).

The HSI did not show a significant difference among dietary treatments but did show a significant difference between size-groups. Fish in the small size-group had a significantly higher mean HSI compared with fish in the large size-group. This indicates that the smaller fish had a larger liver in relation to their overall weight compared with the larger fish. This might be a result of the larger role played by the liver in the rapidly growing fish in the small size-group. Intraperitoneal fat of fish offered the three experimental diets also was shown to be significantly different among size-groups but not among treatments. This is consistent with a study conducted by Robinson et al. (2000), who found no significant increases in lipid stores of fish fed an all-vegetable diet or a diet containing animal protein. In this study, large fish had a significantly larger IPF value compared with the small fish. This can be explained by the smaller fish using more of the consumed energy for growth, not lipid deposition, or the larger fish overconsuming feed relative to that of the smaller fish. Also, a significant difference was shown for the percent lipid content in the flesh as a result of fish size and dietary treatment. Fish fed the MBM diet had a significantly lower percent lipid content in the fillet compared with fish fed either the FM or AV diets. Furthermore, fillets from small fish contained significantly lower levels of lipids than fillets of large fish. This is probably because the small fish used more energy for growth.

Although dress-out and lipid indices are important for reducing the cost of processing, the cost of feed is important for reducing the cost of production. To estimate the cost of the test diets, ingredient costs and percent inclusion (Table 1) were used to determine a basal ingredient cost. Since ingredient prices vary with time and location, market prices for the ingredients are provided for two different points in time. To this, a US$65.60 cost was added for shrinkage, hauling, and the mill's operating margin. When we began our research, cost for the three diets was $232.62 (FM), $230.62 (MBM), and $233.86 (AV). At the time of writing, however, costs for the same diets had risen to $250.40 (FM), $233.12 (MBM), and $233.93 (AV). Factoring in the FCR allows us to calculate the cost per ton of fish. Using the initial prices, the cost of feed to produce 1 ton of fish (1 ton = 907 kg)was $395.45 (FM), $431.25 (MBM), and $404.58 (AV), whereas at the time of writing costs had risen to $425.67 (FM), $435.93 (MBM), and $404.69 (AV). Results clearly indicate that, when fish meal prices are depressed, the use of fish meal in the diet reduces costs of production. However, as would be expected, when fish meal prices rise, feed costs shift and the AV diet becomes the least expensive diet. Note that under pond production conditions, there are numerous variables that influence feed utilization, including mortality rate, feed management strategies, inventory control, and harvest size. Even though price differences between these feeds are real, FCR often varies and a small FCR shift of only 0.1 would essentially overshadow differences in price.

Although catfish producers want to reduce costs, the quality of the final product and consumer health benefits are also important. Perhaps the most outstanding results of the fatty acid profiles were that of the omega-3 fatty acids, such as EPA and DHA, that play an important role in human health. The EPA content was shown to be significantly higher in the flesh of the small size-group fed the FM and MBM diets compared with the flesh of fish fed the AV diet. The results of a study by Manning et al. (2000) showed that channel catfish fed menhaden oil diets had significant increases in omega-3 polyunsaturated fatty acid content compared with channel catfish fed vegetable oil diets. However, fish from the large size-groups in this study did not exhibit significant differences in EPA and DHA. Differences are probably a result of differences in tissue turnover and deposition, where small fish grow more rapidly. Fatty acid profiles of the flesh of fish fed the AV diet tended to have lower levels of polyunsaturated fatty acids. When comparing individual fatty acids, small fish maintained on the AV diet had lower levels of omega-3 polyunsaturated fatty acids. Conversely, more linolenic fatty acid was found in the fillets of large fish fed the vegetable diet compared with the other experimental diets. Yet, when comparing the total pooled omega-3 long-chain fatty acids found in the flesh, no differences were found among the test diets. No significant differences were found among the dietary treatments when the fatty acids were pooled by family (saturated, monounsaturated, polyunsaturated, omega-3, and omega-6 fatty acids); however, the flesh from small fish showed a significantly lower amount of saturated fatty acids compared with the flesh from large fish. Conversely, significantly higher amounts of monounsaturated fatty acids were found in the flesh of small fish when compared with the large fish for all three diets tested.

Conclusion

Fish meal and animal proteins have typically been included in channel catfish feeds because they are believed to have superior nutritional quality and feed palatability. In this study, protein sources in grow-out feeds for mixed-sized channel catfish showed few significant differences in production response, dress-out, and fat indices. Although, the MBM diet had lower lipid content in the fillet, a higher FCR, and a higher feed consumption, no significant differences among the diets for survival, average weight gain, or harvest weight were found. Minimal differences in fatty acid profiles of channel catfish muscle tissue among dietary treatments were detected; however, EPA levels were elevated in the small fish fed the FM diet. Proteins from vegetable, fish meal, and MBM sources contained in grow-out diets for channel catfish had similar influences on channel catfish growth performance. Any of the three protein sources can be used in channel catfish diets, and selection of a protein source should be based on a cost-benefit analysis.

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