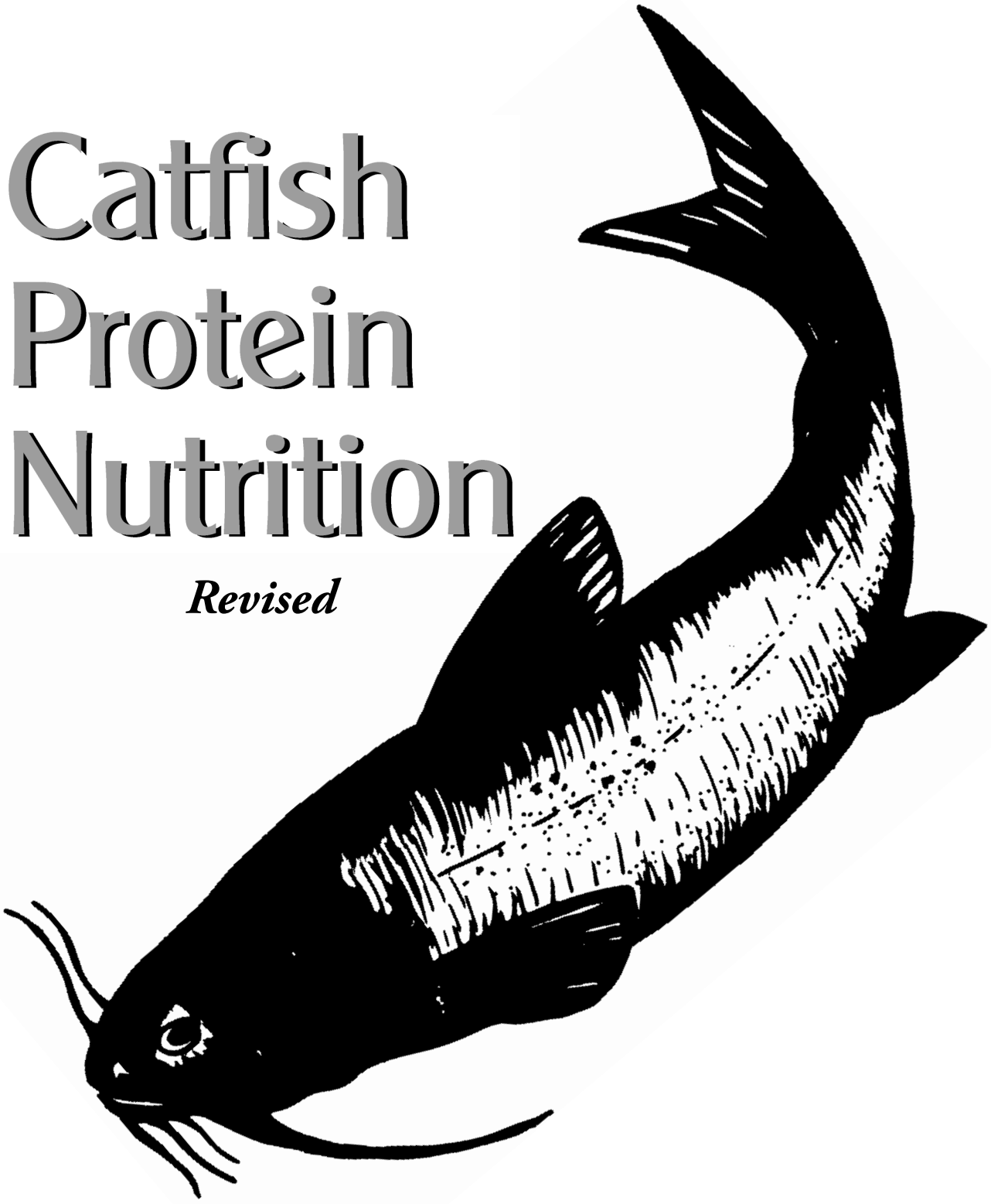
Bulletin 1159 **April 2007**

Catfish Protein Nutrition

Revised



Experiment Station
Vance H. Watson, Director

Mississippi Agricultural & Forestry Experiment Station
Robert H. Foglesong, President • Mississippi State University • Vance H. Watson, Vice President

Catfish Protein Nutrition: Revised

Edwin H. Robinson
Research Professor
Delta Research and Extension Center
Stoneville, Mississippi

Menghe H. Li
Research Professor
Delta Research and Extension Center
Stoneville, Mississippi

Acknowledgments: The authors appreciate the support of all of those who contributed to the work presented herein. Bulletin 1153 was published by the Office of Agricultural Communications, a unit of the Division of Agriculture, Forestry, and Veterinary Medicine at Mississippi State University.

CONTENTS

Catfish Protein Nutrition: Revised

Preface

This bulletin is a revision of MAFES Bulletin 1090 (1999) on catfish protein nutrition. It is a bit more comprehensive than the previous bulletin, in that it provides more information on the general aspects of protein nutrition in addition to data from specific studies that we have conducted. The bulletin is intended for fish nutritionists, catfish producers and feed manufacturers, aquaculture scientists, and students.

Introduction

Proteins are organic compounds composed of amino acids that comprise about 70% of the dry weight of fish muscle. Since protein is in a dynamic state, continually being synthesized and degraded, a dietary supply is needed throughout life to provide amino acids and nonspecific nitrogen for maintenance and growth. There is no single level of dietary protein that is optimum for meeting the nitrogen needs of catfish. This is because several factors affect the dietary protein requirement, including fish size, water temperature, feed allowance, amount of nonprotein energy in the diet, protein quality, natural food available, and management practices. Even so, catfish are typically fed the same diet throughout the grow-out phase. This is largely because of logistical issues associated with manufacturing and supplying a number of different diets. Further, there is a general perception that protein quantity equates to feed quality. That is, the more protein the better the feed; thus, the producer may feed a high-protein feed throughout grow out even though it may not be needed. In reality, the actual percentage of dietary protein is not as critical as the concentrations and proportions of amino acids provided in the protein. To ensure that catfish feeds are of high quality, the nutritionist must consider the amino acid composition of various feedstuffs, their digestibility, and the proper balance of protein and energy. The most economical method to achieve the proper balance between protein quantity and quality is to use a mixture of complementary protein feedstuffs and (if needed) supplemental amino acids.

Feeds used for grow out of catfish have traditionally contained 32–35% dietary protein. Commercial catfish feeds contain a liberal amount of relatively expensive, high-quality protein, and feed cost is the major variable operating cost associated with production of catfish; therefore, considerable effort has been expended to determine the quantity and quality of dietary protein necessary to achieve optimum performance of catfish. A short overview of various aspects of catfish protein nutrition is presented in this bulletin, along with data from our studies on protein nutrition.

METHODS

The research reported in this bulletin was primarily conducted in ponds, but some data are from studies conducted in laboratory growth trials. Pond studies reported here were conducted in small (0.1–1 acre) research ponds using management practices that reflect those used in the industry. Most of the studies were conducted for a single growing season, but some were multiyear studies. The laboratory studies were conducted using well-established procedures for feeding studies with catfish. Generally, small fingerlings (4–6 grams) were raised in glass aquaria (4–5 aquaria per treatment) in a flowing-water, temperature-controlled system for 8–12 weeks. Additional details on the experimental design of specific studies are described in the footnotes of various tables, and a full description can be found in respective references.

AMINO ACIDS

Although we speak of a protein requirement, it is more precise to formulate fish feeds on the basis of amino acid requirements. Nutritionally, amino acids may be classified as either indispensable (essential) or dispensable (nonessential). An indispensable amino acid is one that the animal cannot synthesize or cannot synthesize in quantities sufficient for body needs; thus, it must be supplied in the diet. A dispensable amino acid is one that can be synthesized by the animal in quantities sufficient for maximal growth. Most simple-stomach animals, including catfish, require the same 10 indispensable amino acids (Table1). There are differences between the amount of a specific amino acid required among various species of animals as well as among fish species, but that would be expected since the relative proportion of structural proteins may vary between species as well as physiological needs for certain amino acids.

Catfish can synthesize dispensable amino acids, but there are certain advantages if the nutrients are provided in the diet. For example, energy is saved in their synthesis and some dispensable amino acids can partially replace an indispensable amino acid (cystine can replace about 60% of the methionine, and tyrosine can replace about 50% of the phenylalanine). Practical catfish feeds typically contain liberal amounts of dispensable amino acids inherent in the proteins of various feedstuffs.

In a practical feed, amino acid requirements are best met by feeding a mixture of feedstuffs or by using a mixture of feedstuffs supplemented with amino acids. All 10 essential amino acids have to be present in the diet for growth to occur. If the diet contains an amino acid at a level below the requirement level, growth is reduced; thus, that amino acid is considered the limiting amino acid. Properly formulated catfish feeds with common feedstuffs provide all amino acids in sufficient quantities for maximum growth. If an amino acid deficiency in a feed formulation did occur, it is generally not a problem because it can be overcome by supplementing the diet with the deficient amino acid or by using a feedstuff high in that particular amino acid. Additions of supplemental amino acids are only beneficial if the diet is deficient in that particular amino acid. There appears to be no benefit to adding supplemental amino acids to diets that contain sufficient levels of amino acids from feedstuffs (Table 2). In practice, lysine is currently the only supplemental amino acid used in commercial catfish feeds, although certain other amino acids are commercially available. In reality, if the lysine requirement of a catfish diet is met by using common feedstuffs, all other amino acids are present in amounts that meet or exceed their requirements.

Feedstuffs contain a characteristic level of an amino acid, but all of it may not be available for use by the animal. Thus, it is more accurate to formulate catfish feeds based on available amino acids rather than using the total amount contained in a particular feedstuff. Generally most feedstuffs have relatively high amino acid availabilities (80–90%); however, there are exceptions. For example, only about 66% of the lysine contained in cottonseed meal is actually available to catfish. This is because part of the lysine in cottonseed meal is chemically bound to gossypol, a yellow pigment found in the meal, rendering it unavailable to the animal.

ENERGY-TO-PROTEIN RATIO

Absolute energy requirements for catfish are not known. Estimates of the requirement have been determined by measuring weight gain or protein gain of catfish fed diets containing a known amount of energy. Energy requirements reported for catfish, which have generally been expressed as a ratio of digestible energy (DE) to crude protein (DE/P), range from 7.4–12 kcal/gram. Our work supports previous data in that a DE/P ratio of 8.5–9.5 kcal/gram is adequate for use in commercial catfish feeds (Tables 3–9).

Protein Requirement

Catfish do not require as much dietary protein for maximum growth as has typically been assumed. We examined dietary protein levels from 10–40% in various studies and found no differences in weight gain and feed conversion in fish fed diets containing as low as 24% protein (Tables 3–22). In addition, we found that fish fed 16–20% dietary protein had 80–90% of the growth of fish fed a 32% protein diet. However, as dietary protein decreased, the DE/P ratio increased beyond the recommended range, resulting in an increase in visceral and fillet fat. This effect is quite dramatic in diets containing very low levels of dietary protein. Fish fed a 16%- protein diet grew well but had about twice as much fillet fat as similar sized fish raised on a 32%-protein diet (Table 5). The primary problem with increased fattiness is that too much fat may reduce processed yield. There are many factors other than diet that affect processed yield, but in general fish that are fed 26% or less dietary protein will have reduced processed yield. The data are not as consistent with fish fed a 28%-protein diet, since some studies show a reduction in processed yield and some do not. Overall, there are minimal differences in processed yield of fish fed a 28%- or 32%-protein diet, but the difference may be significant to catfish processors. Diets containing 35% protein or above may result in a decrease in fattiness compared with fish fed a 28%- or 32%-protein diet. This approach to reduce fattiness and increase processed yield may not be economical for the catfish producer, but if the producer is paid a premium for higher processed yield, it may be a more attractive proposition.

Low-protein diets are generally recommended for stockers and food fish, but not for small fingerlings. However, there were no differences in production of fingerling catfish (initial weight: 23 pounds per 1,000) stocked at 100,000 per acre and raised to 100 pounds per 1,000 using either a 28%-, 32%-, or 41%-protein diet (Table 19). It would appear that high-protein diets offer no advantage for fingerlings from about 4 inches in length and larger.

Protein requirements did not differ among catfish strains [Mississippi normal, USDA102, USDA103 (now, NWAC103), and Norris] (Tables 20–22). Thus, it appears that for commonly used catfish strains, dietary protein requirements are similar.

Protein Quality

The quality of protein sources used in catfish feeds must be taken into account to ensure that amino acid requirements are met. Protein quality is dictated primarily by the concentration of indispensable amino acids in a protein and by the biological availability of the amino acids to catfish. Proteins of animal origin, particularly fish meals prepared from whole fish, are considered to be nutritionally superior to proteins of plant origin. This is because animal proteins generally contain a higher level of indispensable amino acids and are more highly digestible by catfish than plant proteins. Commercial catfish feeds typically contain relatively high levels of protein supplied in part by animal protein supplements, but there is a growing body of evidence that animal protein can be reduced or eliminated in feeds for food-sized catfish (Tables 6, 9, 10, 11, 12, and 23). All-plant diets based on soybean meal, wheat, and corn can be formulated to meet the amino acid requirements for grow out of catfish (Table 24). It should also be noted that all-plant diets require additional supplemental phosphorus and the use of a mineral premix. The advantages of using all-plant diets include lower feed cost, milder flavor of fish flesh, and less body fat because of a reduction in dietary energy.

Protein Feedstuffs

Feedstuffs containing 20% crude protein or more are considered protein supplements. Animal proteins used in animal feeds come from inedible tissues from meatpacking or rendering plants, milk products, and marine sources. Those typically used in catfish feeds include fish meal, meat and bone meal, a blend of meat and bone/blood meal, blood meal, and poultry by-product meal.

Fish meal can be replaced (in part or totally) by poultry by-product meal, meat and bone/blood meal, catfish offal meal, hydrolyzed feather meal plus lysine, or a combination of these protein sources (Tables 25 and 26). Care must be used to ensure that these products are of high quality, because processing methods can have a significant effect on their quality. Although these products are good sources of protein for catfish, their use depends on cost and availability. Further, since the perception of using beef products to feed catfish may be detrimental to marketing catfish products (because of its implication of "mad cow" disease), we do not recommend the use of beef by-products in catfish feeds.

The primary plant protein sources used in catfish feeds are oilseed meals, such as soybean meal, cottonseed meal, and peanut meal. Certain other oilseed meals could be used but are not generally available on a timely basis and at an economical cost per unit of protein. Compared with animal

proteins, most plant proteins are deficient in lysine and methionine, the two limiting amino acids in catfish feeds. Also, certain plant proteins contain toxins and antinutritional factors that may or may not be inactivated during processing of the meal.

Cottonseed meal, canola meal, and distillers' grains can be used to replace part or all of the soybean meal (Tables 27–31). If the inclusion rate is higher than 20–25% of the diet, then the diet may need to be supplemented with lysine. The use of these ingredients will depend on their cost per unit of protein. Also, corn gluten feed can be used to replace up to 50% of the corn (Table 32). This will help reduce fattiness because of the decrease in dietary energy resulting from replacing corn with corn gluten feed. Levels of the yellow pigment xanthophyll in corn gluten feed are generally similar to levels in corn grain; thus, it does not result in yellow coloration in catfish fillets.

Dietary Protein and Feeding Rate

Generally, low-protein diets are effective when fish are fed to satiation, but higher-protein diets are required when feed is restricted. It appears that a 28%-protein diet provides for good growth at stocking rates not exceeding 10,000 per acre and feeding rates of 80 pounds per acre per day or more (Tables 13a–15). Also, a 28%-protein diet can be fed throughout the growing season. We find no advantage to begin feeding in early spring with a higher-protein diet and then reducing dietary protein as feeding activity increases. Higher-protein diets (32–35%) may increase net production and weight gain when feeding every other day compared with daily feeding (Tables 17a, b), but the value of this practice may or may not be economical. Regardless of diet, feeding every other day improves feed efficiency and reduces aeration time, but weight, carcass yield, and fillet yield are reduced compared with fish fed daily.

High-Protein Finishing Diets

Finishing catfish on high-protein diets to reduce body fat does not appear to be an effective strategy (Table 16). That is, there is no difference in body fat of fish fed a 28% protein diet for most of the growing season and then fed a high-protein diet for 30–90 days before harvest compared with fish fed the 28%-protein diet for the entire growing season. There were also no differences in fish fed a 28%- or 32%-protein diet for 150 days compared with fish finished for 30 or 60 days on 35%- or 38%-protein diets. Basically, there were no advantages to using high-protein finishing diets.

Dietary Protein and Stocking Rate

There were no differences in fish production using a 28%- or 32%-protein diet when fish were stocked at 6,000, 12,000, or 18,000 per acre (Table 18a). Further, production increased with stocking density, but the fish were smaller. Over two growing seasons, fish weight was 2, 1.5, or 1.4 pounds for fish stocked at 6,000, 12,000, or 18,000 per acre, respectively. Feed efficiency also decreased at the higher stocking densities. Fish fed the 28%-protein diet was slightly fatter than those fed the 32%-protein diet, but there was no effect on processed yield (Table 18b).

Dietary Protein and Disease Resistance

Neither the level of dietary protein nor the source of dietary protein affected the response of catfish exposed to *Edwardsiella ictaluri*, the bacterium causing enteric septicemia of catfish (ESC) (Table 33). Fish fed diets containing 28%, 32%, or 36% protein without animal protein or with fish meal, meat and bone/blood meal, or a combination of the two sources did not differ in survival after challenge with the bacterium. All diets were formulated to meet all nutritional requirements of catfish; thus, no difference would be expected unless dietary protein was a factor. Basically, this illustrates that the nutrients needed for immune response and growth can be supplied by various feedstuffs.

SUMMARY

Catfish food fish have traditionally been fed relatively high-protein diets (32–35%), but they grow just as fast and convert feed as efficiently on diets containing as low as 24% protein. However, fattiness may increase and processed yield may decrease as dietary protein is reduced. We recommend a 28%-protein diet for catfish stocked at rates not exceeding 10,000 per acre and fed daily at a rate of no less than 80 pounds per acre per day because it provides for excellent growth and there is minimal impact on fattiness and processed yield. If fish are fed less than daily a higher-protein diet may be beneficial. For example, a 32%-protein diet provided for additional gain compared with lower-protein diets when fish were fed every other day. However, weight gain was reduced compared with fish fed daily.

We also recommend a diet based entirely on plant proteins for growing catfish food fish. Although animal protein has been thought of as being indispensable to catfish, data presented herein show that it is not needed for catfish food fish. Some animal protein is still needed in catfish fry and fingerling diets.

There is no single feedstuff that can provide all the nutrient needs of catfish; thus, a mixture of feedstuffs is used. Soybean meal generally provides most of the protein in a typical commercial catfish diet, but various other protein sources can be used to replace a part of the soybean meal. Cottonseed meal and distillers' grains are two such feedstuffs. If these products are used at levels exceeding 20–25% of the diet, the diet may need to be supplemented with lysine. Most commercial catfish diets are fairly similar, but yet there can be differences in the actual composition of a specific diet. This is because there are many variations on the mixture of feedstuffs that can be used to supply the nutrients and energy needed by catfish.

Increasing dietary protein did not improve fish performance as stocking density increased. This was true for fish fed to satiation and stocked at rates up to 18,000 fish per acre. As stocking density increased, fish average weight decreased, as did the number of market-sized fish.

It appears that catfish strains commonly used in commercial catfish culture have similar protein requirements. Also, increasing dietary protein did not improve the catfish's resistance to *Edwardsiella ictaluri*.

Common Notes and Abbreviations Used in Tables

1. Individual treatment means or pooled means within a column followed by different letters are statistically different ($P \leq 0.05$).
2. * = significant ($P \leq 0.05$).
3. NS = not significant ($P > 0.05$).
4. DE/P = digestible energy/crude protein ratio.
5. FCR = feed conversion ratio.
6. Fillet composition data were expressed as percentages of wet tissue.

Table 1. Amino acid requirements of channel catfish.[1]

Amino acid	Requirement (% of dietary protein)
Arginine	4.3
Histidine	1.5
Isoleucine	2.6
Leucine	3.5
Lysine	5.1
Methionine + cystine	2.3
Phenylalanine + tyrosine	5.0
Threonine	2.0
Tryptophan	0.5
Valine	3.0

[1]Source: National Research Council. 1993. Nutrient Requirements of Fish. National Academy Press, Washington, D.C.

Table 2. Means of performance and fillet composition data for channel catfish fed practical diets containing various levels of crude protein and supplemental lysine (Lys) and methionine (Met) for 12 weeks in aquaria.[1]

Dietary protein[2]	Supplemental amino acid	Feed consumption	Weight gain[3]	FCR	Survival	Fillet moisture	Fillet protein	Fillet fat	Fillet ash
%		*g/fish*	*g/fish*	*feed/gain*	*%*	*%*	*%*	*%*	*%*
Individual Treatment Means									
24	None	85.9	60.6	1.43	100.0	78.8	16.3	3.5	1.12
24	Lys	88.0	61.3	1.45	99.0	78.8	16.3	3.7	1.14
24	Met	84.9	57.1	1.49	100.0	79.0	16.0	3.8	1.12
24	Lys + Met	86.6	60.0	1.45	100.0	78.6	16.6	3.4	1.14
28	None	88.4	63.9	1.39	100.0	78.4	17.2	3.2	1.14
28	Lys	89.0	63.8	1.41	100.0	78.0	17.4	3.3	1.16
28	Met	90.8	63.5	1.43	100.0	78.6	17.4	2.8	1.15
28	Lys + Met	89.5	64.7	1.39	100.0	77.6	17.8	3.5	1.10
Pooled Means									
24		86.4 v	59.8 v	1.45	99.8	78.8 u	16.3 v	3.6 u	1.13
28		89.4 u	64.0 u	1.41	100.0	78.2 v	17.4 u	3.2 v	1.14
	None	87.2	62.3	1.41	100.0	78.6	16.7	3.3	1.13
	Lys	88.5	62.6	1.43	99.5	78.4	16.9	3.5	1.15
	Met	87.8	60.3	1.47	100.0	78.8	16.7	3.3	1.14
	Lys + Met	88.1	62.3	1.43	100.0	78.1	17.2	3.4	1.12
Analysis of Variance									
Supplemental amino acids (SAA)		*	*	NS	NS	*	*	*	NS
Dietary protein (DP)		NS	NS	NS	NS	NS	NS	NS	NS
SAA X DP		NS	NS	NS	NS	NS	NS	NS	NS

[1]Source: Li, M.H., and E.H. Robinson. 1998. Effects of supplemental lysine and methionine in low protein diets on performance of channel catfish *Ictalurus punctatus.* Aquaculture 163:297–307.
[2]The 24% and 28% protein diets had DE/P ratios of 11.4 and 10 kcal/g protein, respectively.
[3]Mean initial weight was 10 g per fish. Fish were stocked at 20 fish per 30-gallon aquarium and fed to apparent satiation once daily.

Table 3. Means of performance and fillet composition data for channel catfish fed practical diets containing various levels of crude protein and DE/P ratios for 12 weeks in aquaria.[1]

Dietary protein	DE/P ratio	Feed consumption	Weight gain[2]	FCR	Survival	Fillet moisture	Fillet protein	Fillet fat	Fillet ash
%	*kcal/g*	*g/fish*	*g/fish*	*feed/gain*	*%*	*%*	*%*	*%*	*%*
24	8.5	99.0	59.6 b	1.67 a	100.0	79.2 ab	15.7 a	4.1 c	1.00
24	11.4	97.4	64.0 b	1.53 b	100.0	78.2 b	14.6 ab	6.0 a	0.90
28	8.5	99.6	62.8 b	1.59 ab	99.0	79.8 a	14.9 ab	4.1 c	0.87
28	9.9	96.6	75.3 a	1.28 c	100.0	79.5 ab	14.3 ab	4.9 b	0.90
32	8.5	97.2	75.9 a	1.28 c	99.0	78.7 ab	15.3 ab	4.7 bc	0.90

[1]Source: Li, M.H., and E.H. Robinson. 1999. Effect of reducing digestible energy to protein ratio on weight gain and body fat of juvenile channel catfish *Ictalurus punctatus.* Journal of the World Aquaculture Society 30:123–127.
[2]Mean initial weight was 5.2 g per fish. Fish were stocked at 20 fish per 30-gallon aquarium and fed to apparent satiation twice daily.

Table 4. Means of weight gain, processing yield, and fillet composition data for channel catfish fed diets containing various concentrations of crude protein for one growing season in ponds.[1]

Dietary protein	DE/P ratio	Weight gain[2]	Carcass yield	Visceral fat	Fillet composition		
					Fat	Protein	Moisture
%	*kcal/g*	*lb/fish*	*%*	*%*	*%*	*%*	*%*
26	10.8	0.98	63.3 a	2.7	5.6	15.8 b	77.3
28	10.1	0.96	63.5 a	3.0	5.2	16.4 ab	76.8
32	9.1	0.93	62.4 ab	2.9	5.4	16.6 a	76.5
35	8.4	0.93	61.8 b	2.9	5.2	16.9 a	76.4

[1]Source: Robinson, E.H., and M.H. Li. 1993. Protein quality and quantity of catfish feeds. Mississippi Agricultural and Forestry Experiment Station Technical Bulletin No. 189.
[2]Data were based on a sample of 500 fish per pond. Mean initial weight was 500 pounds per 1,000 fish. Fish were stocked at 10,000 fish per acre and fed to apparent satiation once daily.

Table 5. Means of performance, processing yield, and fillet composition data for channel catfish fed diets containing various concentrations of crude protein for one growing season in ponds.[1]

Dietary protein	DE/P ratio	Feed consumption	Weight gain[2]	FCR	Survival	Carcass yield	Visceral fat	Fillet composition			
								Protein	Fat	Moisture	Ash
%	*kcal/g*	*lb/fish*	*lb/fish*	*feed/gain*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
16	16.2	0.93 ab	0.62 b	1.49 a	96.6	55.1	5.2 a	15.7 c	8.2 a	74.4 b	1.10 b
20	13.1	0.95 ab	0.65 b	1.46 ab	97.6	55.7	4.5 b	15.6 c	7.8 a	75.0 ab	1.15 ab
24	11.3	1.01 a	0.72 a	1.40 bc	91.0	56.2	3.8 c	16.1 bc	5.8 b	76.4 a	1.21 a
28	9.7	0.98 a	0.73 a	1.35 cd	96.0	56.5	3.2 d	17.2 ab	5.2 bc	76.1 ab	1.21 a
32	8.9	0.88 b	0.68 ab	1.30 d	92.5	57.0	3.1 d	18.2 a	4.4 c	76.1 ab	1.12 b

[1]Source: Robinson, E.H., and M.H. Li. 1997. Low protein diets for channel catfish *Ictalurus punctatus* raised in earthen ponds at high density. Journal of the World Aquaculture Society 28:224–229.
[2]Mean initial weight was 60 pounds per 1,000 fish. Fish were stocked at 10,000 fish per acre and fed to apparent satiation once daily.

Table 6. Means of performance, processing yield, and fillet composition data for channel catfish fed diets containing various concentrations of crude protein for one growing season in ponds.[1]

Dietary protein	DE/P ratio	Feed consumption	Weight gain[2]	FCR	Survival	Carcass yield	Fillet yield	Visceral fat	Fillet composition		
									Protein	Fat	Moisture
%	*kcal/g*	*lb/fish*	*lb/fish*	*feed/gain*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
24	11.7	1.43	0.79	1.81 a	96.6	59.6	35.3 b	3.2 a	17.1	5.4 a	76.1
28	10.2	1.44	0.84	1.70 c	96.3	60.3	36.1 ab	3.1 a	16.9	5.2 ab	76.3
28-pl[3]	10.2	1.40	0.78	1.80 a	94.3	60.1	35.6 b	3.0 a	17.3	5.1 abc	76.1
32	9.0	1.39	0.79	1.77 ab	96.7	60.4	35.8 ab	3.1 a	17.0	4.6 bc	77.0
36	8.1	1.45	0.84	1.73 bc	94.9	60.5	36.6 a	2.7 b	17.4	4.4 c	77.0

[1]Source: Li, M.H., B.G. Bosworth, and E.H. Robinson. 2000. Effect of dietary protein concentration on growth and processing yield of channel catfish *Ictalurus punctatus*. Journal of the World Aquaculture Society 31:600–606.
[2]Mean initial weight was 60 pounds per 1,000 fish. Fish were stocked at 7,500 fish per acre and fed to apparent satiation once daily.
[3]28%-protein, all-plant diet.

Table 7. Means of performance, processing yield, and fillet composition data for channel catfish fed a 28%-or 32%-protein diet for one growing season in ponds.[1]

Dietary protein	DE/P ratio	Feed consumption	Weight gain[2]	FCR	Carcass yield	Visceral fat	Fillet composition		
							Protein	Fat	Moisture
%	*kcal/g*	*lb/fish*	*lb/fish*	*feed/gain*	*%*	*%*	*%*	*%*	*%*
28	10.0	1.24	1.03	1.27	60.6	2.9	15.2	6.6 a	76.1 b
32	8.7	1.27	0.92	1.37	61.3	3.0	14.7	5.1 b	78.9 a

[1]Source: Robinson, E.H., and M.H. Li. 1999. Catfish protein nutrition. Mississippi Agricultural and Forestry Experiment Station Bulletin No. 1090.
[2]Mean initial weight was 77 pounds per 1,000 fish. Fish were stocked at 6,000 fish per acre and fed to apparent satiation once daily.

Table 8. Means of performance, processing yield, and fillet composition data for channel catfish fed a 28%- or 32%-protein diet for one growing season in ponds.[1]

Dietary protein	DE/P ratio	Feed consumption	Weight gain[2]	FCR	Carcass yield	Visceral fat	Fillet composition		
							Protein	Fat	Moisture
%	*kcal/g*	*lb/fish*	*lb/fish*	*feed/gain*	*%*	*%*	*%*	*%*	*%*
28	10.2	1.00 a	0.75 a	1.35	61.8	3.1	17.6	7.6	74.2
32	9.1	0.83 b	0.61 b	1.34	62.2	3.4	17.1	6.1	75.1

[1]Robinson, E.H., and M.H. Li. 1993. Protein quality and quantity of catfish feeds. Mississippi Agricultural and Forestry Experiment Station Technical Bulletin No. 189.
[2]Mean initial weight was 80 pounds per 1,000 fish. Fish were stocked at 10,000 fish per acre and fed to apparent satiation once daily.

Table 9. Means of performance, processing yield, and fillet composition data for channel catfish fed diets containing various concentrations of crude protein for two growing seasons in ponds.[1]

Dietary protein	DE/P ratio	Feed consumption	Weight gain[2]	FCR	Survival	Carcass yield	Fillet yield	Visceral fat	Fillet composition		
									Protein	Fat	Moisture
%	*kcal/g*	*lb/fish*	*lb/fish*	*feed/gain*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
26	10.9	3.97	2.01	1.97	97.2	63.3	37.6	2.7 ab	18.0	8.0	73.2
28	10.2	4.20	2.10	2.00	97.9	63.1	37.7	2.9 a	17.9	8.2	73.1
28-pl[3]	10.2	4.13	1.95	2.12	96.9	63.5	37.8	2.5 b	18.0	7.5	73.5
32	9.0	3.99	1.97	2.03	99.3	63.7	38.1	2.8 a	18.4	7.8	72.8

[1]Source: Li, M.H., E.H. Robinson, B.B. Manning, and B.G. Bosworth. 2001. Effect of dietary protein concentration on growth and processing yield of channel catfish *Ictalurus punctatus* raised from advanced fingerlings to large marketable size. Journal of Applied Aquaculture 11(4):49–56.
[2]Mean initial weight was 60 pounds per 1,000 fish. Fish were stocked at 10,000 fish per acre and fed to apparent satiation once daily.
[3]28%-protein, all-plant diet.

Table 10. Means of performance, processing yield, and fillet composition data for channel catfish fed diets with various crude protein concentrations and quality once daily to satiation for one growing season in ponds.[1]

Dietary protein[2]	Feed consumption	Weight gain[3]	FCR	Survival	Visceral fat	Carcass yield	Fillet yield	Fillet moisture	Fillet protein	Fillet fat
	lb/fish	*lb/fish*	*feed/gain*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
28% control[4]	1.50 ab	0.96 a	1.56 c	98.4	4.19 d	65.6 a	35.7 a	75.4	16.9 a	6.9 c
28% w/o suppl.[5]	1.59 a	0.90 a	1.77 b	93.0	5.41 c	66.2 a	36.4 a	74.9	15.8 b	8.4 b
18% w/o AP[6]	1.58 a	0.91 a	1.75 b	96.2	4.53 d	64.1 b	34.0 b	74.5	16.1 b	8.6 b
10% w/o suppl.[7]	1.20 c	0.54 c	2.21 a	93.7	6.99 a	59.5 d	28.3 d	74.5	15.1 c	9.3 ab
10%[8]	1.37 bc	0.62 b	2.21 a	96.8	6.10 b	61.2 c	30.7 c	73.7	14.9 c	10.3 a

[1]Source: Robinson, E.H., M.H. Li, and B.B. Manning. 2005. Low quality diets for grow out of channel catfish *Ictalurus punctatus*. Journal of Applied Aquaculture 17 (2):35–45.
[2]The DE/P ratios were 9.9, 9.5, 14, 25, and 25 kcal/g protein for 28% protein control, 28% protein without supplement, 18% protein, 10% protein without supplement, and 10% protein diets, respectively.
[3]Mean initial weight was 141 pounds per 1,000 fish. Fish were stocked at 7,000 fish per acre and fed to apparent satiation once daily.
[4]Nutritionally complete diet.
[5]Without supplemental vitamins, minerals, or fat.
[6]With supplemental lysine, vitamins, and minerals, but without animal protein.
[7]Without animal protein, soybean meal, or supplemental vitamins and minerals
[8]With supplemental lysine, vitamins, and minerals, but without animal protein or soybean meal.

Table 11. Means of performance, carcass yield, and fillet composition data for channel catfish fed diets containing different levels of total protein and animal protein for one growing season in ponds.[1]

Dietary protein[2]	Animal protein[3]	Feed consumption	Weight gain[4]	FCR	Survival	Carcass yield	Visceral fat	Fillet composition			
								Protein	Fat	Moisture	Ash
%	*%*	*lb/fish*	*lb/fish*	*feed/gain*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
Individual Treatment Means											
28	0	1.13	0.74	1.54	89.9	54.0	4.1	15.5	6.1 b	76.8	1.00
32	0	1.12	0.72	1.55	95.6	54.3	3.5	14.9	7.6 ab	75.6	0.96
28	8	1.15	0.78	1.47	93.7	53.2	4.0	14.7	8.6 a	74.6	1.01
32	8	1.05	0.74	1.43	95.0	53.7	2.6	15.6	6.3 b	76.4	0.99
Pooled Means											
28		1.14	0.76	1.50	91.8	53.6	4.0 p	15.1	7.4	75.7	1.00
32		1.08	0.73	1.49	95.3	54.0	3.1 q	15.3	7.0	76.0	0.97
	0	1.13	0.73	1.55	92.8	54.2	3.8	15.2	6.9	76.2	0.98
	8	1.10	0.76	1.45	94.4	53.5	3.3	15.2	7.5	75.5	1.00
Analysis of Variance											
Dietary protein (DP)		NS	NS	NS	NS	NS	*	NS	NS	NS	NS
Animal protein (AP)		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
DP X AP		NS	NS	NS	NS	NS	NS	NS	*	NS	NS

[1]Source: Robinson, E.H., and M.H. Li. 1998. Comparison of practical diets with and without animal protein at various concentrations of dietary protein for performance of channel catfish *Ictalurus punctatus* raised in earthen ponds. Journal of the World Aquaculture Society 29:273–280.
[2]The 28% and 32% protein diets with or without animal protein had DE/P ratios of 10.1, 10.2, 9.1, and 9 kcal/g protein, respectively.
[3]Animal protein included 4% menhaden meal and 4% meat and bone/blood meal.
[4]Mean initial weight was 58 pounds per 1,000 fish. Fish were stocked at 10,000 fish per acre and fed to apparent satiation once daily.

Table 12. Means of performance, carcass yield, and fillet composition data for channel catfish fed diets containing different levels of total protein and animal protein for one growing season in ponds.[1]

Dietary protein[2]	Animal protein[3]	Feed consumption	Weight gain[4]	FCR	Survival	Carcass yield	Visceral fat	Fillet composition			
								Protein	Fat	Moisture	Ash
%	*%*	*lb/fish*	*lb/fish*	*feed/gain*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
Individual Treatment Means											
26	0	1.20	0.84	1.42	95.0	55.8	3.3	16.4	7.6	74.3	1.11
26	2	1.31	0.84	1.54	97.9	54.9	3.5	16.0	7.0	75.8	1.10
26	4	1.33	0.89	1.51	99.0	55.3	3.5	15.8	6.8	75.0	1.11
26	6	1.31	0.85	1.54	96.1	55.6	3.9	16.9	7.2	74.3	1.05
28	0	1.30	0.86	1.52	97.2	56.0	3.3	15.7	6.2	76.1	1.12
28	2	1.27	0.85	1.49	97.7	56.9	3.2	16.6	6.8	75.0	1.10
28	4	1.31	0.90	1.46	96.0	56.6	3.5	17.0	6.5	75.3	1.11
28	6	1.28	0.88	1.46	98.8	55.8	3.5	17.4	6.4	74.8	1.10
32	0	1.34	0.87	1.53	97.0	56.2	3.0	17.2	6.1	75.6	1.13
32	2	1.43	0.96	1.48	97.4	56.1	2.8	16.3	5.5	76.6	1.12
32	4	1.32	0.89	1.49	98.8	56.9	2.9	17.6	6.7	74.4	1.11
32	6	1.30	0.85	1.53	99.3	56.1	2.9	17.4	5.1	75.9	1.06
Pooled Means											
26		1.29	0.86	1.50	97.0	55.4 q	3.6 p	16.3	7.1 p	74.8	1.09
28		1.29	0.87	1.48	97.4	56.3 p	3.4 p	16.7	6.5 pq	75.3	1.11
32		1.35	0.89	1.51	98.1	56.3 p	2.9 q	17.2	5.8 q	75.6	1.11
	0	1.28	0.86	1.49	96.4	56.0	3.2	16.4	6.6	75.3	1.12
	2	1.34	0.89	1.50	97.7	56.0	3.2	16.3	6.4	75.8	1.11
	4	1.32	0.89	1.48	97.9	56.3	3.3	16.8	6.7	74.9	1.11
	6	1.29	0.86	1.51	98.0	55.8	3.4	17.2	6.2	75.0	1.07
Analysis of Variance											
Dietary protein (DP)		NS	NS	NS	NS	*	*	NS	*	NS	NS
Animal protein (AP)		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
DP X AP		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1]Source: Robinson, E.H., and M.H. Li. 1999. Evaluation of practical diets with various levels of dietary protein and animal protein for pond-raised channel catfish *Ictalurus punctatus*. Journal of the World Aquaculture Society 30:147–153.
[2]The 26%, 28%, and 32% protein diets with or without animal protein had a DE/P ratio of 10.9, 10.2, and 9 kcal/g protein, respectively.
[3]Meat and bone/blood meal.
[4]Mean initial weight was 152 pounds per 1,000 fish. Fish were stocked at 10,000 fish per acre and fed to apparent satiation once daily.

Table 13-a. Means of performance data for channel catfish fed once daily to apparent satiation or at a rate of ≤ 80 pounds per acre per day with diets containing various levels of crude protein for one growing season in ponds.[1]

Dietary protein[2]	Feeding rate	Feed consumption	Weight gain[3]	FCR	Survival	Aeration time
%	*lb/A*	*lb/fish*	*lb/fish*	*feed/gain*	*%*	*hours*
Individual Treatment Means						
28	≤ 80	1.34	1.01	1.33	95.2	801
28	Satiation	1.79	1.16	1.55	98.3	966
32	≤ 80	1.40	1.01	1.39	97.9	756
32	Satiation	1.83	1.13	1.62	97.4	897
36	≤ 80	1.41	1.00	1.42	96.6	813
36	Satiation	1.78	1.18	1.51	95.5	922
40	≤ 80	1.38	1.04	1.33	95.1	912
40	Satiation	1.75	1.09	1.61	95.2	879
Pooled Means						
28		1.57	1.08	1.44	96.7	884
32		1.61	1.07	1.50	97.6	826
36		1.60	1.09	1.47	96.1	868
40		1.57	1.07	1.47	95.1	896
	≤ 80	1.38 v	1.02 v	1.37 v	96.2	820 v
	Satiation	1.79 u	1.14 u	1.57 u	96.6	916 u
Analysis of Variance						
Dietary protein (DP)		NS	NS	NS	NS	NS
Feeding rate (FR)		*	*	*	NS	*
DP X FR		NS	NS	NS	NS	NS

[1]Source: Robinson, E.H., M.H. Li, B.B. Manning, C.C. Mischke, and B.G. Bosworth. 2004. Effects of high-protein diets on channel catfish *Ictalurus punctatus* production, composition of gain, processing yield, and water quality. Journal of the World Aquaculture Society 35:468–477.
[2]The 28%, 32%, 36%, and 40% protein diets had DE/P ratios of 10.3, 9.2, 8.3, and 7.6 kcal/g protein, respectively.
[3]Mean initial weight was 141 pounds per 1,000 fish. Fish were stocked at 7,000 fish per acre and fed once daily.

Table 13-b. Means of processing yield and fillet composition data for channel catfish fed once daily to satiation or at a rate of ≤ 80 pounds per acre per day with diets containing various levels of crude protein for one growing season in ponds.[1]

Dietary protein	Feeding rate	Visceral fat	Carcass yield	Fillet yield	Fillet moisture	Fillet protein	Fillet fat
%	lb/A	%	%	%	%	%	%
Individual Treatment Means							
28	≤ 80	3.33	65.9	35.9	75.6	17.1	6.26
28	Satiation	3.53	66.2	36.5	76.2	16.5	6.38
32	≤ 80	3.33	66.2	36.5	76.5	17.1	5.43
32	Satiation	3.60	67.0	37.4	75.1	16.8	7.11
36	≤ 80	2.99	66.6	37.4	77.0	16.6	5.43
36	Satiation	3.28	67.0	37.4	75.5	17.2	6.47
40	≤ 80	3.00	67.0	37.6	76.1	17.6	5.46
40	Satiation	3.48	67.1	37.6	75.6	17.2	6.40
Pooled Means							
28		3.43 pq	66.0 q	36.2 q	75.9	16.8	6.32
32		3.46 q	66.6 p	36.9 q	75.8	17.0	6.27
36		3.14 r	66.8 p	37.4 p	76.2	16.9	5.95
40		3.24 qr	67.0 p	37.6 p	75.9	17.4	5.93
	≤ 80	3.17 v	66.4	36.8	76.3 u	17.1	5.65 v
	Satiation	3.47 u	66.8	37.2	75.6 v	16.9	6.59 u
Analysis of Variance							
Dietary protein (DP)		*	*	*	NS	NS	NS
Feeding rate (FR)		*	NS	NS	*	NS	*
DP X FR		NS	NS	NS	NS	NS	NS

[1]Source: Robinson, E.H., M.H. Li, B.B. Manning, C.C. Mischke, and B.G. Bosworth. 2004. Effects of high-protein diets on channel catfish *Ictalurus punctatus* production, composition of gain, processing yield, and water quality. Journal of the World Aquaculture Society 35:468–477.

Table 14. Means of performance, carcass yield, and fillet composition data for channel catfish fed diets containing 28% or 32% crude protein at different feeding rates for two growing seasons in ponds.[1]

Dietary protein[2]	Feeding rate	Feed consumption	Weight gain[3]	FCR	Survival	Carcass yield	Visceral fat	Fillet composition			
								Protein	Fat	Moisture	Ash
%	lb/A	lb/fish	lb/fish	feed/gain	%	%	%	%	%	%	%
Individual Treatment Means											
28	≤ 80	2.21	1.41	1.57	89.5	55.6	3.0	16.2	3.8	78.0	1.13
28	≤ 100	2.77	1.58	1.76	81.8	55.2	3.3	15.5	5.0	77.7	1.13
28	≤ 120	3.05	1.71	1.78	84.4	55.1	3.4	15.9	5.2	77.4	1.14
28	Satiation	3.07	1.84	1.68	89.9	55.9	4.4	15.5	5.3	77.7	1.11
32	≤ 80	2.43	1.40	1.74	84.3	56.4	2.5	15.8	3.6	78.9	1.16
32	≤ 100	2.67	1.52	1.76	87.4	55.6	2.9	16.2	4.1	78.1	1.12
32	≤ 120	3.04	1.76	1.73	84.7	56.6	3.6	16.0	5.0	77.5	1.13
32	Satiation	3.21	1.81	1.79	86.5	56.7	3.8	16.0	5.2	77.2	1.15
Pooled Means											
28		2.77	1.63	1.70	86.4	55.4 q	3.5 p	15.8	4.8	77.7	1.13
32		2.83	1.62	1.75	85.7	56.3 p	3.2 q	15.8	4.5	77.9	1.14
	≤ 80	2.32 w	1.40 w	1.65	86.9	56.0	2.7 x	16.0	3.7 v	78.4	1.15
	≤ 100	2.72 v	1.54 vw	1.76	84.6	55.4	3.1 w	15.8	4.5 u	77.9	1.12
	≤ 120	3.05 u	1.73 uv	1.75	84.6	55.8	3.5 v	15.7	5.1 u	77.4	1.13
	Satiation	3.14 u	1.82 u	1.73	88.2	56.3	4.1 u	15.7	5.2 u	77.5	1.13
Analysis of Variance											
Dietary protein (DP)		NS	NS	NS	NS	*	*	NS	NS	NS	NS
Feeding rate (FR)		*	*	NS	NS	NS	*	NS	*	NS	NS
DP X FR		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1]Source: Robinson, E.H., and M.H. Li. 1999. Effect of dietary protein concentration and feeding rate on weight gain, feed efficiency, and body composition of pond-raised channel catfish *Ictalurus punctatus*. Journal of the World Aquaculture Society 30:311–318.
[2]The 28% and 32% protein diets had DE/P ratios of 10.2 and 9 kcal/g protein, respectively.
[3]Mean initial weight was 58 pounds per 1,000 fish. Fish were stocked at 10,000 fish per acre and fed once daily.

Table 15. Means of performance, processing yield, and fillet composition data for channel catfish fed diets containing various concentrations of crude protein at two feeding rates (apparent satiation or ≤ 120 pounds per acre per day) for one growing season in ponds.[1]

Dietary protein[2]	Feeding rate	Feed consumption	Weight gain[3]	FCR	Survival	Carcass yield	Visceral fat	Fillet composition			
								Protein	Fat	Moisture	Ash
%	*lb/A*	*lb/fish*	*lb/fish*	*feed/gain*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
Individual Treatment Means											
24	≤ 120	2.04	1.13	1.80	92.7	58.3	3.2	17.7	7.4	73.6	1.17
24	Satiation	2.12	1.17	1.81	94.9	58.9	2.9	17.6	7.3	73.8	1.17
28	≤ 120	1.97	1.11	1.78	99.8	60.1	2.3	17.5	6.7	74.6	1.28
28	Satiation	2.05	1.16	1.76	96.7	59.7	2.4	17.9	5.9	75.1	1.19
32	≤ 120	2.07	1.20	1.73	97.6	60.3	2.2	18.4	5.4	74.7	1.29
32	Satiation	2.08	1.18	1.77	91.9	59.3	2.4	17.6	6.2	74.8	1.17
Pooled Means											
24		2.08	1.15	1.80	93.8	58.6 q	3.1 p	17.6	7.4 p	73.7	1.17
28		2.01	1.13	1.77	98.2	59.9 p	2.4 q	17.7	6.3 q	74.8	1.23
32		2.08	1.19	1.75	94.8	59.8 p	2.3 q	18.0	5.9 q	74.8	1.23
	≤ 120	2.02	1.14	1.77	96.7	59.6	2.6	17.8	6.5	74.3	1.24
	Satiation	2.08	1.17	1.78	94.5	59.3	2.6	17.7	6.5	74.6	1.17
Analysis of variance											
Dietary protein (DP)		NS	NS	NS	NS	*	*	NS	*	NS	NS
Feeding rate (FR)		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
DP X FR		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1]Source: Robinson, E.H., and M.H. Li. 1999. Effect of dietary protein concentration and feeding rate on weight gain, feed efficiency, and body composition of pond-raised channel catfish *Ictalurus punctatus*. Journal of the World Aquaculture Society 30:311–318.
[2]The 24%, 28%, and 32% protein diets had DE/P ratios of 11.7, 10.2, and 9 kcal/g protein, respectively.
[3]Mean initial weight was 820 pounds per 1,000 fish. The fish were stocked at 7,000 fish per acre and fed once daily.

Table 16. Means of performance, processing yield, and fillet composition data for channel catfish fed diets containing different levels of crude protein for varying periods of time in ponds.[1]

Dietary protein[2]	Days fed	Feed consumption	Weight gain[3]	FCR	Survival	Visceral fat	Carcass yield	Fillet moisture	Fillet protein	Fillet fat
%		*lb/fish*	*lb/fish*	*feed/gain*	*%*	*%*	*%*	*%*	*%*	*%*
32	150	1.27	0.92	1.37	92.7	2.98	61.3 ab	78.9 a	14.7	5.1 b
28	150	1.25	0.95	1.27	91.7	2.86	60.6 b	76.1 b	15.2	6.6 a
28/38	90/60	1.29	0.96	1.37	96.4	2.75	62.0 a	77.4 ab	16.3	4.4 b
28/35	90/60	1.29	0.99	1.33	90.0	2.85	62.0 a	77.3 ab	15.7	5.0 b
28/38	120/60	1.27	0.96	1.37	93.2	3.10	62.0 a	77.6 ab	15.4	5.4 ab
28/35	120/60	1.27	0.99	1.33	92.4	2.75	61.9 a	77.5 ab	15.7	4.8 b

[1]Source: Robinson, E.H. 1994. Effects of high-protein "finishing" feeds on performance and fat content of channel catfish. Journal of the World Aquaculture Society 25: 465–470.
[2]The 28%, 32%, 35%, and 38% protein diets had DE/P ratios of 10.4, 10.1, 8.3, and 7.6 kcal/g protein, respectively.
[3]Mean initial weight was 77 pounds per 1,000 fish. Fish were stocked at 6,000 fish per acre and fed to apparent satiation once daily.

Table 17-a. Means of performance data for channel catfish fed once daily or once every other day (EOD) to satiation with different protein diets for one growing season in ponds.[1]

Dietary protein[2]	Feeding regimen	Amount of feed fed	Net production	Feed consumption	Weight gain[3]	FCR	Survival[3]	Aeration time	Market-sized fish[4]
%		*lb/A*	*lb/A*	*lb/fish*	*lb/fish*	*feed/gain*	*%*	*hour*	*%*
Individual Treatment Means									
28	Daily	10,303 a	3,563	2.58	0.89	2.89	91.0	830	34.7
28	EOD	5,641 c	2,290	1.43	0.58	2.47	91.3	683	16.7
32	Daily	8,622 b	3,396	2.39	0.94	2.54	84.5	860	40.0
32	EOD	5,015 c	2,283	1.44	0.66	2.19	82.5	743	22.5
35	Daily	8,223 b	3,251	1.94	0.76	2.53	91.4	799	31.5
35	EOD	5,867 c	2,470	1.57	0.66	2.38	86.8	794	14.7
Pooled Means									
28			2,926	2.01	0.73	2.68 p	91.1	756	25.7 q
32			2,839	1.92	0.80	2.37 q	83.5	801	31.3 p
35			2,861	1.75	0.71	2.46 q	89.1	796	23.1 q
	Daily		3,403 u	2.30 u	0.86 u	2.66 u	88.9	829 u	35.4 u
	EOD		2,348 v	1.48 v	0.63 v	2.35 v	86.9	740 v	18.0 v
Analysis of Variance									
Dietary protein (DP)		*	NS	NS	NS	*	NS	NS	*
Feeding regimen (FR)		*	*	*	*	*	NS	*	*
DP X FR		*	NS	NS	NS	NS	NS	NS	NS

[1]Source: Li, M.H., E.H. Robinson, B.B. Manning, and B.G. Bosworth. 2004. Effect of dietary protein concentration on production characteristics of pond-raised channel catfish fed once daily or once every other day to satiation. North American Journal of Aquaculture 66:184–190.
[2]Commercial feeds.
[3]Initial weight was 205 pounds per 1,000 fish. Fish were stocked at 4,500 fish per acre and fed to apparent satiation. Weight gain and survival were estimated based on a 500-fish random sample per pond.
[4]Fish of 1.25 pound and above were considered market size.

Table 17-b. Means of visceral fat, processing yield, and fillet composition data for channel catfish fed once daily or once every other day (EOD) to satiation with different protein diets for one growing season in ponds.[1]

Dietary protein	Feeding regimen	Visceral fat	Carcass yield	Fillet yield	Fillet moisture	Fillet protein	Fillet fat
%		*%*	*%*	*%*	*%*	*%*	*%*
Individual Treatment Means							
28	Daily	4.26	65.6	36.2	75.5	16.6	7.08
28	EOD	2.75	64.7	35.4	78.6	16.0	4.58
32	Daily	4.04	66.3	36.5	75.7	16.7	6.68
32	EOD	2.50	65.1	36.1	77.9	16.2	4.98
35	Daily	4.22	65.7	36.6	75.8	16.3	6.79
35	EOD	2.65	64.7	35.0	78.3	16.4	4.49
Pooled Means							
28		3.51	65.2	35.8	77.1	16.3	5.83
32		3.27	65.7	36.3	76.8	16.5	5.83
35		3.44	65.2	35.8	77.1	16.3	5.64
	Daily	4.17 u	65.9 u	36.4 u	75.7 v	16.6	6.85 u
	EOD	2.63 v	64.8 v	35.5 v	78.3 u	16.2	4.69 v
Analysis of Variance							
Dietary protein (DP)		NS	NS	NS	NS	NS	NS
Feeding regimen (FR)		*	*	*	*	NS	*
DP X FR		NS	NS	NS	NS	NS	NS

[1]Source: Li, M.H., E.H. Robinson, B.B. Manning, and B.G. Bosworth. 2004. Effect of dietary protein concentration on production characteristics of pond-raised channel catfish fed once daily or once every other day to satiation. North American Journal of Aquaculture 66:184–190.

Table 18-a. Means of performance data for channel catfish stocked at three densities and fed a 28%- or 32%-protein diet for two growing seasons in ponds.[1]

Stocking density	Dietary protein[2]	Net production	Feed consumption	Weight gain[3]	FCR	Survival
fish/A	*%*	*lb/A*	*lb/fish*	*lb/fish*	*feed/gain*	*%*
Individual Treatment Means						
6,000	28	11,835	3.67	2.02	1.84	97.5
6,000	32	12,390	3.61	2.09	1.74	98.7
12,000	28	17,875	2.74	2.51	1.82	98.3
12,000	32	17,580	2.80	1.49	1.88	98.0
18,000	28	23,860	2.86	1.43	1.99	92.6
18,000	32	23,508	2.80	1.42	1.97	91.8
Pooled Means						
6,000		12,113 w	3.64 u	2.05 u	1.79 v	98.1 u
12,000		17,719 v	2.77 v	1.50 v	1.85 v	98.2 u
18,000		23,684 u	2.83 v	1.43 v	1.98 u	92.2 v
	28	17,851	3.09	1.65	1.88	96.1
	32	17,826	3.07	1.67	1.86	96.2
Analysis of Variance						
Stocking density (SD)		*	*	*	*	*
Dietary protein (DP)		NS	NS	NS	NS	NS
SD X DP		NS	NS	NS	NS	NS

[1]Source: Li, M.H., B.B. Manning, E.H. Robinson, and B.G. Bosworth. 2003. Effect of dietary protein and stocking density on production characteristics of pond-raised channel catfish *Ictalurus punctatus*. Journal of the World Aquaculture Society 34:147–155.
[2]The 28%- and 32%-protein diets had DE/P ratios of 10.4 and 9.3 kcal/g protein, respectively.
[3]Mean initial weight was 107 pounds per 1,000 fish. Fish were fed to apparent satiation once daily.

Table 18-b. Means of processing yield and fillet composition data for channel catfish stocked at three densities and fed a 28%- or a 32%-protein diet for two growing seasons in ponds.[1]

Stocking density	Dietary protein	Visceral fat	Carcass yield	Fillet yield	Fillet moisture	Fillet protein	Fillet fat	Fillet ash
fish/A	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
Individual Treatment Means								
6,000	28	3.00	67.1	37.2	75.4	17.5	6.02	1.22
6,000	32	2.86	67.5	38.2	76.9	17.4	4.79	1.19
12,000	28	2.87	67.8	37.9	77.2	16.8	4.74	1.17
12,000	32	2.54	67.4	37.6	77.4	16.4	4.78	1.19
18,000	28	3.08	66.8	37.4	76.0	16.7	5.76	1.20
18,000	32	2.64	67.0	37.8	76.9	17.2	5.03	1.22
Pooled Means								
6,000		2.93	67.3	37.7	76.1	17.4	5.41	1.20
12,000		2.71	67.6	37.7	77.3	16.6	4.76	1.18
18,000		2.86	66.9	37.6	76.4	16.9	5.40	1.21
	28	2.98 u	67.2	37.5	76.2	17.0	5.51 u	1.20
	32	2.68 v	67.3	37.9	77.1	17.0	4.87 v	1.20
Analysis of Variance								
Stocking density (SD)		NS	NS	NS	NS	NS	NS	NS
Dietary protein (DP)		*	NS	NS	NS	NS	*	NS
SD X DP		NS	NS	NS	NS	NS	NS	NS

[1]Source: Li, M.H., B.B. Manning, E.H. Robinson, and B.G. Bosworth. 2003. Effect of dietary protein and stocking density on production characteristics of pond-raised channel catfish *Ictalurus punctatus*. Journal of the World Aquaculture Society 34:147–155.

Table 19. Means of performance data for channel catfish fingerlings fed diets containing 28%, 32%, or 41% crude protein for one growing season in ponds.[1]

Dietary protein	Fingerlings produced[2]	Gross production[2]	Final weight[3]	Amount of feed fed	Estimated Survival[2]	Estimated FCR[2]
%		*lb/A*	*lb/1,000*	*lb/A*	*%*	
28	77,878	8,006	104	14,391	77.9	2.58
32	76,505	8,114	107	14,398	76.5	2.54
41	74,466	7,859	107	14,132	74.5	2.60

[1]Source: Robinson, E.H., M.H. Li, and B.B. Manning. 2002. Evaluation of low-protein diets for production of fingerling channel catfish. National Warmwater Aquaculture Center Newsletter 5 (1):4–5.
[2]Values were based on the number and weight of fish harvested. Each pond was seined three times and fish that remained in the pond were considered to be negligible.
[3]Mean initial weight was 23 pounds per 1,000 fish. Fish were stocked at a rate of 100,000 fish per acre and fed to apparent satiation once daily.

Table 20. Means of performance and fillet composition data of different channel catfish strains fed practical diets containing various levels of crude protein for 8 weeks in aquaria.[1]

Strain	Dietary protein[2]	Feed consumption	Weight gain[3]	FCR	Survival	Fillet moisture	Fillet protein	Fillet fat	Fillet ash
	%	*g/fish*	*g/fish*	*feed/gain*	*%*	*%*	*%*	*%*	*%*
Individual Treatment Means									
USDA102	25	94.9	42.4	2.25 b	100.0	78.3	17.3	3.3	1.12
USDA102	35	104.9	64.3	1.65 c	100.0	77.4	17.9	3.8	1.11
USDA102	45	100.9	48.0	2.11 b	100.0	78.1	17.7	3.0	1.09
USDA103	25	100.4	59.8	1.69 c	99.0	77.8	17.1	3.9	1.09
USDA103	35	115.9	87.8	1.32 d	100.0	77.7	17.1	4.0	1.06
USDA103	45	114.0	67.2	1.70 c	100.0	78.6	16.8	3.3	1.01
MN[4]	25	83.0	32.2	2.60 a	98.0	79.7	16.4	2.4	1.14
MN	35	101.5	59.6	1.71 c	100.0	78.4	17.5	2.8	1.11
MN	45	96.5	46.8	2.10 b	100.0	79.0	17.4	2.3	1.07
Pooled Means									
USDA102		100.3 q	51.6 q	2.00	100.0	77.9 q	17.6	3.3 p	1.10 p
USDA103		110.1 p	71.6 p	1.57	99.7	78.1 q	17.0	3.8 p	1.05 q
MN		93.6 r	46.2 r	2.14	99.3	79.0 p	17.1	2.5 q	1.11 p
	25	92.7 w	44.8 w	2.18	99.0	78.6 u	16.9	3.2 uv	1.12 u
	35	107.4 u	70.6 u	1.56	100.0	77.8 v	17.6	3.6 u	1.09 u
	45	103.8 v	54.0 v	1.97	100.0	78.6 u	17.3	2.9 v	1.06 v
Analysis of Variance									
Strain (ST)		*	*	*	NS	*	NS	*	*
Dietary protein (DP)		*	*	*	NS	*	NS	*	*
ST X DP		NS	NS	*	NS	NS	NS	NS	NS

[1]Source: Li, M.H., E.H. Robinson, and W.R. Wolters. 1998. Evaluation of three strains of channel catfish *Ictalurus punctatus* fed diets containing three concentrations of dietary protein. Journal of the World Aquaculture Society 29:156–161.
[2]The 25%, 35%, and 45% protein diets had DE/P ratios of 10, 8.1, and 6.8 kcal/g protein, respectively.
[3]Mean initial weight was 15.1 g per fish. Fish were stocked at 20 fish per 30-gallon aquarium and fed to apparent satiation twice daily.
[4]Mississippi “normal” strain.

Table 21. Means of performance, processing yield, and fillet composition data of USDA103 and Mississippi "normal" (MN) strains of channel catfish fed diets containing three levels of crude protein for one growing season in ponds.[1]

Fish strain	Dietary protein[2]	Feed consumption	Weight gain[3]	FCR	Survival	Visceral fat	Carcass yield	Fillet yield	Fillet moisture	Fillet protein	Fillet fat
	%	*lb/fish*	*lb/fish*	*feed/gain*	%	%	%	%	%	%	%
Individual Treatment Means											
USDA103	26	1.46	0.88	1.66	95.6	2.95	61.9	36.0	73.0	18.4	7.1
MN	26	1.31	0.78	1.67	96.3	3.44	60.3	36.1	74.2	18.2	6.9
USDA103	28	1.47	0.90	1.65	98.6	2.59	62.4	36.4	72.9	18.1	7.8
MN	28	1.28	0.84	1.53	92.0	3.41	60.7	36.1	73.6	18.7	6.4
USDA103	32	1.47	0.90	1.65	96.1	2.46	63.5	37.3	73.0	17.8	8.0
MN	32	1.36	0.84	1.61	96.4	3.18	60.9	36.5	74.5	18.0	6.1
Pooled Means											
USDA103		1.47 p	0.89 p	1.65	96.8	2.67 q	62.6 p	36.5	73.0 q	18.1	7.6 p
MN		1.32 q	0.82 q	1.60	94.9	3.34 p	60.6 q	36.2	74.1 p	18.3	6.5 q
	26	1.39	0.83	1.67	96.0	3.19 u	61.1 v	36.1 v	73.6	18.3	7.0
	28	1.38	0.87	1.59	95.3	3.00 uv	61.5 v	36.2 uv	73.3	18.4	7.1
	32	1.41	0.87	1.63	96.3	2.82 v	62.2 u	36.9 u	73.8	17.9	7.1
Analysis of Variance											
Strain (ST)		*	*	NS	NS	*	*	NS	*	NS	*
Dietary protein (DP)		NS	NS	NS	NS	*	*	*	NS	NS	NS
ST X DP		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1]Source: Li, M.H., E.H. Robinson, and B.B. Manning, B.G. Bosworth, and W.R. Wolters. 2001. Comparison of growth, processing yield, and body composition of USDA103 and Mississippi "normal" strains of channel catfish *Ictalurus punctatus* fed diets containing three concentrations of protein. Journal of the World Aquaculture Society 32:402–408.
[2]The 26%, 28%, and 32% protein diets had DE/P ratios of 10.8, 10.2, and 9.2 kcal/g protein, respectively.
[3]Mean initial weight was 72 and 104 pounds per 1,000 fish for USDA103 and MN strains, respectively. Fish were stocked at 7,500 fish per acre and fed to apparent satiation once daily.

Table 22. Means of performance and fillet composition data of USDA103 and Norris strains of channel catfish fed practical diets containing 28% or 32% protein twice daily to satiation or about ⅔ of satiation for 10 weeks in aquaria.[1]

Fish strain	Feeding rate[2]	Dietary protein[3]	Feed consumption	Weight gain[4]	FCR	Survival	Fillet moisture	Fillet protein	Fillet fat
		%	*g/fish*	%	*feed/gain*	%	%	%	%
Individual Treatment Means									
Norris	S	28	43.0	827	1.75	99.0	77.9	16.2	4.6
Norris	S	32	46.1	869	1.74	98.0	78.1	17.0	3.6
Norris	R	28	25.6	625	1.38	99.0	78.2	16.3	4.1
Norris	R	32	26.7	652	1.35	98.0	78.2	16.4	4.1
NWAC103	S	28	100.8	1,637	1.29	99.0	77.7	16.7	4.7
NWAC103	S	32	98.2	1,530	1.33	98.0	77.2	17.6	3.9
NWAC103	R	28	50.2	913	1.16	100.0	78.8	16.8	3.1
NWAC103	R	32	49.7	938	1.15	100.0	78.3	17.2	3.2
Pooled Means									
Norris			35.3	742	1.53	98.5	78.1	16.5	4.1
NWAC103			74.8	1,254	1.23	99.3	78.0	17.1	3.7
	S		72.0	1,215	1.49	98.5	77.7	16.9	4.2
	R		38.1	781	1.25	99.3	78.4	16.7	3.6
		28	54.9	1,000	1.36	99.3	78.1	16.5	4.1
		32	55.2	998	1.36	98.5	77.9	17.0	3.7
Analysis of Variance									
Strain (ST)			*	*	*	NS	NS	NS	NS
Feeding rate (FR)			*	*	*	NS	NS	NS	NS
Dietary protein (DP)			NS	NS	NS	NS	NS	*	NS
ST X FR			*	*	*	NS	NS	NS	NS
ST X DP			*	NS	NS	NS	NS	NS	NS
FR X DP			NS	NS	NS	NS	NS	NS	*
ST X FR X DP			NS	NS	NS	NS	NS	NS	NS

[1]Source: Jackson, L.S., E.H. Robinson, M.H. Li, W.R. Wolters, D.A. McKee. 2003. Restricted and satiate feeding of two genetically isolated strains of juvenile channel catfish *Ictalurus punctatus* reared on 28% and 32% protein diets. Journal of the World Aquaculture Society 34:478–486.
[2]S = satiation; R = restricted to about 2/3 satiation.
[3]The 28% and 32% protein diets had DE/P ratios of 9.8 and 8.8 kcal/g protein, respectively.
[4]Mean initial weight was 3 and 4.7 g per fish for Norris and NWAC103 strains, respectively. Fish were stocked at 20 fish per 30-gallon aquarium and fed to apparent satiation twice daily.

Table 23. Means of performance, carcass yield, and fillet composition data for channel catfish fed diets with or without animal protein for one growing season in ponds.[1]

Diet[2]	Feed consumption	Weight gain[3]	FCR	Carcass yield	Visceral fat	Fillet composition		
						Protein	Fat	Moisture
	lb/fish	*lb/fish*	*feed/gain*	*%*	*%*	*%*	*%*	*%*
Animal protein[4]	2.18	1.28	1.71	61.1	4.1 a	17.3	5.5	75.6
No animal protein	2.09	1.20	1.73	60.7	3.2 b	17.0	4.7	76.4

[1]Source: Robinson, E.H., and M.H. Li. 1994. Use of plant proteins in catfish feeds: replacement of soybean meal with cottonseed meal and replacement of fish meal with soybean meal and cottonseed meal. Journal of the World Aquaculture Society 25:271–276.
[2]The diet with or without animal protein had DE/P ratios of 9.1 and 8.8 kcal/g protein, respectively.
[3]Mean initial weight was 400 pounds per 1,000 fish. Fish were stocked at 10,000 fish per acre and fed to apparent satiation once daily.
[4]Animal protein included 4% menhaden meal and 4% meat and bone/blood meal.

Table 24. Percentage of the amino acid requirement met by a 28% or 32% protein, all-plant diet based on soybean meal and corn.

Amino acid	Pct. of the requirement
Arginine	158
Histidine	140
Isoleucine	144
Leucine	185
Lysine	107
Methionine + cystine	104
Phenylalanine + tyrosine	134
Threonine	148
Tryptophan	219
Valine	130

Table 25. Mean performance, visceral fat, and fillet composition data for channel catfish fed practical diets containing 5% of each animal protein source for 9 weeks in aquaria.[1]

Animal protein source[2]	Feed consumption	Weight gain[3]	FCR	Visceral fat	Fillet protein	Fillet fat	Fillet moisture	Fillet ash
	g/fish	*g/fish*	*feed/gain*	*%*	*%*	*%*	*%*	*%*
Menhaden fish meal	76.4	56.7	1.35	3.52	16.6	5.8	75.7	1.18
Meat and bone/blood meal	72.6	51.3	1.43	3.28	16.4	5.9	75.8	1.17
Catfish by-product meal	75.5	52.9	1.43	3.40	16.7	6.4	74.9	1.21
Poultry by-product meal	76.7	55.9	1.37	3.69	16.3	6.4	75.6	1.17
Hydrolyzed feather meal + lysine	74.3	51.6	1.45	3.64	16.4	6.3	75.6	1.17

[1]Source: Li, M.H., E.H. Robinson, and B.B. Manning. 2002. Comparison of various animal protein sources for growth, feed efficiency, and body composition of juvenile channel catfish *Ictalurus punctatus*. Journal of the World Aquaculture Society 33:489–493.
[2]Diets contained 32% protein with DE/P ratios of 8.8–9 kcal/g protein.
[3]Mean initial weight was 6.4 g per fish. Fish were stocked at 20 fish per 30-gallon aquarium and fed to apparent satiation twice daily.

Table 26. Means of performance, carcass yield, and fillet composition data for channel catfish fed a 32%-protein diet containing 8% menhaden fish meal or 8% meat and bone/blood meal for one growing season in ponds.[1]

Diet	Weight gain[2]	FCR	Survival	Carcass yield	Visceral fat	Fillet composition			
						Protein	Fat	Moisture	Ash
	lb/fish	*feed/gain*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
Menhaden fish meal	0.61	1.33	99.9	62.2	3.4	17.0	6.2	75.1	1.2
Meat and bone/blood meal	0.59	1.36	100.0	61.9	3.4	16.0	5.8	75.8	1.2

[1]Source: Robinson, E.H. 1992. Evaluation of MSM fish formula as a replacement for fish meal in catfish feeds. The Catfish Journal 6 (12):12–13.
[2]Mean initial weight was 100 pounds per 1,000 fish. Fish were stocked at 10,000 fish per acre and fed to apparent satiation once daily.

Table 27. Means of performance data of fingerling channel catfish fed diets in which soybean meal was replaced with cottonseed meal and lysine for 12 weeks in aquaria.[1]

Percent soybean meal replaced[2]	Weight gain[3]	FCR	Survival
	%	*feed/gain*	*%*
0 (control)	396 ab	1.72 bc	95
25	437 a	1.63 c	100
50	396 ab	1.72 bc	99
100	326 c	1.98 a	99
50 + lysine	421 ab	1.69 bc	100
100 + lysine	387 b	1.77 bc	98

[1]Source: Robinson, E.H. 1991. Improvement of cottonseed meal protein with supplemental lysine in feeds for channel catfish. Journal of Applied Aquaculture 1:1–14.
[2]Diets contained 32% protein with DE/P ratios of 8.4–8.8 kcal/g protein.
[3]Mean initial weight was 7.2 g per fish. Fish were stocked at 20 fish per 30-gallon aquarium and fed at 4% of fish body weight per day divided into two equal feedings.

Table 28. Means of performance, processing yield, and fillet composition data for channel catfish fed diets in which soybean meal was replaced with cottonseed meal and lysine for one growing season in net pens suspended in ponds.[1]

Percent soybean meal replaced[2]	Weight gain[3]	FCR	Survival	Carcass yield	Fillet yield	Fillet moisture	Fillet protein	Fillet fat	Fillet ash
	lb/fish	*feed/gain*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
0 (control)	0.60 b	1.61 bc	97	61.7 ab	39.6 abc	76.1	15.9 ab	6.3 ab	1.1
50	0.66 a	1.53 cd	96	61.4 ab	39.8 ab	76.5	15.4 b	6.5 a	1.2
100	0.50 c	1.84 a	96	61.0 b	38.8 c	76.3	15.3 b	6.9 a	1.1
50 + lysine	0.66 a	1.46 d	95	62.3 a	40.4 a	76.5	16.4 a	5.8 b	1.2
100 + lysine	0.58 b	1.66 b	97	61.1 b	39.0 bc	76.6	16.4 a	5.5 c	1.1

[1]Source: Robinson, E.H. 1991. Improvement of cottonseed meal protein with supplemental lysine in feeds for channel catfish. Journal of Applied Aquaculture 1:1–14.
[2]Diets contained 32% protein with DE/P ratios of 8.4–8.8 kcal/g protein.
[3]Mean initial weight was 119 pounds per 1,000 fish. Fish were stocked at 40 fish per cage and fed to apparent satiation once daily.

Table 29. Means of performance data of male channel catfish fed diets containing different levels of cottonseed meal for two growing seasons in ponds.[1]

Cottonseed meal[2]	Feed fed	Weight gain[3]	FCR	Survival	Testis weight	Initial sperm motility	24-hour sperm motility
%	*lb/A*	*lb/fish*	*feed/gain*	*%*	*% BW*[4]	*%*	*%*
0	17,420	2.80 a	4.2	96 a	0.47	59 b	61
25	17,330	2.40 ab	4.2	88 ab	0.47	53 b	51
37.5	19,200	1.81 b	5.9	86 b	0.61	65 ab	67
52	17,060	2.01 b	6.1	92 ab	0.61	73 a	71

[1]Source: Robinson, E.H., and T.R. Tiersch. 1995. Effect of long-term feeding of cottonseed meal on growth, testis development, and sperm motility of male channel catfish *Ictalurus punctatus* broodfish. Journal of the World Aquaculture Society 26:426–431.
[2]The diets contained 32% protein with free gossypol levels of 0, 200, 300, and 400 ppm, respectively.
[3] Mean initial weight was 2.73 pounds per fish. Fish were stocked at 1,200 fish per acre and fed to apparent satiation once daily.
[4]BW = body weight.

Table 30. Means of performance, processing yield, and fillet composition data for channel catfish fed diets containing 0% or 25% canola meal for one growing season in ponds.[1]

Canola meal[2]	Feed consumption	Weight gain[3]	FCR	Survival	Visceral fat	Carcass yield	Fillet moisture	Fillet protein	Fillet fat	Fillet ash
%	*lb/fish*	*lb/fish*	*feed/gain*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
0	1.45	0.89	1.63	95.9	3.04	60.0	75.4	16.2	6.8	1.2
25	1.33	0.85	1.57	94.2	3.04	57.5	76.9	16.4	6.2	1.1

[1]Source: Li, M.H., and E.H. Robinson. 1994. Use of canola meal in catfish feeds. Aquaculture Magazine 19 (5):60–63.
[2]The diets contained 32% protein with a DE/P ratio of 8.8 kcal/g protein.
[3] Mean initial weight was 250 pounds per 1,000 fish. Fish were stocked at 10,000 fish per acre and fed to apparent satiation once daily.

Table 31. Means of performance, processing yield, and fillet composition data for channel catfish fed diets containing 0% or 22.5% distillers' grains with solubles for one growing season in ponds.[1]

Distillers' grains[2]	Feed consumption	Weight gain[3]	FCR	Survival	Visceral fat	Carcass yield	Fillet moisture	Fillet protein	Fillet fat	Fillet ash
%	*lb/fish*	*lb/fish*	*feed/gain*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
0	1.83	1.11	1.65	97.6	3.9 b	61.3	76.3	16.9	5.4	1.1
22.5	1.71	1.15	1.49	97.8	4.8 a	61.2	74.2	16.8	6.6	1.2

[1]Source: Robinson, E.H., and M.H. Li. 2005. A summary of nutrition research conducted under a cooperative agreement between MAFES and Delta Western Research Center. Mississippi Agricultural and Forestry Experiment Station Bulletin No. 1144.
[2]The diets contained 32% protein with a DE/P ratio of 8.8 kcal/g protein.
[3]Mean initial weight was 350 pounds per 1,000 fish. Fish were stocked at 10,000 fish per acre and fed to apparent satiation once daily.

Table 32. Means of performance, processing yield, and fillet composition data for channel catfish fed diets containing 0%, 25%, or 50% corn gluten feed for one growing season in ponds.[1]

Corn gluten feed[2]	Feed consumption	Weight gain[3]	FCR	Survival	Visceral fat	Carcass yield	Fillet moisture	Fillet protein	Fillet fat
%	*lb/fish*	*lb/fish*	*feed/gain*	*%*	*%*	*%*	*%*	*%*	*%*
0	1.80	1.07	1.68	99.0	4.0 a	56.8 b	73.6 b	18.1	8.1 a
25	2.00	1.17	1.72	99.1	3.3 b	57.5 a	75.5 ab	16.7	7.0 ab
50	1.77	1.01	1.75	98.8	2.9 b	57.8 a	76.3 a	17.0	5.7 b

[1]Source: Robinson, E.H., M.H. Li, and B.B. Manning. 2001. Evaluation of corn gluten feed as a dietary ingredient for pond-raised channel catfish *Ictalurus punctatus*. Journal of the World Aquaculture Society 32:68–71.
[2]The diets contained 32% protein with a DE/P ratio of 8.8–9 kcal/g protein.
[3]Mean initial weight was 126 pounds per 1,000 fish. Fish were stocked at 7,500 fish per acre and fed to apparent satiation once daily.

Table 33. Means of performance data and survival 4 weeks after challenge with *Edwardsiella ictaluri* for channel catfish fed practical diets containing various levels of total protein and animal protein for 9 weeks in aquaria.[1]

Dietary protein	Animal protein source[2]	DE/P ratio	Feed consumption	Weight gain[3]	FCR	Survival before challenge	Survival after challenge
%		*kcal/g*	*g/fish*	*g/fish*	*feed/gain*	*%*	*%*
32	None[4]	8.8	55.7	49.0 ab	1.14 abc	99.0	51.5
32	6% MFM	9.0	54.5	48.7 ab	1.12 bc	100.0	53.0
32	12% MFM	9.1	55.7	52.1 a	1.07 c	100.0	44.0
32	6% MBB	8.8	52.5	43.5 c	1.21 a	100.0	45.0
32	12% MBB	8.8	54.5	46.3 bc	1.18 ab	99.0	64.8
28	6% MFM + 6% MBB	10.1	54.2	46.7 bc	1.16 ab	100.0	45.0
32	6% MFM + 6% MBB	9.0	53.8	48.5 ab	1.11 bc	100.0	41.0
36	6% MFM + 6% MBB	8.2	56.5	50.0 ab	1.13bc	99.0	54.0

[1]Source: Li, M.H., D.J. Wise, B.B. Manning, and E.H. Robinson. 2003. Effect of dietary total protein and animal protein on growth and feed efficiency of channel catfish *Ictalurus punctatus* and their response to *Edwardsiella ictaluri* challenge. Journal of the World Aquaculture Society 34:223–228.
[2]MFM = menhaden fish meal; MBB = meat and bone/blood meal.
[3]Mean initial weight was 6.6 g per fish. Fish were stocked at 20 fish per 30-gallon aquarium and fed to apparent satiation twice daily.
[4]All-plant protein diet (no animal protein used).

Mississippi State University

Printed on Recycled Paper