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Nutrient Characteristics of Pond-Raised Channel Catfish

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Introduction

The nutrient content of farm-raised channel catfish muscle tissue has been published in part in various research articles over the years; the latest and most comprehensive publication of this kind was that of Nettleton et al. (1990). Generally, the nutrient profile of catfish shows that it is highly nutritious – high in protein, low in fat and cholesterol, and a good source of certain vitamins and minerals. Over the past 10 years, several changes have been implemented in the channel catfish diet that may affect nutrient composition of the fish. Such changes include an increase in the digestible energy to protein ratio (DE:P) of the diet, a decrease in the concentration of marine fish meal, and a reduction or elimination of certain nutrients in the vitamin and mineral premixes typically used by the catfish feed industry. Also, feeding rates have continued to increase, and this may affect tissue nutrient content. For these reasons, this study was conducted to update information on nutrient content of farm-raised channel catfish muscle tissue. The study also determined liver nutrient concentrations. These data were intended to be used in conjunction with the data from muscle tissue to provide baseline nutritional information that may be useful in assessing the nutritional status of a healthy catfish.

Methods

Fifty marketable-sized channel catfish were collected from a local catfish processing plant at three times during the growing season (May and October 1998 and February 1999) to evaluate seasonal variation in body composition. The fish were processed with equipment and procedures similar to those used in the catfish processing industry. Muscle (fillet) and liver tissues were collected for analysis of various nutrients. Proximate composition of muscle was determined using AOAC methods (AOAC 1995). Fatty acids in muscle and liver tissues were determined by gas chromatography. Vitamin concentrations were determined by using either microbiological or enzymatic assays or high-pressure liquid chromatography, depending on the vitamin under study. Minerals were analyzed using atomic absorption.

Mean and standard deviation of data derived from samples taken in each season and the overall mean and standard deviation of the three seasons were reported. Because the mean fish weights were different in samples taken in the three seasons, the differences in proximate composition that might be caused by the differences in fish weight were corrected by analysis of variance using fish weight as a covariant (Steel and Torrie 1980).

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RESULTS

Proximate composition of muscle averaged over the three seasons was fairly typical of food-sized channel catfish. Crude protein averaged 16.3 grams per 100 grams of raw tissue (g/100 g); crude fat, 5.4 g/100 g; moisture, 77.3 g/100 g; and ash, 1.1 g/100 g (Table 1). Crude fat was somewhat lower than the 6.9 g/100 g reported by Nettleton et al. (1990). We typically observe significant variation in the fat content of individual catfish, which may be related to genetic variation, diet composition, or feed intake. When fat data from our study were corrected for fish size, fish sampled in the fall contained a higher level of fat compared with fish sampled in the spring or winter. No other seasonal changes in proximate composition were observed. This same trend was previously reported for channel catfish (Nettleton et al. 1990). Mean energy value for muscle tissue from our study was 118 kilocalories per 100 grams of raw tissue (kcal/100 g) (Table 1), which was lower than the 128 kcal/100 g reported by Nettleton et al. (1990) and the 145 kcal/100 g reported by Clement and Lovell (1994). The lower energy value observed in our study appears to be related to the lower level of fat contained within the muscle.

The major fatty acids – which accounted for about 75% of the total – in fillets were 16:0, 18:0, 18:1, and 18:2 n-6 (Table 2). Concentrations of saturated fatty acids were 23.8% of total lipids; monoenoic, 43.8%; dienoic, 15.3%; and trienoic, 4.1%. These values are typical of those previously reported for catfish (Nettleton et al. 1990; Tidwell and Robinette 1990; Clement and Lovell 1994). Muscle tissue contained 3.7% n-3 fatty acids and 21.5% n-6 fatty acids. These values are within the range generally found in catfish muscle tissue, but their concentrations are dramatically influenced by diet. For example, feeding a source high in n-3 fatty acids (marine fish oil) results in a significant increase in n-3 fatty acids deposited in the tissue.

The major fatty acids found in the liver were the same as those found in muscle (Table 3). There were two primary differences between fatty acids in liver and muscle: (1) dienoic was markedly lower in liver; and (2) both n-3 and n-6 highly unsaturated fatty acids were higher in liver.

There were some seasonal differences in both liver and muscle fatty acids. For example, n-3 fatty acids were higher in the winter and spring than in early fall. Catfish are fed sparingly during the winter and spring. Tidwell et al. (1992) and Webster et al. (1994) reported that n-3 fatty acids increase in catfish muscle and liver during starvation. They suggested that n-3 fatty acids were conserved for proper physical and metabolic functions. In addition, when feeding is reduced, catfish may consume natural food organisms that are rich in these fatty acids (Robinson and Li 1996).

Vitamin concentrations (Table 4) of muscle tissue were similar to values reported by Nettleton et al.

Table 1. Proximate nutrient composition and energy value of the fillet of pond-raised channel catfish expressed as unit per 100 grams of raw tissue at three sampling dates.[1]

	May 12, 1998		Oct. 13, 1998		Feb. 17, 1999		Overall
	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
Protein (g)	16.6±0.7	14.1-18.0	16.5±0.5	15.5-17.7	15.8±0.9	13.8-18.7	16.3±0.4
Fat (g)	5.1±1.9	1.9-10.9	5.4±1.8	1.9-9.6	5.6±1.6	3.2-9.7	5.4±0.3
Moisture (g)	77.3±1.7	70.9-80.4	76.9±1.7	72.6-81.0	77.6±1.8	73.2-80.3	77.3±0.4
Ash (g)	1.09±0.06	0.99-1.39	1.03±0.04	0.98-1.12	1.03±0.04	0.94-1.10	1.05±0.03
Energy (kcal) [2]	117		119		118		118
Fish weight (g)	685±146	440-974	536±182	358-1098	827±136	588-1238	683±146
Least square means using live weight as covariant							
Protein (g)	16.6		16.5		15.8		
Fat (g)	5.1		6.1		5.0		
Moisture (g)	77.3		76.2		78.2		
Ash (g)	1.09		1.04		1.02		

[1]Mean represents 50 fish; SD = Standard Deviation.
[2]Energy was calculated by using 4.27 kcal/g protein and 9.02 kcal/g fat (USDA 1987).

Table 2. Fatty acid composition (mean±SD) of the fillet of pond-raised channel catfish expressed as percentage of fat.[1]

Fatty acid	May 12, 1998	Oct. 13, 1998	Feb. 17, 1999	Overall
14:0	1.00±0.11	1.00±0.05	0.90±0.09	0.97±0.06
16:0	15.85±0.66	16.80±0.65	16.12±0.39	16.26±0.49
16:1	2.63±0.23	3.08±0.18	2.56±0.17	2.75±0.28
18:0	6.51±0.18	5.95±0.65	6.62±0.27	6.36±0.36
18:1	37.10±3.55	44.38±3.17	36.64±3.06	39.37±4.34
18:2 n-6	14.54±0.33	12.17±0.38	13.97±0.31	13.56±1.24
18:3 n-6	0.46±0.05	0.39±0.06	0.87±0.13	0.57±0.26
18:3 n-3	1.13±0.09	0.81±0.13	0.81±0.15	0.92±0.19
20:1	1.35±0.39	1.47±0.10	1.35±0.09	1.39±0.07
20:2 n-6	1.79±0.53	1.67±0.47	1.81±0.47	1.76±0.07
20:3 n-9	0.48±0.05	0.71±0.14	0.81±0.14	0.67±0.17
20:3 n-6	1.90±0.19	1.46±0.17	2.46±0.32	1.94 ±0.50
20:4 n-6	2.51±0.56	1.36±0.29	3.18±0.49	2.35±0.92
20:5 n-3	0.58±0.07	0.00	0.44±0.14	0.34±0.29
22:5 n-6	1.39±0.20	0.96±0.29	1.76±0.27	1.37±0.40
22:5 n-3	0.55±0.12	0.17±0.24	0.54±0.30	0.42±0.22
22:6 n-3	2.70±0.56	1.16±0.46	2.25±0.25	2.04±0.79
Saturated	23.63±0.76	23.88±0.56	23.76±0.47	23.76±0.12
Monoenes	41.08±4.00	48.93±3.33	41.25±3.23	43.75±4.48
Dienes	16.33±0.64	13.84±0.16	15.75±0.49	15.31±1.30
Trienes	3.97±0.20	3.37±0.33	4.86±0.49	4.07±0.75
n-3	4.96±0.72	2.16±0.63	4.11±0.56	3.74±1.44
n-6	22.60±1.19	18.02±0.86	23.76±1.08	21.46±3.04
n-3 HUFA[2]	3.82±0.73	1.35±0.65	3.31±0.63	2.83±1.31
n-6 HUFA	3.91±0.75	2.33±0.55	4.77±0.74	3.67±1.24

[1]Mean of each sample time represents five composite samples with 10 fish per sample; SD = Standard Deviation.
[2]Highly unsaturated fatty acids include fatty acids with a minimum of 20 carbons and four double bonds.

Table 3. Fatty acid composition (mean±SD) of the liver of pond-raised channel catfish expressed as percentage of fat.[1]

Fatty acid	May 12, 1998	Oct. 13, 1998	Feb. 17, 1999	Overall
14:0	0.50±0.26	0.46±0.08	0.42±0.04	0.46±0.12
16:0	13.58±0.54	14.08±0.46	14.89±0.87	14.18±0.22
16:1	0.67±0.12	0.65±0.08	0.76±0.05	0.69±0.04
18:0	11.09±2.62	8.79±0.74	9.64±1.96	9.84±0.96
18:1	32.91±6.89	35.12±5.38	33.68±3.84	33.90±1.52
18:2 n-6	6.62±1.81	4.39±0.50	7.24±1.09	6.08±0.66
18:3 n-6	0.39±0.06	0.63±0.14	1.77±0.52	0.93±0.25
18:3 n-3	0.39±0.22	0.16±0.06	0.29±0.04	0.28±0.10
20:1	1.82±0.35	1.98±0.30	1.09±0.08	1.63±0.14
20:2 n-6	1.38±0.07	1.30±0.13	1.15±0.10	1.28±0.03
20:3 n-9	1.02±0.08	1.92±0.22	0.75±0.15	1.23±0.07
20:3 n-6	3.31±0.61	3.12±0.47	2.71±0.41	3.05±0.10
20:4 n-6	6.58±2.38	6.52±1.00	7.48±2.05	6.86±0.72
20:5 n-3	0.55±0.28	0.21±0.11	0.81±0.29	0.52±0.10
22:4 n-6	0.46±0.09	0.39±0.05	0.61±0.12	0.48±0.03
22:5 n-6	3.17±0.76	4.66±0.69	2.65±0.73	3.49±0.04
22:5 n-3	0.53±0.30	0.31±0.12	1.03±0.22	0.63±0.09
22:6 n-3	6.77±2.51	4.11±0.80	3.65±0.93	4.84±0.95
Saturated	25.17±2.51	23.35±1.00	24.60±1.55	24.37±0.76
Monoenes	33.43±10.80	42.41±4.93	39.49±4.56	38.44±3.50
Dienes	8.00±1.77	5.58±0.59	8.36±1.16	7.31±0.59
Trienes	5.12±0.50	5.61±0.50	5.53±0.43	5.42±0.04
n-3	8.25±2.89	4.36±0.79	5.59±1.64	6.07±1.05
n-6	21.69±2.58	20.20±2.84	22.88±2.53	21.59±0.17
n-3 HUFA[2]	7.86±3.01	4.24±0.89	5.32±1.66	5.80±1.07
n-6 HUFA	9.99±3.25	10.99±1.80	10.26±3.13	10.41±0.81
Total fat (% wet tissue)	3.56±0.47	3.63±0.46	5.05±0.46	4.08±0.84

[1]Mean of each sample time represents five composite samples with 10 fish per sample; SD = Standard Deviation.
[2]Highly unsaturated fatty acids include fatty acids with a minimum of 20 carbons and four double bonds.

(1990). In our study, there were some seasonal variations in tissue concentrations of pantothenic acid and choline.

Concentrations of vitamins in liver tissue were generally higher than in muscle, except for thiamin and choline (Table 5). These values were similar to values of pond-raised channel catfish fed a diet containing supplemental vitamins at recommended levels reported by Robinson et al. (1998). These researchers showed that riboflavin, pyridoxine, and folic acid concentrations in catfish liver tissue did not differ between fish fed a diet either with or without supplemental vitamins.

Mineral concentrations in muscle (Table 6) were similar to values reported by Nettleton et al. (1990) and Clement and Lovell (1994). No appreciable seasonal variation was observed in mineral concentrations. Pond-raised channel catfish are a good source of phosphorus, potassium, and selenium.

Table 4. Concentrations (mean±SD) of selected vitamins in the fillet of pond-raised channel catfish expressed as microgram per gram of wet tissue.[1]

Vitamin	May 12, 1998	Oct. 13, 1998	Feb. 17, 1999	Overall
Thiamin	2.3±0.5	1.8±0.1	1.5±0.5	1.9±0.4
Riboflavin	1.4±0.3	1.2±0.1	1.5±0.2	1.4±0.2
Pyridoxine	1.3±0.2	1.8±0.1	1.1±0.1	1.2±0.1
Folic acid	0.24±0.01	0.14±0.01	0.08±0.03	0.15±0.08
Niacin	15.9±2.4	12.3±1.4	12.4±2.5	13.5±2.1
Pantothenic acid	4.8±0.8	16.5±1.3	8.9±2.2	10.1±5.9
Choline	369±123	665±84	800±48	611±220
Ascorbic acid	4.5±1.1	4.31±0.31	2.9±0.2	2.5±2.2

[1]Mean of each sample time represents five composite samples with 10 fish per sample; SD = Standard Deviation.

Table 5. Concentrations (mean±SD) of selected vitamins in the liver of pond-raised channel catfish expressed as microgram per gram of wet tissue.[1]

Vitamin	May 12, 1998	Oct. 13, 1998	Feb. 17, 1999	Overall
Thiamin	0.49±0.20	0.54±0.06	0.38±0.05	0.47±0.08
Riboflavin	12.2±0.8	12.7±0.8	11.8±0.6	12.2±0.4
Pyridoxine	4.2±0.1	4.4±0.01	3.5±0.4	4.0±0.5
Folic acid	0.63±0.04	0.54±0.14	1.7±0.6	0.96±0.65
Niacin	98.4±10.4	97.8±6.8	60.8±3.4	85.7±21.5
Pantothenic acid	19.6±2.2	24.0±2.2	22.4±1.5	22.0±2.23
Choline	595±96	548±229	668±223	604±60
Ascorbic acid	57.8±8.7	41.1±7.5	12.1±2.9	37.0±23.1

[1]Mean of each sample time represents five composite samples with 10 fish per sample; SD = Standard Deviation.

Table 6. Concentrations (mean±SD) of selected minerals in the fillet of pond-raised channel catfish express as microgram per gram of wet tissue.[1]

Mineral	May 12, 1998	Oct. 13, 1998	Feb. 17, 1999	Overall
Potassium	3,711±53	3,388±148	3,508±171	3,536±163
Phosphorus	1,761±77	1,688±98	1,888±114	1,799±101
Sodium	372±41	431±24	410±17	404±30
Magnesium	219±10	246±11	205±9.2	224±21
Calcium	80±22	92±27	100±30	91±10
Zinc	6.5±0.3	5.9±0.2	5.2±0.2	5.9±0.6
Iron	5.3±0.7	5.2±0.5	4.5±0.4	5.0±0.5
Selenium	0.11±0.01	0.13±0.01	0.10±0.02	0.11±0.01
Copper	< 0.3	< 0.3	< 0.3	< 0.3
Manganese	< 1.1	< 1.1	< 1.1	< 1.1
Cobalt	< 1.1	< 1.1	< 1.1	< 1.1

[1]Mean of each sample time represents three composite samples with 16-17 fish per sample; SD = Standard Deviation.

Summary

In summary, the data presented in this report are intended to provide baseline information on nutrient characteristics of catfish muscle and liver. The muscle nutrient profile shows that channel catfish is highly nutritious – high in protein, low in fat, and a good source of certain vitamins and minerals. The liver nutritional profile may be useful in assessing the nutritional status of the fish. Further, it appears that the changes that have been implemented in commercial catfish diets during the last few years – such as a slight increase in the DE:P ratio, a decrease in marine fish meal, and a reduction in the concentrations of supplemental vitamins and minerals – have not appreciably affected the nutrient composition of the fish.

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