Growth of Juvenile Walleye, *Stizostedion vitreum*, Fed Two Dietary Protein Levels in Ponds

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ABSTRACT. Juvenile walleye, *Stizostedion vitreum*, (127.4 ± 3.2 g) trained to accept artificial diets, were stocked into six 0.04-ha ponds at a density of 8,275 fish/ha and fed one of two practical diets containing either 44% or 53% protein. Fish meal comprised approximately 53% of dietary protein in both diets. Fish were fed daily all of the floating test diets they would consume in 30 minutes at temperatures >15°C. At temperatures < 15°C, walleye were fed a commercial sinking trout diet at 1% of body weight three days per week. The study period lasted 18 months (November 1995-May 1997). At final harvest there were no significant differences ($P > 0.05$) in total harvest weight (1,800 kg/ha), total specific growth rate (0.27), summer specific growth rate (0.59), or feed conversion ratios (8.4) between fish fed the two diets. However, fish fed 53% protein were significantly larger ($P < 0.05$) than those fed 44% protein: 304 vs. 256 g, respectively. These results indicate that walleye likely benefit from relatively high protein levels. Growth rates and feed efficiencies were relatively poor, with the best growth rates occurring at temperatures higher than predicted by previous studies.

KEYWORDS. Walleye, protein, pond, growth

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INTRODUCTION

In the north-central region of the United States and southern Canada the walleye, *Stizostedion vitreum*, is one of the most popular recreational and food fishes (Buttner 1989). The optimum culture temperature for walleye appears to be between 22°C (Smith and Koenst 1975) and 26°C (Hokansen and Koenst 1986). Water temperatures in Kentucky average approximately 24°C during the summer period (Tidwell and Mims 1990), making the region appear promising for walleye pond culture. However, while considerable information is available on fingerling production, information on growout of walleye to food size is scarce (Held and Malison 1996), especially in ponds (Summerfelt 1996).

The amount of information available on the nutritional requirements of walleye is extremely limited (Barrows and Lellis 1996). Studies on small fish (8-50 g) indicate a dietary protein requirement between 42% and 51% (Barrows 1987, 1990). However, there appears to be no information available on protein requirements of larger fish. Fish usually have lower protein requirements during later phases of growth (Lovell 1989). This information is essential to the development of "grower diets" which constitute both the greatest quantity of feed and the greatest feed expense in food fish production (Barrows and Lellis 1996). This study was conducted to evaluate the effects of dietary protein level on growth and survival of juvenile walleye over an 18-month growth period and their impacts on pond water quality.

MATERIALS AND METHODS

Test diets contained either 44% or 53% protein (Table 1) and were formulated to be isocaloric based on gross energy values of 5.64 kcal/g protein, 4.11 kcal/g carbohydrate, and 9.44 kcal/g fat (NRC 1993). The percentage of dietary protein contributed by fish meal was maintained at approximately 53% in both diets. Diets were extruded into floating pellets by a commercial feed mill (Integral Fish Foods, Inc., Grant Junction, Colorado[1]) and stored at −10°C until fed. Diets were analyzed for crude protein, lipid, ash, and moisture (Table 1). Crude protein was determined using a LECO FP-228 nitrogen determinator (Sweeney and Rexroad 1987), crude lipid by chloroform-ethanol extraction; ash was determined in a muffle furnace (600°C) for 24 hours and moisture by drying to constant weight (AOAC 1990). Diets were analyzed for fatty acid composition (Table 2) and amino acid composition (Table 3) by a commercial analytical laboratory (Woodson-Tenent Laboratories, Dayton, Ohio).

1. Use of trade or manufacturer's name does not imply endorsement.

TABLE 1. Composition of experimental diets (containing various percentages of protein and lipid) fed to juvenile walleye.

Ingredient	Diet	
	44% protein	53% protein
Anchovy meal (64%)	40.0	52.5
Soybean meal	10.0	19.5
Wheat flour	30.0	17.5
Hydrolyzed feathers	5.0	5.0
Corn grain	8.5	0.0
Menhaden oil	4.2	2.6
Trout premix	2.0	2.0
Monocalcium phosphate	0.1	0.5
Choline chloride (60%)	0.3	0.2
Ascorbic phosphate	0.1	0.1
Chemical analysis		
Moisture (%)	11.1	7.9
Protein (%)[1]	44.4	53.1
Lipid (%)[1]	10.7	9.6
Ash (%)	9.5	12.5
Fiber (%)	1.3	1.4
Energy[2]	4.04	3.87
P/E[3]	109.98	137.18

[1] Moisture-free basis.
[2] Available energy in kcal/g of diet.
[3] P/E = protein to energy ratio in mg protein/kcal.

Pellet-trained walleye 127.4 ± 3.2 g that averaged from a previous feed-training study were randomly stocked on 9 November 1995 into six 0.04-ha ponds at a rate of 8,275 fish/ha. At temperatures >15°C fish were fed the appropriate test diet once daily, all they would consume in a 30-minute period. During periods when water temperatures were < 8°C, a commercial sinking trout feed (Nelson and Sons Inc., Murray, Utah) was fed at 1% body weight three times per week. Each of two treatments (diets) was replicated in three ponds. Ponds used in this study were approximately 1.5 m deep and were supplied with water from a reservoir filled by rain runoff. Water levels

TABLE 2. Fatty acid composition (% of total fatty acids) of experimental diets (44% and 53% protein). Diet values are for comparative purposes and represent one replication.

Fatty acid	Diet	
	44% protein	53% protein
14:0	4.87	4.23
16:0	17.61	17.69
16:1 n-7	8.01	7.73
18:0	4.01	4.49
18:1 n-9	20.95	23.28
18:3 n-3	1.85	1.84
18:4 n-3	1.09	0.89
20:4 n-6	1.59	1.60
20:5 n-3	9.19	8.23
22:6 n-3	5.72	5.89
Saturates	27.79	27.75
Monoenes	33.07	36.00
Diene	9.76	8.02
PUFA	23.17	22.30
n-3	19.84	18.80
n-6	11.13	9.51
n-3/n-6	1.78	1.98
n-6/n-3	0.56	0.51

in the pond were maintained at a constant depth by periodic additions. Water temperature and dissolved oxygen (DO) were determined daily. Total ammonia-nitrogen, nitrite, and pH were determined weekly at 1600 using a HACH DREL/2000 spectrophotometer (HACH, Loveland, Colorado).

After stocking, a sample of >50 fish were captured monthly, weighed, counted, and returned to the pond for determination of average individual weights. Total number and weight of fish in each pond were determined at harvest (May 20, 1997). Fifty fish were then randomly sampled from each pond and individually weighed (g) and measured for total length (cm).

Feed conversion ratio (FCR) was calculated using the formula FCR =

TABLE 3. Amino acid composition (% of protein) of experimental diets feed to juvenile walleye in ponds. ND is not determined. All values are on a dry-weight basis.

	Diet	
Amino acid	44%	53%
Arginine	4.51	5.27
Cystine	0.94	0.99
Histidine	3.00	2.19
Isoleucine	3.00	3.56
Leucine	5.35	5.76
Lysine	5.75	4.79
Methionine	1.64	1.77
Phenylalanine	4.34	3.49
Threonine	3.50	3.75
Tryptophan	ND	ND
Tyrosine	2.92	2.32
Valine	3.60	4.15

weight of feed fed (kg)/live weight gain (kg). Specific growth rate (SGR, % body weight per day) was calculated using the formula SGR = $[(\ln W_f - \ln W_j)/t] \times 100$, where W_f is final weight; W_j is initial weight; and t is time in days (Ricker 1975).

Differences between treatments were assessed by analysis of variance (ANOVA) using the Statistical Analysis System (Statistical Analysis Systems 1988) to determine the effects of dietary protein level on growth, feed conversion, survival, body composition, dressout weights, and water quality variables. All percentage and ratio data were transformed to arc sin values prior to analysis (Zar 1984).

RESULTS AND DISCUSSION

Overall means for water quality variables over the 18-month study did not differ significantly ($P > 0.05$) between ponds in which fish were fed 44% or 53% protein. For the 18-month period overall means average: temperature 13.9°C, dissolved oxygen 11.8 mg/L, pH 8.5, total ammonia-nitrogen 0.68 mg/L, unionized ammonia 0.08 mg/L, and nitrite 0.027 mg/L.

At the end of 18 months of culture, walleye fed 53% protein were significantly larger ($P < 0.05$) than walleye fed 44% protein (Figure 1; Table 4). These data agree with Barrows (1990), who reported a protein requirement of 42-51% in small walleye and indicate that high protein levels are still advantageous, even at advanced fish sizes. Most rapid growth occurred during July-August (SGR = 0.63%) at average water temperatures of 26-28°C (Figure 1). This is higher than temperatures previously reported as optimum for walleye growth (22-26°C) (Smith and Koenst 1975; Hokansen and Koenst 1986). Different life stages have been shown to have different temperature preferences (Silverthorn and Reese 1978), and large walleye may have a higher optimum temperature than the juveniles used in previous laboratory studies. Also, there can be an interaction of temperature and day length (Calbert and Huh 1976), which would not be evident in lab studies.

FCRs were relatively high, averaging 8.4 overall, with no significant difference ($P > 0.05$) in FCR of walleye fed the two protein levels (Table 4). Feed conversion data on walleye raised in ponds are not available for comparison. However, these values are similar to those reported for hybrid bluegill (5-6) under similar culture conditions (Tidwell et al. 1994). Flickinger (1996) reported FCRs of 2.5-3.7 for walleye raised in tanks and 3.0-3.1 for those raised in cages. High FCRs in this study are at least partially due to its long duration, including two winter periods. At temperatures below 8°C, walleye were offered feed at 1% of body weight three times per week.

FIGURE 1. Mean sample weights of walleye fed diets containing 44% or 53% protein for 18 months in ponds.

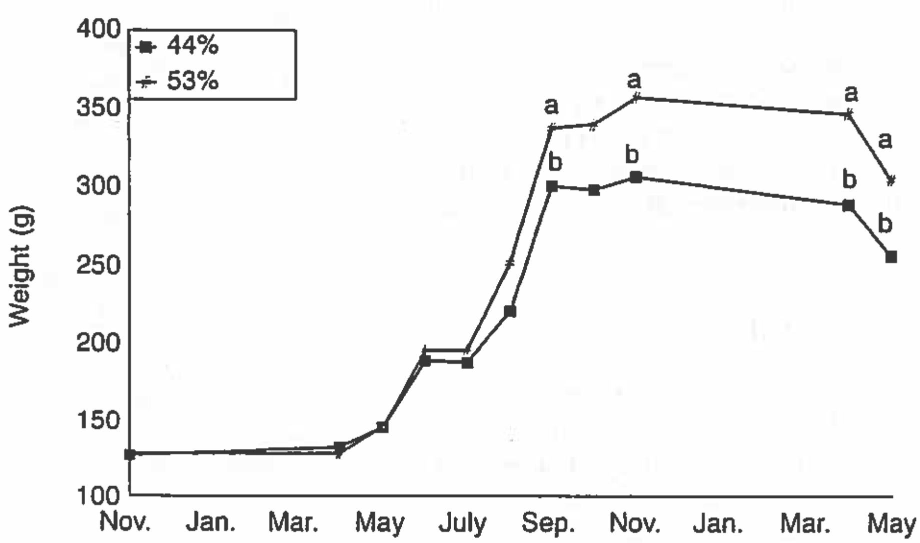

TABLE 4. Mean ± SE individual weight, average individual gain, total harvest weight, survival, specific growth rate (SGR), and feed conversion ratio (FCR) for walleye fed 44% or 53% protein diets. Means within a row followed by different letters are significantly different ($P < 0.05$).

	Diet	
	44%	53%
Mean weight (g)	256.4 ± 16.4b	304.1 ± 19.5a
Average weight gain (%)	102.7 ± 17.3a	137.2 ± 13.7a
Total harvest weight (kg/ha)	1691 ± 147a	1910 ± 71a
Survial (%)	80.3 ± 7.8a	75.1 ± 4.4a
SGR (%/day)–Total	0.23 ± 0.03a	0.31 ± 0.03a
SGR (%/day)–Summer	0.55 ± 0.03a	0.63 ± 0.08a
FCR	9.9 ± 2.8a	7.0 ± 0.7a

However, these were sinking diets, and consumption could not be monitored. It is likely that this feed was not well utilized, as Summerfelt (1996) predicted no growth below 15.6°C. Low-temperature feeding may not be required but was provided in this initial work because of potential health maintenance benefits that have been demonstrated in other fish, such as channel catfish (Lovell 1989).

There was no significant difference ($P > 0.05$) in total harvest weights of walleye fed two protein levels, averaging 1,801 kg/ha overall (Table 4). These figures are relatively low compared to other species and are likely subject to improvement. Specific growth rates were similar to those reported by Tidwell et al. (1994) for hybrid bluegill under similar culture conditions. Survival averaged 78% overall and did not differ significantly ($P > 0.05$) between treatments. Fish were not size graded during the study, but cannibalism does not seem to have been a problem. At harvest, some fish showed evidence of bird attacks, though no predation was observed during daylight hours.

There were no significant differences ($P > 0.05$) in dressout percentages of walleye fed different protein levels (Table 5). Proximate composition of fillets from fish fed 44% or 53% protein did not differ ($P > 0.05$) in percentage moisture or protein. Fillet lipid was significantly higher ($P < 0.05$) in walleye fed 44% protein (2.7%) than in those fed 53% protein (2.5%), though the actual magnitude of difference was very small.

In summary, walleye survived and handled well under summer and winter pond culture conditions. However, growth rates and feed efficiencies were

TABLE 5. Average (Mean ± SE) whole weight, whole dressed weight (% of whole weight), head weight (%), visceral weight (%), fillet weight (%) and proximate composition of fillets from walleye fed 44 or 53% protein diets in ponds. Means within a row followed by different letters are significantly different ($P < 0.05$). Fillet composition values are on a dry-weight basis.

	Diet	
	44%	53%
Whole fish (g)	240 ± 13b	287 ± 59a
Whole dressed (%)	66.1 ± 0.8a	68.1 ± 2.1a
Head (%)	24.4 ± 1.4a	24.3 ± 2.1a
Viscera (%)	6.2 ± 0.7a	6.9 ± 0.9a
Fillet (%)	40.0 ± 3.5a	40.6 ± 0.4a
Fillet Composition		
Moisture (%)	78.6 ± 1.0a	77.8 ± 0.3a
Lipid (%)	2.7 ± 0.9a	2.5 ± 0.2b
Protein (%)	90.5 ± 3.9a	95.2 ± 2.5a

relatively poor. Walleye appeared to benefit from high protein levels, even at larger sizes. Best growth was at higher temperatures than predicted by previous studies. Further studies on growth of advanced walleye at different temperatures should be conducted.

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