

Trout, General

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J. J. Kenney

DRY DIETS FOR TROUT:

Successful Diets to Rear Trout in the Hatchery

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INTRODUCTION

Trout have been reared in hatcheries on dry diets extensively, if not always successfully, in the United States during the last decade. By 1959, trout hatcheries in Wisconsin used dry feed plus a meat supplement as a standard diet for production of domesticated trout.

The objective of this report is to present results of feeding a "complete" dry diet to domesticated trout in Wisconsin hatcheries. In Wisconsin, domesticated rainbow, brown, and brook trout reared on dry diets in the Westfield Research Hatchery from fry to legal-size of 6 inches generally survived and grew as well in the hatchery as their counterparts reared on dry diets supplemented with fresh meat. Domesticated lake trout reared on dry diets in the hatchery from 6 months of age to 13 months of age grew as well and survived nearly as well as their counterparts fed dry diets supplemented with fresh meat.

Some of the dry diets developed during the last decade were as satisfactory for rearing trout in hatcheries as diets fortified with fresh meat products (Grassel, 1957, 1958; Miller *et al.*, 1959; Miller and Miller, 1962; Phillips, 1964; Phillips *et al.*, 1964).

Other dry diets, although efficient producers of trout flesh, were less successful as a complete brown trout food in the hatchery because blue-slime and lesions appeared periodically on the trout (Phillips, Hammer, and Pyle, 1964). Because vitamin and essential amino acids requirements for trout were generally established (Halver, 1957; Halver *et al.*, 1957; Phillips and Brockway, 1957; Shanks *et al.*, 1962), Phillips *et al.*, (1964) suggested an addition of an anti-oxidant and an increase of niacin to the diet as a possible corrective agent for the lesions on the trout. After an increase of vitamins in the dry pellets, trout did not appear significantly different from other trout held at the hatchery (Phillips, 1964).

Methods

The feeding trials on domesticated brook, brown, rainbow, and lake trout were conducted at the Westfield Research Hatchery, Westfield, Wisconsin. Water supply came from artesian wells and was moderately high in mineral content (methyl orange alkalinity 175 ppm. Ca^{++} 32 ppm, Mg^{++} 15 ppm). Water temperature in the concrete tanks of the hatchery building was a uniform 50°F. In the outside concrete raceways, the water temperature ranged from 48°F in winter to 56°F in summer.

Three dry feeds, designated A-1, A-2, C, C-1, and C-2, were tested in the feeding trials. The feeds were manufactured in pellet form by a commercial feed company according to our specifications (Table 1). Results of chemical analyses of the three feeds are presented in Table 2.

Domesticated trout hatched and reared at the Westfield Research Hatchery were subjected to the following feeding trials:

Fall-hatched rainbow trout

- Lot 1. -- 100% beef liver, weeks 1-12;
60% Diet C-1 and 40% beef liver, weeks 13-24;
70% Diet C-2 and 30% beef melts, weeks 25-56.
- Lot 2. -- 100% Diet C, weeks 1-12;
100% Diet C-1, weeks 13-36;
100% Diet C-2, weeks 37-56.
- Lot 3. -- 100% Diet A-1, weeks 1-12;
100% Diet A-2, weeks 13-24;
100% Diet C-2, weeks 25-56.
- Lot 4. -- 100% Diet A-1, weeks 1-8;
100% Diet C, weeks 9-36;
100% Diet C-1, weeks 36-40 (feeding trial discontinued
after the 40th week).

Spring-hatched rainbow trout

- Lot 1. -- 60% Diet C-1 and 40% beef liver, weeks 1-12;
70% Diet C-1 and 30% beef liver, weeks 13-24;
70% Diet C-2 and 30% beef melts, weeks 25-36.
- Lot 2. -- 100% Diet C-1, weeks 1-16;
100% Diet C-2, weeks 17-36.
- Lot 3. -- 100% Diet A-1, weeks 1-20 (feeding trial discontinued
after the 20th week).

Brown trout

- Lot 1. -- 50% beef liver and 50% Diet C-1, weeks 1-8;
40% beef liver and 60% Diet C-1, weeks 9-21;
25% beef liver and 75% Diet C-1, weeks 22-25;
8% beef liver, 8% beef melts, and 84% Diet C-2, weeks 26-42.
- Lot 2. -- 50% beef liver and 50% Diet C-1, weeks 1-21;
35% beef liver and 65% Diet C-1, weeks 22-25;
15% beef liver, 15% beef melts, and 70% Diet C-2,
weeks 26-30.
- Lot 3. -- 100% Diet C-1, weeks 1-25;
100% Diet C-2, weeks 26-42.
- Lot 4. -- 100% Diet C-1, weeks 1-25;
100% Diet C-2, weeks 26-30.
- Lot 5. -- 100% Diet C-1, weeks 1-8.

- 3 -
Brook trout

Lots 1 and 2. -- 50% beef liver and 50% Diet C-1, weeks 1-8;
40% beef liver and 60% Diet C-1, weeks 9-20;
15% beef liver, 15% beef melts and 70% Diet C-1,
weeks 21-24;
8% beef liver, 8% beef melts and 84% Diet C-2,
weeks 25-40.

Lots 3 and 4. -- 100% Diet C-1, weeks 1-24;
100% Diet C-2, weeks 25-40.

Lake trout

Lot 1. -- 71% Diet C-2 and 29% beef liver, weeks 1-33;

Lot 2. -- 85% Diet C-2 and 15% beef liver, weeks 1-33;

Lot 3. -- 100% Diet C-2, weeks 1-33.

The trout selected for the feeding trials were members of a group of fry several times the size of all diet lots in a given feeding trial. This larger group of fry were progeny of several females whose eggs were placed in a common container, mixed and fertilized with sperm from several males. Fall-hatched rainbow trout eggs came from Nevin Hatchery, Madison, Wisconsin; spring-hatched rainbow trout and lake trout eggs were from brood stock reared at Westfield Research Hatchery; brown trout eggs were from Wild Rose Hatchery, near Westfield Hatchery; and brook trout eggs were from Osceola Hatchery in northwest Wisconsin.

The 4 diet lots of fall-hatched rainbow trout consisted of 2 replicates containing 4,000 trout each during the first 8 weeks of feeding. Trout in each replicate were reduced to 2,000 from the 8th to the 19th week after which the replicates of each lot were combined and each lot again contained 4,000 trout until the 25th and 49th weeks when trout were removed for release into streams (See Table 3). The diet lots of the spring-hatched rainbow, brown, brook, and lake trout did not consist of replicates.

The feeding trials began when the trout fry started to "swim up". Each lot of trout was held in a shallow metal tank provided with a movable divider which allowed for expansion of space as the trout grew. At the onset of the feeding trials, the fry were held in a small segment of the tank, thus duplicating general conditions in Wisconsin trout production hatcheries. When the trout became too large for the shallow tanks, they were transferred to 3-foot deep concrete tanks and eventually to outdoor concrete raceways.

All diet lots of trout were fed according to specifications in the Wisconsin Conservation Department Feeding Table and were treated identically. Brook, brown and rainbow trout were fed by hand and the lake trout were fed by automatic feeders. Production records were kept on each diet lot and relative survival, growth, feed conversion, and cost of trout reared on the various diets were analyzed. As the trout grew with time, their numbers per diet lot were reduced at intervals to prevent overcrowding or as in the brown trout feeding trials, lots 2 and 4 were discontinued

after the 30th week because of lack of space (Table 3). The reeding trials were terminated when 1,000 trout from a given lot were fin-clipped and released into the wild environments of several streams and one lake to determine survival and growth in the wild.

Results & Discussion

Percentage mortality of trout produced in the hatchery under the diet programs is presented in Table 4. Mortality during the first 6 to 8 weeks of the feeding program was slightly higher in the lots fed dry feed when the trout were fry and young fingerlings. There was no apparent difference in appearance of the trout fed the different diets. Feeding trials with diet lot 4 of the fall-hatched rainbow trout and diet lot 3 of the spring-hatched rainbow trout was discontinued when mortality increased and the trout showed symptoms of nutritional deficiency (See Table 3). Both these lots were reared entirely on high-protein dry diets. Trout which were fed high-protein dry feed as a "starter" but later were reared on low-protein diets did not have an increased in mortality rates nor show symptoms of nutritional deficiency.

All 3 diet lots of lake trout were periodically attacked by furunculosis, and the total mortality of the lake trout in the dry diet lot 3 was higher than it was in the lots receiving a meat supplement (Table 4). Without replication of the various diet lots, however, it is impossible to suggest that lake trout receiving a fresh meat supplement were more resistant to furunculosis than were lake trout fed the Wisconsin Conservation Department dry diets.

Total conversion of feed to trout flesh when compared to other conversion ratios obtained on brown trout (Schumacher, 1958; Phillips, 1964), brook and rainbow trout (Schumacher, 1958), were relatively low (Table 5).

The total conversion of 2.08 in lot 5 of the brown trout occurred during the 8 weeks when the trout were young fingerlings before they were incorporated into lots 3 and 4. Conversion ratios of feed to trout flesh were lower as the trout grew larger in all the feeding trials. These conversion ratios are given as total conversion and are calculated from the total feed fed a given diet lot during any given trial and the total weight gained during that trial.

The trout fed dry feed grew as well in the hatchery as did their counterparts fed dry feed plus fresh meat supplements.

It is evident from the feeding trials that it was cheaper to feed dry feed to our domesticated trout in the hatchery.

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TABLE 1

Composition of Wisconsin Conservation Department
Dry Trout Diets in Pounds per 1,000 Pounds of Feed

	Diet A-1	Diet A-2	Diet C	Diet C-1	Diet C-2
Fish meal (white fish)	220	160	325	250	200
Fish solubles, condensed	20	20	20	20	20
Skim milk, dried, spray process	100	100	200	100	50
Yeast, primary, 50-B	40	20	80	--	--
Yeast, brewer's	40	50	--	80	80
Distiller's solubles, dried ^{1/}	100	100	100	100	50
Alfalfa meal	40	60	50	50	50
Blood flour	40	40	50	25	--
Liver meal (beef liver nonextracted)	140	90	125	75	50
Wheat, red dog	100	150	--	100	200
Cotton seed meal (degossypolized)	100	150	--	100	200
Corn gluten meal	--	--	--	50	50
Feeding oil, 300 D and 2,250 A	40	40	40	40	40
Salt, trace, mineralized	20	20	10	10	10
<u>Vitamin mixture added in grams</u>					
Riboflavin	50	50	50	50	50
Pantothenate	60	60	60	60	60
Niacin	250	250	250	250	250
Choline chloride	250	250	250	250	0
Thiamin	40	40	40	40	40
Ascorbic acid	100	100	100	100	100
Vitamin E	0.8	0.8	0.8	0.8	0.8
Vitamin B ₁₂	0.4	0.4	0.04	0.04	--

^{1/} Commercial Solvents Co. Soluferm

TABLE 2

Chemical Composition of Wisconsin Conservation Department Dry Trout Diets

Percentage Composition*					
	Diet A-1	Diet A-2	Diet C	Diet C-1	Diet C-2
Protein	44.0	35.0	42.0	40.5	37.7
Fat	8.3	8.4	7.6	8.9	8.1
Ash	10.5	10.5	13.2	11.7	10.0
Moisture	9.6	9.3	9.4	9.0	8.9
Ca	1.4	2.4	3.5	2.9	2.2
P	1.2	1.2	1.8	1.7	1.5
Na	1.1	1.0	.7	0.7	0.7
K	2.3	-	-	1.0	1.2
Fe	0.05	0.03	0.04	0.04	0.03
Zn	-	-	-	13.5 mg/lb.	10.5 mg/lb.
Cu	-	-	-	17.1 mg/lb.	12.2 mg/lb.

* Average of 2 lots of diets A-1, A-2, and C. Average of 5 lots of diets C-1 and C-2.

TABLE 3

Size of Diet Lots on Given Dates During the Diet Programs
(Duration Dates of the Programs in Parentheses)

Fall-hatched Rainbow Trout (10/11/60-11/7/61)			Spring-hatched Rainbow Trout (3/1-11/7/61)			Brown Trout (11/24/61-9/21/62)		
Date	Lot*	Number Per Lot	Date	Lot	Number Per Lot	Date	Lot	Number Per Lot
Oct. 11-Dec. 6	1	8,000	Mar. 1-Apr. 7	1	3,000	Nov. 24-Jan. 22	1	2,200
	2	8,000		2	3,000		2	2,200
	3	8,000		3	3,000		3	2,200
	4	8,000	Apr. 8-Aug. 16	1	2,500	4	2,200	
1	4,000	2		2,500	5	2,200		
Dec. 7-Feb. 15	2	4,000	Aug. 17-Nov. 7	3	2,500	Jan. 23-Jun. 27	1	2,700
	3	4,000		1	2,500		2	1,600
	4	4,000		2	2,500		3	2,700
Feb. 16-Mar. 28	1	4,000		3	***		4	3,100
	2	4,000					5	added to 3 & 4
	3	4,000				Jun. 28-Sept. 21	1	2,700
	4	4,000					2	***
Mar. 29-Jul. 20	1	3,000					3	2,700
	2	3,000					4	***
	3	3,000						
	4	3,000						
Jul. 21-Sept. 13**	1	3,000						
	2	3,000						
	3	3,000						
	4	***						
Sept. 14-Oct. 4**	1	2,000						
	2	2,000						
	3	2,000						
Oct. 4-Nov. 7	1	1,000						
	2	1,000						
	3	2,000						

Brook Trout (12/2/61-9/12/62)			Lake Trout (7/8/64-2/24/65)		
Date	Lot	Number Per Lot	Date	Lot	Number Per Lot
Dec. 2-Jan. 30	1	2,600	Jul. 8-Sept. 9	1	5,600
	2	2,600		2	5,600
	3	2,600		3	5,600
	4	2,600	Sept. 10-Feb. 24	1	2,600
	5	2,600		2	2,600
Jan. 31-Sept. 12	1	2,350		3	2,600
	2	2,600			
	3	2,350			
	4	2,600			
	5	2,000			

* Until March 28, each lot of fall-hatched rainbow trout consisted of 2 replicates which were combined after that date.

** On September 13, a thousand trout were removed from lots 1, 2, and 3 and on Oct. 4, another thousand trout were removed from lots 1 and 2 and released in streams to determine survival and growth in a wild environment.

*** Discontinued.

TABLE 4

Percentage Mortality of Trout on Different Diet Programs

Date	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
<u>Fall-hatched Rainbow Trout</u>					
Oct. 11-Nov. 23	7.3	8.0	12.2	14.0	-
Nov. 24-Dec. 21	0.8	0.3	1.2	0.4	-
Dec. 22-Feb. 15	0.0	0.0	0.0	0.0	-
Feb. 16-Jul. 20	0.0	0.0	0.0	2.6	-
Jul. 21-Nov. 7	0.0	0.0	0.0	Discontinued	-
<u>Spring-hatched Rainbow Trout</u>					
Mar. 1-Apr. 27	1.3	1.9	2.0	-	-
Apr. 28-Jun. 21	0.1	0.2	0.4	-	-
Jun. 22-Aug. 16	0.2	0.9	13.0	-	-
Aug. 16-Nov. 7	0.0	0.0	Discontinued	-	-
<u>Brown Trout</u>					
Nov. 24-Dec. 23	3.8	1.8	4.1	2.0	2.9
Dec. 24-Jan. 22	1.0	1.2	3.4	4.1	2.4
Jan. 23-Feb. 18	0.4	1.0	0.7	7.9	Added to 3 and 4
Feb. 19-Jun. 27	0.6	1.9	0.3	3.8	-
Jun. 28-Sept. 21	<0.1	Discontinued	0.1	Discontinued	-
<u>Brook Trout</u>					
Dec. 2-31	5.1	4.7	5.4	3.8	4.0
Jan. 1-30	1.2	1.3	3.2	2.2	2.2
Jan. 30-Feb. 25	<0.1	<0.1	0.0	<0.1	<0.1
Feb. 26-Sept. 12	0.2	0.3	0.2	0.3	1.8
<u>Lake Trout</u>					
Jul. 8-Sept. 9	0.1	0.1	0.1	-	-
Sept. 10-Nov. 11	0.0	0.2	<0.1	-	-
Nov. 12-Dec. 23	0.2	0.5	0.1	-	-
Dec. 24-Feb. 4	0.2	0.3	1.1	-	-
Feb. 5-Feb. 24	0.4	0.2	1.6	-	-

TABLE 5

Cost Analysis of Trout Produced in the Hatchery
Under Different Diet Programs

Diet Lots*	Feed Fed (Pounds)	Starting Weight of Diet Lots (Pounds)	Weight Gain (Pounds)	Total Conversion	Feed Cost Per Pound	Feed Cost Per Pound of Trout
<u>Fall-hatched Rainbow Trout</u>						
1 (Dry feed + meat)	720.0	1.0	458.2	1.57	0.080	0.126
2 (Dry feed)	634.5	1.0	489.2	1.30	0.075	0.098
3 (Dry feed)	564.9	1.0	436.3	1.29	0.075	0.097
4 (Dry feed)	260.2	1.0	165.4	1.57	0.075	0.118
<u>Spring-hatched Rainbow Trout</u>						
1 (Dry feed + meat)	225.4	0.5	168.5	1.34	0.080	0.107
2 (Dry feed)	183.7	0.5	153.5	1.20	0.075	0.090
3 (Dry feed)	49.3	0.5	32.3	1.53	0.075	0.115
<u>Brown Trout</u>						
1 (Dry feed + meat)	289.6	0.6	227.7	1.27	0.082	0.104
2 (Dry feed + meat)	52.5	0.6	31.1	1.69	0.100	0.169
3 (Dry feed)	235.0	0.6	218.4	1.08	0.073	0.079
4 (Dry feed)	53.7	0.6	46.6	1.15	0.073	0.084
5 (Dry fee)	2.5	0.6	1.2	2.08	0.073	0.152
<u>Brook Trout</u>						
1 (Dry feed + meat)	237.3	0.8	175.9	1.52	0.083	0.126
2 (Dry feed + meat)	235.3	0.8	151.6	1.55	0.083	0.129
3 (Dry feed)	209.1	0.8	170.4	1.23	0.073	0.090
4 (Dry feed)	207.5	0.8	169.4	1.22	0.073	0.089
5 (Dry feed)	187.4	0.8	147.9	1.27	0.073	0.093
<u>Lake Trout</u>						
1 (Dry feed + meat)	512.3	75.0	252.2	2.03	0.099	0.201
2 (Dry feed + meat)	475.9	75.0	264.0	1.80	0.089	0.160
3 (Dry feed)**	438.4	75.0	245.3	1.79	0.078	0.140

* See Table 3 for size of diet lots on various dates.

** Lot 3 received no meat supplement until the late states of the feeding trials when it was necessary to feed 30 percent liver for administering sulfa drugs for a total of 16 days.