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THE PROTEIN REQUIREMENT OF CHANNEL CATFISH, Ictalurus Punctatus (RAFINESQUE)[1]

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ABSTRACT

A study was made to determine the level of dietary protein needed by channel catfish for optimum growth. The experimental work was conducted in the Farm Ponds Laboratory of Auburn University, Auburn, Alabama. Each of 40 stainless steel troughs was stocked with 25 six- to seven-inch fish. These fish were fed experimental diets at a rate of 2.5 percent of their body weight per day. Every 14 to 21 days from June 22 to September 3, 1961, the fish were re-weighed and their daily amount of food adjusted to the new weight.

Eight purified diets were fed, each to five randomly-assigned troughs. These diets contained protein levels of 6.3, 15.8, 25.3 and 34.8 percent at carbohydrate levels of 9.8 and 18.6 percent. Samples of fish were randomly selected at the beginning and at the end of the experiment for carcass analysis. Growth for each diet was compared along with the amount of protein deposited in an effort to determine the level of protein which produced optimum growth.

Statistical analyses indicated that of the levels tested a level of 25.3 percent protein produced optimum growth. Growth was obtained on the lowest level or 6.3 percent protein diet. The estimated maintenance requirement of protein for channel catfish in this experiment was 0.079 gram of protein per day per hundred grams of fish on the 9.3 percent carbohydrate diets and 0.029 gram of protein on the 18.6 percent carbohydrate diets. Based on this data, 0.23 gram of carbohydrate fed per hundred grams of fish would spare 0.05 gram of protein.

INTRODUCTION

The protein requirements of higher animals have been studied extensively for over 100 years. In these studies many attempts have been made to evaluate proteins in relation to such functions as growth, reproduction, maintenance, and milk secretion. From these studies information has been obtained to enable increased and more economical production of all species studied.

Nutritional studies on fish have been conducted for a relatively short period of time. Thus far, the majority of the work conducted on fish nutrition has been done with cold-water species. There has been virtually no nutritional work on warm-water fish reported in the literature.

It has been established that protein is required by all animals for maintenance and growth. However, the level of protein needed for these functions varies with the species. It was the purpose of this experiment to determine the level of protein needed by channel catfish for optimum growth.

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1 This paper taken from a thesis presented to the Graduate Faculty of Auburn University in partial fulfillment for the Master of Science Degree. This work was directed by Dr. E. W. Shell.

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EXPERIMENTAL UNITS

This experiment was conducted in the Farm Ponds Laboratory of Auburn University, Auburn, Alabama. Forty stainless steel troughs, each 7′ x 1′ x 0.8′, set in groups of four (two upper and two lower), were utilized in this experiment. Each trough contained an individual air and water supply and a drain pipe. Compressed air for aeration was supplied through copper tubing from an air compressor. The water was piped into the laboratory from the City of Auburn's filtered and chlorinated domestic water supply and then passed through an activated-charcoal filter in the laboratory to remove the residual chlorine.

Each group of troughs had a 100-watt light bulb located between the upper and lower troughs. In addition, four 300-watt bulbs were suspended from the ceiling. Although the lower trough received more light, there was no noticeable difference in the actions or appetites of the fish.

An individual cleaning brush and scouring pad was provided for each group of troughs to reduce the possibility of the spread of parasites or disease organisms. It was necessary to clean each trough every 2 to 3 days to prevent the accumulation of fecal material and to reduce algal growth to a minimum.

The water supply was regulated to give equal flow through the troughs. The water temperature varied from 25° C. to 28° C. during the course of the experiment.

EXPERIMENTAL FISH

The fish used were of the 1960 spawn of channel catfish produced on the Farm Ponds Project of the Agricultural Experiment Station of Auburn University. On May 15, 1961, approximately 1,200 of these fish were brought into the Farm Ponds Laboratory. At that time, the fish were in the 6- and 7-inch groups. One thousand of these fish were then randomly selected and placed into the stainless steel troughs at the rate of 25 fish per trough. The remainder of the fish were placed in wooden feeding troughs and received the same treatment as the fish in the stainless steel troughs. This latter group of fish was used to replace any fish in the stainless steel troughs that were lost during the acclimation period.

PREPARATION OF THE EXPERIMENTAL DIETS

Eight diets were fed in this experiment. Each diet was fed to fish in five troughs. In addition, an acclimation diet was fed to catfish in all troughs before the experiment was initiated. The composition of these diets in given in Table I.

TABLE I

DIET INGREDIENTS AND THEIR PERCENTAGES IN THE DIETS FED

Ingredients	*Acclimation*	*Diets* 1	2	3	4	5	6	7	8
Casein*	20.0	9.3	23.3	37.2	51.2	9.3	23.3	37.2	51.2
Dextrin	9.3	9.3	9.3	9.3	9.3	18.6	18.6	18.6	18.6
Corn Oil	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
Minerals	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
Alphacel†	51.6	62.3	48.4	34.4	20.5	53.0	39.1	25.1	11.2
Vitamin Mix‡	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Agar	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Actual % Protein	13.6	6.3	15.8	25.3	34.8	6.3	15.8	25.3	34.8

* Contained 68.0 percent protein.
† Used as diet filler.
‡ A vitamin fortification mixture was added at the rate of 20 grams per 1,000 grams of diet.

The diets were prepared by mixing 1,000 grams of the ingredients and 1,000 milliliters of a 5 percent agar solution which had been heated to 100° C. A vitamin fortification mixture was stirred into the agar solution when it reached 100° C. to insure the homogeneous mixing of the vitamins in the diet. The agar solution containing the vitamins was poured into the dry ingredients and mixed thoroughly. The diet was then placed in gallon jars and sealed with a double layer of Saran Wrap. It was then cooled for 3 to 4 hours. After cooling, the material was passed through a meat grinder which pelleted the food into a size that provided easier handling and allowed for better utilization by the fish.

The diet was offered to the fish about 6 hours after they were stocked into the steel troughs. Some of the fish accepted the diet at that time but 5 to 6 days were required for fish in all troughs to begin eating the diet. Within 10 days all the fish accepted the diet readily and consumed their daily ration within 1 to 2 minutes.

EXPERIMENTAL PROCEDURE

On June 22, 1961, the fish from each trough were weighed. These fish were fed subsequently at a rate of 2.5 percent of their body weight per day. The fish were re-weighed at 14 to 21 day intervals and their daily amount of diet adjusted to their new body weight.

The 8 purified diets were fed, each to catfish in five randomly assigned troughs. The diets were formulated in 1,000 gram lots and stored in gallon jars kept in a walk-in refrigerated room at a temperature of 10° C. These diets were formulated every 4 to 5 days at the beginning of the experiment and every 3 to 4 days in the latter stages of the experiment.

The experiment was terminated on September 3, 1961, due to a water supply failure which resulted in the death of large numbers of the larger fish. There was no mortality within any of the treatments during the course of the experiment.

Prior to the beginning of the experiment, several fish were randomly selected from the troughs for carcass analysis for protein and fat content. These fish were weighed, frozen, and stored in polyethylene bags in the freezer locker at the Farm Ponds Laboratory. At the termination of the experiment four fish from each of the eight diets (two fish from each of two troughs) were randomly selected and analyzed as the fish previously mentioned.

The fish were prepared for protein and fat analysis in the following manner. Each frozen fish was cut into small pieces and placed into a Waring Blender. As the experiment developed the frozen fish blended much more completely than those which were allowed to thaw. Distilled water was added at a ratio of 2 to 1 and the solution was blended for 10 to 15 minutes depending on the size of the fish. This homogeneous solution was then poured into weighed evaporating dishes and dried in an oven at 110° C. for 24 hours. The dishes were then cooled in a desiccator and re-weighed. The dry weight of each fish was obtained in this manner. After weighing, the dry material in the evaporating dishes was scraped into a mortar and ground with a pestle to obtain a homogeneous mixture. From this dry mixture, weighed samples were analyzed for protein [3] and fat content.[4]

THE EFFECTS OF THE DIFFERENT PROTEIN LEVELS ON GROWTH

The percentage of gain for the fish in each trough is given in Table II. During this experiment all troughs showed an increase in weight. However, the troughs receiving Diet No. 1 were somewhat erratic in growth at the beginning of the experiment. At the first weighing period only two of the troughs on this diet had gained weight; one had no gain and two had lost weight. This could have been due to the inability of the fish to adjust themselves during that period of time to the reduced protein and energy levels from that fed during the acclimation period. The troughs receiving the other seven diets showed a gain in weight throughout the experiment.

The percentages gained for the troughs receiving the different diets were compared by use of an "analysis of variance" table (Steel and Torrie, 1960). The results of these computations showed that, at an alpha level of confidence of 0.05, there was a significant difference between the levels of protein and between the carbohydrates levels. It also showed that there was no significant interaction involved. By use of orthogonal comparisons it was determined that the diets containing 25.3 percent protein was significantly different from the diets containing 6.3 and 15.8 percent protein, but there was no significant difference from diets containing 34.8 percent protein.

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3 Kejldahl method.

4 Continuous Ether Extraction.

TABLE II

INITIAL WEIGHTS, FINAL WEIGHTS, AND PERCENTAGE GAINS OF TROUGHS OF FISH RECEIVING THE EIGHT EXPERIMENTAL DIETS

		Percent Carbohydate							
		9.3					18.6		
Percent Protein	*Trough Number*	*Initial Weight (gm)*	*Final Weight (gm)*	*Percentage Gain*	*Percent Protein*	*Trough Number*	*Initial Weight (gm)*	*Final Weight (gm)*	*Percentage Gain*
	6	861	1,038	20.55		2	891	1,239	39.05
	8	942	1,068	13.37		3	756	1,082	43.12
6.3	19	856	1,034	20.79	6.3	18	800	1,073	34.12
	28	823	1,024	24.42		22	839	1,106	31.82
	29	819	1,043	27.35		33	783	1,077	37.54
	1	650	1,335	105.38		9	948	1,866	96.83
	10	763	1,416	85.58		21	815	1,616	98.28
15.8	23	849	1,575	85.51	15.8	31	881	1,689	91.71
	25	809	1,438	77.75		35	825	1,723	108.84
	26	833	1,471	76.59		38	789	1,583	100.63
	11	846	2,070	144.68		13	865	2,285	164.16
	12	765	1,977	158.43		15	838	2,256	169.21
25.3	27	806	2,003	148.51	25.3	17	846	2,286	170.21
	32	900	2,124	136.00		20	839	2,202	162.45
	34	833	2,143	157.26		39	827	1,957	136.64
	4	880	2,379	170.34		5	858	2,327	171.21
	7	844	2,339	177.13		14	895	2,175	143.01
34.8	36	797	2,166	171.76	34.8	16	864	2,453	183.91
	37	840	2,301	173.92		24	845	2,058	143.55
	40	785	2,190	168.67		30	827	2,344	183.43

These results indicate that of the levels of protein tested, a level of 25.3 percent protein is needed for optimum growth by growing channel catfish. This level is higher than those levels required by most warm blooded animals. Norris and Heuser (1930) and Munson *et al.* (1954) have reported that chicks require 18 percent protein. Pigs require a level of 18 percent during their growing period and a level of 15 percent has proven adequate for an animal of 100 pounds or more (Mitchell and Hamilton, 1935). Miller and Keith (1941) reported that the optimum quantity of protein in the ration for pigs for the growth span from 40 to 210 pounds was 15 to 17 percent. Levels of 20, 22, 25, and 27 percent were also used but were not superiorly outstanding. The trend of their results show that higher levels of protein were needed for weaning pigs (75 lbs.) and lower levels for pigs weighing 120 to 200 lbs. There are some mammals that are similar to fish in their high protein requirement. Heinicke *et al.* (1956) in their studies with guinea pigs reported that a 30 percent level of casein is needed for optimum growth. Harris (1951) found that young foxes should be fed 25 to 35 percent protein.

Phillips *et al.* (1957) reported that the protein level needed by trout in 28 percent. Delong *et al.* (1958) using casein as a source of protein, reported that the optimum protein requirement for chinook salmon was dependent upon the water temperature. At 47° F. they found that the salmon require 40 percent casein and at 58° F. the level required was 55 percent. These values seem to be high by comparison. Work conducted by Phillips *et al.* (1957) suggests that these levels could be reduced by proper attention to the calorie balance in the diet.

EFFECTS OF DIETARY PROTEIN LEVELS ON PROTEIN DEPOSITION

Tunison *et al.* (1939), while working on the protein requirement of trout, reported that trout are similar to higher animals inasmuch as the content of the body in protein tends to remain relatively the same. This appears to be true also of channel catfish. Table III gives the composition of the carcasses of a sample of fish before the experiment started and of fish that had received the experimental diets. The percentage of protein in the carcasses ranged from 12 to 16. The majority of the fish analyzed ranged around 14 percent protein.

In Table IV, the amount of dietary protein that was converted into body protein has been tabulated. This was accomplished by expanding the average grams of protein in the fish analyzed before the experiment started to the wet weight of the fish in the trough. At the termination of the experiment, the grams of protein in each fish analyzed was expanded to the wet weight of the fish in its respective trough. By subtracting the former from the latter, the amount of protein deposited was obtained. The protein conversion rate was calculated by dividing the amount of protein deposited into the amount of protein fed.

The grams of protein deposited, like growth rates, indicated that the diets containing 25.3 percent protein produced optimum protein deposition.

It would seem that the level of protein giving the most optimum growth would have a better conversion of dietary protein into body protein. However, this was not the case in the experiment. By using an "analysis of variance" table (Steel and Torrie, 1960), the conversion rates for the different diets were compared statistically. The results indicated that at an alpha level of confidence of 0.05 there was no difference in protein levels or was there any significant inter-action. It did indicate that there was a difference in the conversion rates of fish receiving the different levels of carbohydrate. This inability to show a difference in the protein conversion was probably due to the small number of fish from each diet and the large variation between fish treated alike.

MAINTENANCE REQUIREMENTS

Since all troughs showed an increase in weight and there were no mortalities, it is safe to assume that all were receiving an excess of protein in relation to maintenance.

The lowest level of protein fed was 6.3 percent. The troughs receiving this level had an overall average percentage gain of 21.29 and 37.13 when fed carbohydrate levels of 9.3 percent and 18.6 percent, respectively. In Figure 1, the

TABLE III

WATER, PROTEIN, AND FAT CONTENT OF CARCASSES OF CHANNEL CATFISH FED ON ACCLIMATION DIET AND ON THE EIGHT EXPERIMENTAL DIETS

Diet	*Trough and Sample No.*	*Wet Wt. in Grams*	*Dry Wt. in Grams*	*Percent Water*	*Percent Protein*	*Percent Fat*
Acclimation diet		30.20	6.8	77.49	15.59	0.26
		29.70	7.3	75.43	14.98	1.75
		27.80	6.1	78.06	13.20	3.27
	AVERAGE*	29.23	6.7	76.99	14.59	1.76
	19A	53.91	14.35	73.39	14.56	4.74
1	19B	42.11	11.99	71.53	16.00	7.31
	28A	43.50	11.70	73.11	13.49	5.63
	28B	48.69	14.60	70.02	13.10	8.89
	10A	83.90	21.95	73.84	14.49	5.31
2	10B	62.20	14.80	76.21	14.19	2.73
	26A	68.00	15.45	77.28	10.45	2.33
	26B	63.60	13.50	78.78	12.23	3.97
	11A	118.83	30.90	74.00	14.53	6.22
3	11B	134.11	35.55	74.24	16.00	4.95
	32A	140.02	35.75	74.47	14.64	5.44
	32B	120.59	32.30	73.22	15.42	4.98
	4A	148.89	39.25	73.64	12.41	6.03
4	4B	144.28	38.72	73.17	16.23	6.21
	36A	146.61	38.95	73.44	14.73	6.74
	36B	120.23	29.95	75.09	14.88	5.11
	2A	66.60	19.64	70.52	13.48	9.68
5	2B	82.80	21.60	73.91	14.48	4.93
	18A	55.50	15.90	71.36	13.47	7.67
	18B	72.80	20.05	72.46	13.36	7.33
	9A	72.00	20.30	71.81	14.69	8.12
6	9B	73.30	18.80	74.36	14.50	4.74
	35A	83.50	23.45	71.92	14.15	6.49
	35B	60.20	15.80	73.76	15.11	5.31
	17A	88.89	24.30	72.67	14.82	6.73
7	17B	76.65	20.50	73.25	14.24	6.37
	20A	145.40	37.25	74.38	14.08	5.74
	20B	98.50	25.90	73.71	15.05	5.56
	5A	132.70	34.35	74.12	14.47	6.39
8	5B	114.50	29.50	74.24	14.19	5.37
	14A	109.00	29.45	72.99	14.97	6.38
	14B	102.50	28.70	72.00	15.48	6.49

* These values used in calculating the amount of protein deposited.

TABLE IV

CONVERSION RATES OF DIETARY PROTEIN INTO BODY PROTEIN OF CHANNEL CATFISH RECEIVING THE EXPERIMENTAL DIETS

Diet	*Trough and Sample No.*‡	*Gms. Protein at Start*	*Gms. Protein at End*	*Gms. Protein Fed*	*Pro. Conversion Rate*
	19A	125.2	150.6	78.4	3.2
1	19B		165.5		1.9
(6.3)*	28A	120.3	138.2	77.6	4.3
(9.3)†	28B		134.2		5.6
	10A	111.6	205.2	218.1	2.3
2	10B		201.1		2.4
(15.8)*	26A	121.8	153.8	231.3	7.2
(9.3)†	26B		179.4		4.4
	11A	126.7	300.8	433.4	2.5
3	11B		331.4		2.1
(25.3)*	32A	131.6	310.9	447.2	2.5
(9.3)†	32B		327.8		2.3
	4A	128.7	295.4	652.5	3.9
4	4B		386.3		2.5
(34.8)*	36A	116.5	319.3	598.6	3.0
(9.3)†	36B		322.5		2.9
	2A	130.3	167.1	86.3	2.3
5	2B		179.4		1.8
(6.3)*	18A	117.0	144.6	77.2	2.8
(18.6)†	18B		143.4		2.9
	9A	138.6	274.2	259.2	1.9
6	9B		220.6		1.9
(15.8)*	35A	120.6	243.9	240.9	1.9
(18.6)†	35B		260.5		1.7
	17A	123.7	339.0	448.2	2.0
7	17B		325.7		2.2
(25.3)*	20A	122.7	311.6	444.7	2.3
(18.6)†	20B		333.0		2.1
	5A	125.4	336.9	622.7	2.9
8	5B		330.3		3.0
(34.8)*	14A	130.9	325.7	644.3	3.3
(18.6)†	14B		336.8		3.1

* Percentage protein in diet.
† Percentage carbohydrate in diet.
‡ Two fish were randomly sampled from each trough.

average percentage gains have been plotted against the amount of protein fed per day per hundred grams of fish and the resulting lines representing the two levels of carbohydrate have been extrapolated to the X axis. This graph shows that there was a linear relationship between growth and the amount of protein fed, up to the 25.3 percent level. As to the exact maintenance requirement one can only speculate due to lack of information, but from the extrapolated lines of Figure 1, it might be assumed that the daily amount of protein needed for a similar diet containing 9.3 percent carbohydrate would be 0.079 grams per hundred grams of fish and 0.029 gram with a diet containing 18.6 percent carbohydrate.

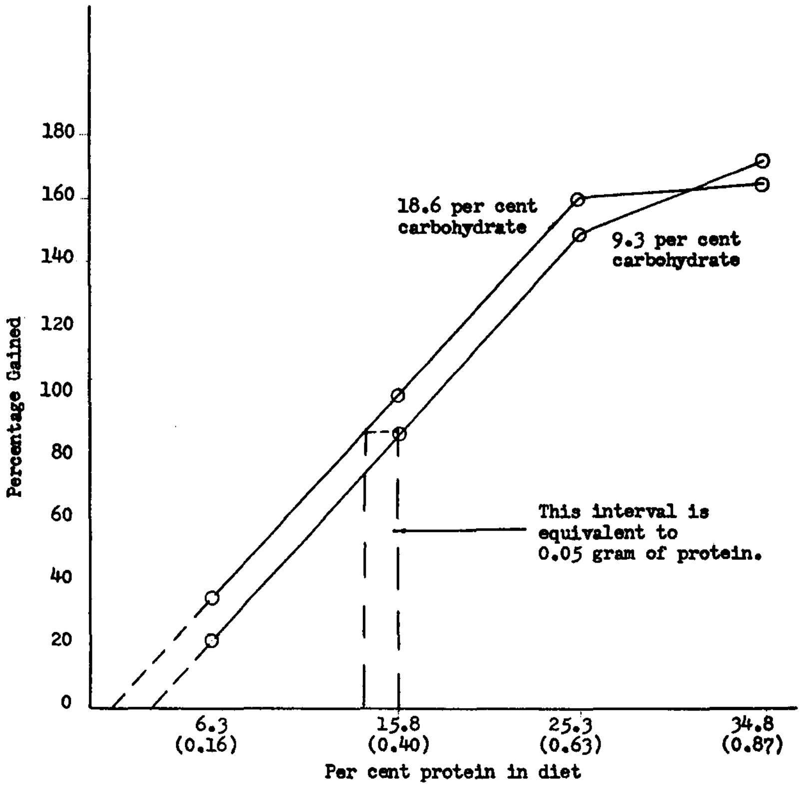

Figure 1. Percentage gains of channel catfish on experimental diets. (Each point represents the average of five replicate troughs. Numbers in parentheses are grams of protein fed per hundred grams of fish per day.)

UTILIZATION OF CARBOHYDRATE BY CHANNEL CATFISH

Earlier workers in fish nutrition have reported that fish were unable to utilize high levels of carbohydrate. McLaren *et al.* (1946) reported that trout were capable of absorbing a large percentage of the carbohydrate supplied in the diet but were unable to excrete large quantities of carbohydrate in their urine. Consequently, high levels of dietary carbohyrates caused growth inhibition, pathological glycogen deposition and death. It was therefore concluded that levels of carbohydrate in excess by 9 to 12 percent of the diet were toxic to trout. Phillips *et al.* (1948) by feeding rainbow trout purified diets with increasing amounts of glucose reported that these fish developed pathological conditions of the liver. However, in these diets the increase in the amount of carbohydrate was at the expense of protein and vitamins. It is very likely that these investigators were studying the effect of protein and/or vitamin deficiencies rather than high dietary carbohydrate levels. More nutritionally adequate diets were fed by McLaren *et al.* (1947) and no deleterious effects were noticed with diets containing as much as 45 percent carbohydrate. DeLong *et al.* (1958) reported the incorporation of as much as 63 percent carbohydrate in the diets of chinook salmon without any ill effects or decrease in growth. Buhler and Halver (1961) in their work with chinook salmon fingerlings reported that the use of 48 percent carbohydrate in the diet produced good fish growth with no increase in mortalities or gross liver pathology.

In this experiment the fish receiving the diets containing 18.6 percent carbohydrate gave the best growth performances. The livers of 32 fish receiving the experimental diets were examined at the termination of the experiment and all were found to be normal in appearance. It would seem that channel catfish can utilize carbohydrate levels of 18.6 percent very well. Further investigation is needed for verification but it is suspected that a much higher level could be utilized.

SPARING ACTION OF CARBOHYDRATE

As compared to protein there is little carbohydrate in the animal body. The carbohydrate in the animal body is in the form of glucose (simple sugar) and glycogen (animal starch). After being ingested carbohydrates are burned for energy, stored temporarily as glycogen or converted into fat.

If there is insufficient energy in the diet the body will burn protein for energy at the expense of growth and tissue repair. The use of carbohydrate for energy to save protein for other purposes is known as the sparing action of carbohydrate. Fat also possesses this ability to spare protein, but not to as great extent as carbohydrate. In a comprehensive review, Munro (1951) concluded that in the normal animal both carbohydrate and fat promote protein utilization, but that carboyhdrate exerts greater sparing action on endogenous nitrogen metabolism than fat.

Although the nature of the mechanism by which carbohydrates spares protein is not known, Munro (1951) reported that a possible way by which the ingested carbohydrate might affect the rate of protein synthesis is through the formation of non-essential amino acids. Geiger *et al.* (1950) reported that it is conceivable that carbohydrates carried to the liver cells through the portal circulation have some specific physiological functions which enable them to expedite the utilization of dietary amino acids.

The sparing effect of carbohydrate in this experiment can be seen by comparing the performance of the troughs receiving the 9.3 percent level with those receiving the 18.6 percent level. Diets 5, 6, and 7 contain the same percentages of nutrients as diets 1, 2, and 3, respectively, with the exception of an additional 9.3 percent carbohydrate. However, the diets containing the higher level of carbohydrate had a higher average percentage gain for the experimental period (Figure 1).

There was a difference of 0.23 gram of carbohydrate fed per hundred grams of fish per day between the diets receiving 9.3 percent carbohydrate and those receiving 18.6 percent. The sparing action of this amount of carbohyrate on the amounts of protein fed can be seen in Figure 1. It was calculated that 0.23 gram of carbohydrate "spared" the use of 0.05 gram of protein per hundred grams of fish for energy. The method for this calculation is described as follows: first, a line was drawn which was parallel to the X axis and which intersected the two lines representing the amounts of carbohydrate in the diets; second, a line from each of the intersection points was drawn perpendicular to the X axis; third, the interval between these perpendicular lines was measured and calculated to be equivalent to 0.05 gram of protein. Therefore, by feeding an extra 0.23 gram of carbohydrate per hundred grams of fish, the same amount of growth was obtained on 0.05 gram less protein.

SUMMARY

Forty stainless steel troughs, each 7.0′ x 1′ x 0.8′ set in groups of four, were used as experimental units. Each trough was stocked with 25, randomly selected, 6- to 7-inch channel catfish which were produced by the Farm Ponds Project of the Agricultural Experiment Station of Auburn University.

On June 22, 1961, the fish were weighed and subsequently fed at a rate of 2.5 percent of their body weight per day. Eight purified diets were fed, each to five randomly assigned troughs. These diets contained protein levels of 6.3, 15.8, 25.3 and 34.8 percent, respectviely, and carbohydrate levels of 9.3 and 18.6 percent.

Growth rates of the fish receiving the different diets were compared. The results of this comparison indicated that a level of 25.3 percent protein was better than 6.3 or 15.8, but there was no difference between the 25.3 and 34.8 percent levels.

The amount of protein deposited, as shown by carcass analysis, supported the conclusion that 25.3 percent protein was the optimum level to feed of the levels tested. There was no difference in the protein conversion rates between the protein levels. This was probably due to the small sample number and the large variation between fish treated alike.

It was estimated that the amount of protein needed daily for maintenance by channel catfish receiving the diets containing 9.3 percent carbohydrate was 0.079 gram of protein per hundred grams of fish. On the basis of this estimate, the fish receiving the diets containing 18.6 percent carbohydrate would need 0.029 gram of protein per hundred grams of fish.

It was calculated that 0.25 gram of carbohydrate fed per hundred grams of fish spared 0.05 gram of protein for growth in the fish receiving the protein levels of 6.3, 15.8, and 25.3 percent.

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