

Metabolism of Amino Acids in Aquatic Animals—I

The effect of the addition of phosphate salts, indigestible materials and algae to the diets of carp and the relationship of intestinal retention time to their growth rate

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Abstract

The amino acid test diet is remarkably inferior to casein diet in maintaining growth of carp. By the addition of NaH_2PO_4 , *Scenedesmus* and cellulose powder in the diet, the retention time of the diet in the intestine became longer.

The amino acid test diet failed to maintain the growth of young carp, one reason seems to be the shorter retention time of it in the intestine.

The amino acid diet for carp, *Cyprinus carpio*, has been studied by several researchers (1-5). A mixed amino acid diet, based on the formula of HALVER (6) failed to maintain the growth of young carp, even though there was no difficulty in its consumption. The casein hydrolyzates, prepared with trypsin, pepsin or pronase, were fed to young carp, but those hydrolyzates were inferior to casein itself in sustaining the growth of young carp (2). Young carp showed some growth on an amino acid test diet neutralized with sodium hydroxide, but the growth rate was slower than when fed the casein diet (3, 4). On the other hand, TAKAMATSU *et al* (7) reported that the mixture of fish meal and wheat flour containing Na_2PO_4 could improve the growth rate of carp.

It has also been reported that carp will grow on a protein diet containing undigestible compounds. DUPREE *et al.* (8) have found that channel cat fish grow on a diet containing small amounts of cellulose powder, as it lengthens the retention time in the intestine and makes the diet easier to digest and absorb.

The present study was undertaken in order to determine the growth rate using an amino acid test diet containing phosphate salts and 10% cellulose powder. *Scenedesmus sp.*, an alga, grows in lakes of ponds and is a valuable nutritive source for herbivorous or omnivorous fish. Therefore, an attempt has also been made to determine the effect of an amino acid test diet containing 10% *Scenedesmus sp.* on the growth of carp.

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Materials and Methods

1. Experimental fish and feeding methods: Carp averaging 5 g in body weight were purchased from a local fish hatchery. Nine aquaria were prepared.

Table 1. The composition of test diets for carp.

Composition	Lot. (gm)								
	A	B	C	D	E	F	G	H	I
Casein	50		50						
Amino acid mixture*		50		50	50	50	50	50	50
Soybean oil	5	5	5	5	5	5	5	5	5
Cod liver oil	2	2	2	2	2	2	2	2	2
Dextrin	19	19	19	19	19	19	19	19	19
Cellulose powder + Vitamin**	10	10	10	10	10	10	10	10	10
Mineral mixture**	4	4	4	4	4	4	4	4	4
Scenedesmus				10					
Cellulose powder					10				
NaH ₂ PO ₄			740 mg			740 mg			
Na ₂ HPO ₄							740 mg		
KH ₂ PO ₄								740 mg	
K ₂ HPO ₄									740 mg
Carboxy methyl cellulose	10	10	10	10	10	10	10	10	10
Water	100	100	100	100	100	100	100	100	100

* See Table 2.

** See Table 3 and Table 4.

Table 2. The composition of amino acid mixture.

Constituents	Amount (%)
L-Arginine·HCl	7.0
L-Histidine·HCl·H ₂ O	3.0
L-Isoleucine	6.0
L-Leucine	8.5
L-Lysine·HCl	7.0
L-Methionine	2.5
L-Phenylalanine	5.0
L-Threonine	4.0
L-Tryptophan	1.5
L-Tyrosine	5.5
L-Valine	6.0
Glycine	8.0
L-Alanine	6.0
L-Aspartic acid	8.0
L-Cystine	1.0
L-Glutamic acid	10.0
L-Proline	7.0
L-Serine	4.0

Each aquarium was equipped with a filter aid and during feeding times the water was circulated, aerated at 400 ml per minute and kept at room temperature. Twenty carp were released in each tank and initially fed the diet shown in **Table 1**. **Table 2** shows composition of the amino acid mixture and components of the vitamin and mineral combination diet are listed in **Table 3** and **4** as devised by *Halver et al.* (10). Phosphate salts (740 mg/100), 10% cellulose powder and *Scenedesmus sp.* were added to the amino acid test diet. The fish were fed the experimental diet four times a day for four weeks and weighed once a week. The amount of the experimental diet used was 10% of the fish's body weight.

2. Retention time of the diet in the intestine: Each test diet was mixed with sudan black and the average retention time was calculated from the start of feeding to the excretion of the digested matter.

Table 3. The composition of vitamins and mineral mixture.

Vitamin mixture		Mineral mixture	
B ₁	5 mg	U. S. P. XII Salt mixture No. 2*	100 mg
B ₂	20	Aluminum chloride	18 mg
B ₆	5	Zinic sulfate	357
Choline chloride	500	Copper(ous) chloride	11
Calcium pantothenate	50	Manganese(ous) sulfate	80
Inositol	200	Potassium iodide	17
Biotin	0.5	Cobalt(ous) chloride	105
Folic acid	1.5	* See Table 4.	
C	100		
Nicotinic acid	75		
K ₃	4		
E-acetate	40		
B ₁₂	0.01		

Table 4. U. S. P. XII Salt Mixture No. 2

Sodium chloride	43.5 gm
Magnesium sulfate	137.0
Sodium biphosphate	87.2
Potassium phosphate	239.8
Calcium biphosphate	135.8
Ferric citrate	29.7
Calcium lactate	327.0

Results and Discussion

Results of the feeding experiments for four weeks are shown in **Table 5**. All the experimental fish showed a good appetite. The amino acid test diet proved to be re-

Table 5. Weight and Growth Rates

Diet	Average Body Weight (gm)		Gain (gm)	Increment (%)	Rate of Growth
	at start	at end			
Casein	5.02±0.90	6.65±1.09	1.63±0.19	32.85±2.11	100
Amino acid	4.63±0.84	4.75±0.93	0.12±0.09	1.92±1.92	6.26± 6.23
Amino acid + Cellulose powder	4.77±0.87	4.96±0.89	0.19±0.02	4.04±0.32	12.29± 0.19
Amino acid + Scenedesmus	4.86±0.68	5.16±0.72	0.30±0.04	6.18±0.44	18.89± 1.09
Casein+NaH ₂ PO ₄	5.04±0.84	6.92±1.01	1.88±0.17	37.79±2.93	114.94± 1.54
Amino acid+Na ₃ HPO ₄	4.85±0.75	5.29±0.98	0.44±0.23	8.54±3.42	26.78±12.13
Amino acid+Na ₃ HPO ₄	4.62±0.64	4.82±0.77	0.20±0.13	4.02±2.26	12.74± 7.70
Amino acid+KH ₂ PO ₄	4.21±0.55	4.42±0.66	0.21±0.11	4.73±2.00	14.85± 7.04
Amino acid+K ₂ HPO ₄	4.52±0.59	4.76±0.70	0.24±0.11	5.08±1.77	15.88± 6.41

Table 6. Comparison: Intestinal Retention Period and Growth Rate

Test diets	Average Retention Time (minutes)	Rate of Growth
Casein	265±10	100
Casein+NaH ₂ PO ₄	295	114.94± 1.54
Amino acid	105	6.26± 6.23
Amino acid+Cellulose powder	170	12.29± 0.19
Amino acid+Scenedesmus	120	18.89± 1.09
Amino acid+NaH ₂ PO ₄	160	26.78±12.13
Amino acid+Na ₃ HPO ₄	145	12.74± 7.70
Amino acid+KH ₂ PO ₄	140	14.85± 7.04
Amino acid+K ₂ HPO ₄	130	15.88± 6.41

markedly inferior to casein in maintaining the growth of the carp. Using the amino acid test diet, the growth rate was $6.26 \pm 0.23\%$ of that of casein. With the addition of NaH₂PO₄ to the diet, the retention time was increased by an hour and a half (**Table 6**). The addition of *Scenedesumus*, to the phosphate salt and cellulose powder diet also increased the retention time in the intestine, and in turn accelerated the growth rate.

The amino acid test diet failed to maintain the growth of young carp, perhaps because of its shorter retention time in the intestine, as was shown by the addition of *Scenedesumus*, cellulose powder or phosphate salts to the diet.

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