

The Effect of Phosphorus Supplementation to 40% Soybean Meal Substituted Diet for Common Carp

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A series of growth experiment on the effect of phosphate addition to a common carp feed containing a large amount of soybean meal were conducted at the Fish Culture Experiment Station of the National Fisheries University of Pusan from November 2, 1984 to February 3, 1985.

Carp feed containing 40% soybean meal performs very poorly but when supplemented with 2% dibasic sodium phosphate the feed gave a very good performance almost similar to one of the best carp feed commercially available.

In this 94 day experiment, phosphate added feed resulted in 1.431 in food coefficient, and 1.619 in daily growth rate for common carp of 73.3g in initial weight, and 1.558 and 1.589% for those of 26.7g, respectively, compared to the performance of the feed without phosphate addition, which resulted in 1.863 in food coefficient and 1.365% in daily growth rate for the large ones, and 1.820 and 1.438% for the small ones, respectively, thus indicating that carp feeds containing a large amount of soybean meal could effectively be used if a proper amount of phosphorus is supplemented.

Introduction

A possibility to use a substantial amount of soybean meal in the diet of common carp has been suggested by Kim et al. (1984), Abel et al. (1984) and some others. However, the performances both in fish growth rate and feed efficiency have shown a gradual decrease with increased content of soybean meal in the diets. It was pointed out that the amount of available phosphorus decreased to a significant extent with increase of soybean meal substituted for fish meal (Kim et al., 1984), and the low performance in the growth of fish, including channel catfish, appeared to be caused because about two thirds of phosphorus in such ingredients

as soybean is phytate phosphorus, which is poorly available to fish (Lovell, 1979, 1982).

According to studies conducted to date, the amount of phosphorus required for the normal growth and building of skeleton has been shown to range 0.27% to 0.8% of feed consumed by the fish (Nose and Arai, 1978; Andrews et al., 1973; Ketola, 1975; McCartney, 1969), and especially in common carp feed, from the results of experiments with purified diets, it has been known that the optimum growth can be obtained when the amount of available phosphorus ranges 0.6% to 0.7% in the diets (Ogino and Takeda, 1976).

Phosphorus is one of the essential nutrients for the growth of fish, and is supplied mostly from

the food they consume (Phillips et al., 1953), though it may partly be available from the environmental water medium. The phosphorus dissolved in the water medium is so small in amount (normally 0.005 to 0.05 ppm) that fish can hardly uptake it from the water (Nose and Arai, 1979), therefore the fish must obtain majority of their requirements from their diets.

Though a sufficient amount of phosphorus is normally available when a large amount of animal protein is used, the feeds containing a large amount of plant matter, such as soybean meal, etc. have been thought to give rise to reduced performance because of phosphorus deficiency (Kim et al., 1984).

In this experiment the efficiency of phosphorus supplementation to carp feed which contains a large amount of soybean meal was tested.

Materials and Methods

First, in September and October 1984, a series of growing experiments were undertaken to examine the effect of phosphorus supplementation to 20 % soybean diets, but the results of experiments were unexpectedly poor showing good growth of all lots of animals. In that experiment all experi-

mental aquariums were supplied with water from a common filtering chamber which has probably resulted in the mixing of dissolved phosphorus which was added to some of experimental diets.

Next, 3 240 l aquariums and another 3 160 l aquariums all with a built-in filtering chamber each, were stocked with 15 73.3 g carp and 15 26.7 g carp respectively. The fish were conditioned for 22 days before the start of experiment in the same aquariums, and the experiment was implemented for 94 days from November 2, 1984 to February 3, 1985.

During the experiment, the weight of the animal was checked at 14 to 20 day intervals to ascertain if the proper performance of the experiment was taking place.

The feed used for the experiment are shown in Table 1. A commercial feed (CF) used as control was assumed one of the best feeds available locally and the experimental feed (SBP) was 40% soybean-substituted carp feed containing 2% dibasic sodium phosphate ($\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$), and the same without phosphate supplementation (SB) was also used as another control.

The feeding amount was almost ad libitum. During the early period of the experiment, the groups of large fish (initially 73.3 g average) consumed 5.4% body weight daily, and the small ones (26.7 g av-

Table 1. Ingredients of the feeds used for the experiment

Ingredient	Commercial feed	40% Soybean meal substituted feed	
		Phosphate added	Phosphate not added
Notation	CF	SBP	SB
Soybean meal(solvent extracted 44% protein)	6	40	40
Fish meal	40	22.4 (white)	22.4 (white)
Flour	26	33.6	33.6
Middlings	23	—	—
Yeast	0.5	1	1
Vitamine mix.*	0.975	1	1
Inorganic salt mix.*	1	1	1
Table salt	0.9	1	1
$\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$	0.4 ^a (1)	0.8 ^a (2)	
Others	1.625		
Total	100.4	100.8	100.0
Protein content (estimated)	34.9	34.7	35.0

* Vitamin and inorganic salt mixtures were those commercially available for livestock use.

a) Non-hydrated calculation of phosphate. Numbers in parentheses indicate hydrated amounts actually added.

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erage) 6.4%. As the weight of the fish increased the feeding rate also gradually decreased to 1.2% for large groups, and 1.7% for small ones, respectively. Automatic feeding devices were employed to evenly dispense the feed, from 8:00 to 18:30 hours, divided into 20 to 22 times.

Through the experiment total ammonia ranged 1.7 to 14.2 ppm, pH 7.2 and temperature 21 to 26°C (mean 24°C).

Results and Discussion

The results of the study obtained from November 2, 1984 to February 3, 1985 are shown in Table 2. The food coefficient and daily growth rates for those fed commercial feed were 1.340 and 1.696% for large group (CF-1), 1.368 and 1.708% for small fish group (CF-2), respectively; and for those fed phosphate added 40% soybean-substituted feed 1.431 and 1.619% for large fish group (SBP-1) and 1.558 and 1.589% for small fish group (SBP-2), thus showing only slight

differences in performance between the best commercial feed and phosphate added test feed. On the other hand the 40% soybean substituted test feed without phosphate addition gave a very poor performance, food coefficient and daily growth rate being 1.863 and 1.365% for large fish group (SB-1) and 1.820 and 1.438% for small fish group (SB-2), respectively.

The amount of available phosphorus contained in the experimental feeds are as shown in Table 3, which indicates that the total available phosphorus in the 40% soybean substituted feed without phosphate addition is only 0.446% compared to 0.584% in the phosphate added test feed with the same ingredients as the former except added phosphate. The amount of available phosphorus, 0.584% in the test feed appears to be very near the commonly known optimum amount for common carp, 0.6 to 0.7% of the feed, and further investigations on the proper amount of phosphate to be added to the feed containing a large amount of soybean meal are required. Anyhow, according to this ex-

Table 2. Results of the rearing experiment from November 2, 1984 to February 3, 1985 (for 94 days)¹⁾

Division ²⁾	Initial			Final		
	No.	Weight (g)		No.	Weight (g)	
		Total	Mean		Total	Mean
CF —1	15	1,100	73.3	15	5,345	356.3
SB —1	15	1,100	73.3	15	3,935	262.3
SBP—1	15	1,100	73.3	15	4,980	332.0
CF —2	15	400	26.7	15	1,965	131.0
SB —2	15	400	26.7	15	1,531	102.1
SBP—2	15	400	26.7	15	1,760	117.3

Division ²⁾	Feed used (g)	Body increment (g)	Feed co-efficient	Growth rate	
				Total (times initial wt.)	Daily (%)
CF —1	5,687.6	4,245	1.340	4.859	1.696
SB —1	5,282.2	2,835	1.863	3.577	1.365
SBP—1	5,554.1	3,880	1.431	4.527	1.619
CF —2	2,141.2	1,565	1.368	4.913	1.708
SB —2	2,058.1	1,131	1.820	3.828	1.438
SBP—2	2,118.5	1,360	1.558	4.400	1.589

1) During the experiment water temperatures were maintained 21 to 26°C (mean 24°C).

2) CF—1, CF—2: Commercial feed.

SB—1, SB—2: 40% soybean meal substituted feed.

SBP—1, SBP—2: Phosphate added 40% soybean substituted feed.

Numericals 1 and 2 denote the test groups with large fish and small fish, respectively.

Table 3. Available phosphorus in the experimental diets

Feed	Source of phosphorus						Total
	Fish meal	Soybean meal	Flour	Middlings	Yeast	Na ₂ HPO ₄ ·12H ₂ O	
Commerical feed (control)	0.600	0.012	0.007	0.062	0.008	0.069	0.758
Test feed (40% soybean substituted feed, phosphorus supplemented)	0.336	0.083	0.010		0.017	0.138	0.584
Test feed (40% soybean substituted feed, no phosphorus supplemented)	0.336	0.083	0.010		0.017		0.446

* The basis of caculation:

Fish meal—Phosphorus content 3%, availability to fish 50%.

Soybean meal—Phosphorus content 0.63%, availability to fish 33%.

Flour (white)—Phosphorus content 0.09%, availability to fish 33%.

Middlings—Phosphorus content 0.83%, availability to fish 33%.

Na₂HPO₄·12H₂O—Phosphorus content 8.66%, availability to fish 80%.

Yeast—Phosphorus content 1.72%, availability to fish 99%.

periment, carp feed containing a large amount of soybean meal could be converted to a highly efficient diet for the growth of common carp if a proper amount of phosphorus is supplemented.

Concerning the amino acid balance of the 40% soybean-substituted carp feed, all essential amino acids are in excess of the requirement except methionin, which could also be in excess if combined with cystine, the same phosphorus containing amino acid (Kim et al., 1984). Kim et al (1984) were concerned if the increased use of soybean meal, which in turn results in the fall of methionin, could bring about a poor performance in the carp growth, but it may not be true since phosphorus addition only could negate the poor performance caused by the increased soybean use.

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40% 大豆粕粉 代替 잉어 飼料에 대한 磷의 添加效果

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1984年 11月 2일부터 1985年 2月 3일까지 釜山水產大學 魚類養殖 研究室에서 平均 73.3 g 및 26.7 g되는 이스라엘잉어 각각 15尾(總重量 1,100 g 및 400 g)씩을 收容하고, 우리 나라에서 質이 우수하다고 認定되고 있는 商品飼料과 40% 大豆粕粉 代替飼料을 對照區 飼料로 하고, 인산일수소나트륨($\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$)을 2% 添加하여 만든 磷添加 40% 大豆粕粉 代替飼料을 實驗飼料區로 하여 飼料効率 試驗을 하였다.

商品飼料에서는 큰 個體群과 작은 個體群에서 각각 飼料係數 1.340, 1.368, 1日 成長率 1.696%, 1.708%로 나타났고, 磷添加 40% 大豆粕粉 代替飼料에서는 飼料係數 1.431, 1.558, 1日 成長率 1.619%, 1.589%로 成長率이 商品飼料에 비해 약간 떨어지기는 했지만 거의 비슷한 結果를 나타내었다. 그런데 40% 大豆粕粉 代替飼料은 飼料係數 1.863, 1.820, 1日 成長率 1.365%, 1.438%로 成長率이 크게 뒤떨어진 結果를 나타내었다.

그러므로 이상의 實驗結果에 의하면 40% 大豆粕粉 代替飼料은 잉어의 飼料로서는 적절하지 못했지만, 이에 適當量의 磷을 添加하게 되면 우수한 飼料로 될 수 있다는 것을 밝혀주고 있다.