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On the Efficiency of Soybean Meal as a Protein Source Substitute in Fish Feed for Common Carp

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An experiment on the efficiency of soybean meal substituted for fish meal in the diet of common carp was carried out at the Fish Culture Experiment Station of the National Fisheries University of Pusan from June 27 to August 25, 1983. The carp used for the experiment were 50 fish each lot, each averaging 26 *g* in initial weight (total weight 1300 *g*). The experimental diets contained 10%, 20%, 30%, and 40% soybean meal (44%-protein) at iso-protein content basis in place of white fish meal in the control diet which contained 35% protein.

The growth rate in the control division was highest with progressive decrease in performance of the fish with increasing rates of soybean meal substituted in the test diets. Nevertheless, the 10% and 20% soybean meal test diet groups showed acceptable conversions and growth rates, i.e. feed coefficients being 1.28 and 1.30 and daily growth rates, 1.708% and 1.694% compared to 1.22% and 1.758% for the control group, respectively.

Therefore, soybean meal could be substituted for fish meal in carp diet by 20% without significant differences of performance with some saving in feed cost.

Introduction

For the normal growth of fish, proper amounts of proteins, carbohydrates, fats, vitamins and minerals must be contained in the diet the fish consumes. Among a variety of ingredients in the diet, protein occupies more than 60% of the total cost of the feed ingredients (Andrews, 1977). Especially in Korea where the extensive method of fish culture, which is widely used in many countries as in the United States and south-eastern Asian countries, is hardly applicable because of highly limited land area available to fish culture, fish under rearing should be stocked highly intensively and must be fed completely balanced prepared diets.

White fish meal brought from northern Pacific Ocean has been the main feedstuff used in fish feed as the protein source in Korea. White fish meal is quite expensive and its regular availability is uncertain, leading to frequent price increase. Therefore some cheap high protein feedstuff should be sought to substitute costly fish meal and it seems to be rather urgent task in near future because the demand for this feedstuff should grow rather rapidly as food fish culture in Korea started in the late 1970's has been rather rapidly developing and this rapid develop-

ment seems likely to continue for sometime to come.

The present study carried out an experiment on the use of soybean meal, which has been playing an important role as a protein source in fish feed as well as livestock feed in the United State and elsewhereas a protein source substitute in carp feed.

Soybean meal is an excellent protein source containing about 44-50% protein, 40% carbohydrate, 1% fats and 5 to 6% ash.

The previous researches on the use of soybean meal for channel catfish and rainbow trout have shown acceptable results (Smith 1977, Lovell 1980, 1982, Reinitz et. al. 1978, Brandt 1979). When plant protein in fish feed is substituted for animal protein, methionine, lysine and a few other amino acids are first problem falling short for the requirement of the animals. In case of channel catfish as the requirement of methionine and lysine is rather small, soybean can be used without supplementation of these amino acids, but in case of eels, soybean can not be directly substituted for fish meal because the requirement for these amino acids as well as threonine is very high compared to the availability of these amino acid in soybean.

Thus, as there exists species-specific requirement for amino acid, use of soybean has to be determined by each species, and common carp which is a major culture species in Korea was selected as the experimental animal for the present study.

Materials and Methods

The initial design of the experiment was to use 10 indoor glass aquariums equipped with water recirculating filters, consisting of 5 duplicated experimental divisions. Because of continued outbreaks of gill flukes and columnaris disease which could not be controlled with chemicals such as DDVP, formalin, $KMnO_4$ and nitrofurans, the experiment was carried out at single lots in 5 outdoor concrete tanks measuring about 7 m^2 each, with about 60 cm in water depth.

The feed used for the experiment, as shown in Table 1, contained 35% protein as the basal content in the control diet containing white fish meal as the main source of protein. In the experimental diets, defatted soybean meal (44% protein) was substituted for fish meal at 10, 20, 30 and 40%. For each soybean meal added to the diets, fish meal was subtracted on a isoprotein content basis. The current prices of the diet materials per kilogram were 479 won, 455.4 won, 431.8 won, 408.2 won and 384.6 won for control, 10%, 20%, 30% and 40% soybean substituted diets respectively.

The fish were fed daily about 2.2% of body weight of the animals, evenly divided into 15 times by automatic feeder. The amount of feed

Table 1. Feeds used for the experiment

Ingredient	S-0	S-10	S-20	S-30	S-40
Soybean meal	0	10.0	20.0	30.0	40.0
Fish meal (white)	49.6	42.8	36.0	29.2	22.4
Wheat flour	46.4	43.2	40.0	36.8	33.6
Yeast	1.0	1.0	1.0	1.0	1.0
Vitamin mix.	1.0	1.0	1.0	1.0	1.0
Mineral	1.0	1.0	1.0	1.0	1.0
Salt	1.0	1.0	1.0	1.0	1.0
Total	100.0	100.0	100.0	100.0	100.0
Protein content	35	35	35	35	35
Price/*kg* (won)	479	455.4	431.8	408.2	384.6

* Vitamin mix. and minerals were those commercially available for livestock use.

Table 2. Results of rearing experiment of carp on soybean meal substituted diets

Rearing period	Temp. (Mean)	Division	Stocking No.	Stocking Weight (g)	Stocking Mean (g)	Yield No.	Yield Weight (g)	Yield Mean (g)
June 27-Aug. 25, 1983 (60 days)	21.0-35.5(23.5)	S-0*	50	1300	26.0	50	3700	74.0
		S-10	50	1300	26.0	50	3592	71.8
		S-20	50	1300	26.0	49	3539	72.2
		S-30	50	1300	26.0	50	3363	67.3
		S-40	50	1300	26.0	50	3312	66.2

Division	Mortality (g)	Feed given (g)	Gain (g)	F.C.	Growth rate Total (time)	Growth rate Daily (%)
S-0*		2943	2400	1.22	2.846	1.758
S-10		2939.8	2292	1.28	2.763	1.708
S-20	1(22.0)	2943	2239	1.30	2.739	1.694
S-30		2939.8	2063	1.42	2.587	1.597
S-40		2943	2012	1.46	2.548	1.571

* S-0 to S-40 denote the content of soybean meal 0% to 40%, respectively.

was adjusted with the growth of fish and the feeding condition observed during the feeding practice.

During the experiment, total ammonia ranged from 0.12 to 1.3 ppm, pH 7.2 to 7.3 ppm, and nitrates 0.07 to 0.73 ppm. Water temperature fluctuated between 21.0 and 35.5 C the mean temperature being 28.5 C.

For the experiment, Israeli strain of common carp was stocked with 50 fish, 26 *g* in average weight, in each tank and total weight in each experimental tank was adjusted at 1300 *g*. The feeding experiment was started on June 27, 1983, and continued until August 25th, total experimental period being 60 days, and the fish were weighed every 15 days.

Based on the results of the growth experiment, the growth rate and feed conversion were calculated, and then, economic consideration for the use of soybean meal in the carp diet is given.

Results and Discussion

The growth of the fish during the experimental period is shown in Table 2, showing gain of the fish, feed coefficient, and total and daily growth rates. The growth in the control division was highest, total weight of the fish at the end of the experiment being 3700 *g*, average individual weight 74 *g*, with feed coefficient 1.22 and the daily growth rate, 1.758%, with progressive decrease in performance of the fish with increasing rates of soybean meal in the test diets. Nevertheless, the 10% and 20% soybean meal test diet groups showed acceptable growth rates with slightly decreasing performance, feed coefficients being 1.28 and 1.30 and daily growth rates, 1.708% and 1.694% respectively. Soybean meal 30% and 40% groups showed 1.42 and 1.46 in feed coefficient and 1.597% and 1.571% in daily growth rate, respectively.

The economic analysis on the use of soybean substituted for fish meal was made on the basis of feed coefficients and material prices of each test diet (Table 3). For the production of 1 *kg* fish, feed cost was 584 won for control, while 582 won for 10% soybean meal group and 561 won for 20% soybean meal group, this representing the least-cost production of all the groups tested. The feed cost remained almost constant or a little higher for the groups 30% and 40% soybean diet groups.

As for the growth rate of the fish, it is calculated that it needs 136 days and 137 days in cases of 10% and 20% soybean diet groups, respectively compared to 132 days in case of control group, to increase the body weight by

Table 3. Economic evaluation of the test diets containing soybean meal for rearing common carp

Division	Feed coefficient	Unit price of diet per *kg* (won)	Feed cost for 1 *kg* gain (won)	Days to increase 10 times initial body weight
S-0	1.22	479.0	584	132
S-10	1.28	455.4	583	136
S-20	1.30	431.8	561	137
S-30	1.42	408.2	579	145
S-40	1.46	384.6	561	147

Table 4. Contents of amino acids in the test feeds and amino acid requirement by common carp (%)

	Test feed used					Common carp requirement*
	S-0	S-10	S-20	S-30	S-40	
Arginine	2.14	2.12	2.11	2.09	2.07	1.47
Histidine	0.89	0.89	0.90	0.89	0.89	0.74
Isoleucine	2.09	2.10	2.14	2.13	2.15	0.81
Leucine	2.98	2.96	2.98	2.93	2.92	1.19
Lysine	3.34	3.16	2.99	2.82	2.64	1.99
Methionine+Cystine	1.35	1.30	1.24	1.20	1.14	1.08
Methionine	0.95	0.89	0.83	0.78	0.72	—
Cystine	0.40	0.41	0.41	0.42	0.42	—
Phenylalanine+Tyrosine	2.58	2.61	2.63	2.66	2.69	2.28
Threonine	1.55	1.52	1.49	1.46	1.43	1.37
Tryptophan	0.39	0.41	0.42	0.43	0.44	0.28
Valine	1.99	1.96	1.92	1.89	1.86	1.26

* Lovell (1982)

10 times thus requiring only 4 and 5 days delay for the experimental diets. On the other hand it needs 145 days and 147 days for 30% and 40% soybean meal diets, these being appreciable delay of 10% or more, e.g. 13 and 15 days, respectively. Anyhow, the delay of the growth rate of carp due to the limited substitution of soybean meal for fish meal was relatively low. Therefore, 20% soybean meal substitution for fish meal in the carp diet seems to be most acceptable for the practical diet.

Ten times rearing is normal procedure in carp farming to produce marketable fish, about 1*kg* each from fish seeds of 100*g* or less. The reason during this experiment that the growth rates of the fish were relatively low is due to limited feeding rates owing to difficulty to manage water quality in the test tanks.

The contents of available amino acids in the experimental diets is shown in Table 4. This table was prepared from Morrison (1959) and common carp requirement in the table was converted from Lovell (1982). As shown in the table only two amino acids, lysin and methionine, show appreciable decrease with increased soybean meal in the diet.

Though lysin is decreasing (from 3.34% to 2.64%), it is still far excess of requirement by carp (1.99%) even in the S-40 test diet, which contains 40% soybean meal in the ration. On the other hand, the amount of methionine plus cystine in the S-40 diet (1.14%) is approaching to the minimum requirement by common carp (1.08%), owing to significant decrease of methionine alone, leaving the amount of cystine constant or rather slightly inereasing (0.40% to 0.42%). The amounts of methionine are decreasing from 0.95% to 0.89%, 0.83%, 0.78%

and 0.72% in control, 10%, 20% 30% and 40% soybean meal diet, respectively.

Therefore, the progressive decrease in performance of soybean meal substituted diets might have resulted from methionine deficiency in the test diet. In this respect, an experiment to supplement methionine in the test diets containing increased soybean meal is recommended. The addition of either intact or free methionine may be used as a source of this amino acid.

Though free amino acids, lysine and methionine, are not adequately utilized by catfish (Andrews, 1977), Spinelli (1980) described that common carp can effectively utilize them.

Progressive lower performance of diets containing increased amounts of soybean meal might also be attributable to the less availability of phosphorus in the test diets. Concerning phosphorus in the diet containing soybean meal, its amount is not only significantly lower than control (Table 5), but also two thirds of phosphorus is in the state of phytate phosphorus which is not adequately available to fish (Lovell, 1982) including catfish (Lovell, 1977).

Further test to determine the effectiveness of phosphorus supplemented to the carp diet containing increased soybean meal seems to be required.

Table 5. Available phosphorus calculated in the test diets (%)

Feed	Source			Total
	Fish meal	Soybean meal	Flour	
S-0	0.744	0	0.01392	0.75792
S-10	0.642	0.021	0.01296	0.67596
S-20	0.540	0.042	0.01200	0.59400
S-30	0.438	0.063	0.01104	0.51204
S-40	0.336	0.084	0.01008	0.43008

The basis of calculation :

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%

Conclusion

Soybean meal could be substituted for fish meal by 20% without significant differences of performance in growth rate and feed coefficient, with about 4% saving in the feed cost at the current price. Futuremore, availability of soybean meal also seems to be much brighter than that of white fish meal, which is gradually decreasing in yield and increasing in demand accompanied with unfavourable price fluctuations.

For the improvement in efficiency at higher rates of soybean meal substitution for fish meal, further researches by supplementing those factors as phosphorus and/or methionine that appear to be short for the requirement of common carp seem to be necessary.

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잉어 飼料 蛋白質 代替源으로서의 大豆粕粉의 效率

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1983年 6月 27日부터 8月 25日까지 釜山水產大學 養魚場에서 平均 26g되는 이스라엘잉어 50尾(總 重量 1300g)씩을 收容하고, 蛋白質含量 35%를 基準으로 하여 蛋白質源으로 魚粉만을 使用한 飼料를 對照區로 하고 大豆粕粉을 10%, 20%, 30%, 40%씩 混合하여 만든 試驗飼料를 使用하여 飼料效率試驗을 하였다.

對照區에서는 平均 74g, 總 3700g으로 자라서 飼料係數 1.22, 1日成長率 1.758%로 가장 成長에 좋았으며, 大豆粕粉의 含量이 10%, 20%, 30% 및 40%區에서의 飼料係數는 1.28, 1.30, 1.42, 1.46, 1日成長率은 1.708%, 1.694%, 1.597%, 1.571%로 각각 나타나서, 魚粉의 代替蛋白質源으로서 大豆粕粉을 使用했을 때 各 實驗區의 魚類 1kg을 生產하는데 소요되는 飼料費用은 각각 583원, 561원, 579원, 561원으로 對照區의 584원과 거의 동일하거나 약간 낮게 나타났다. 魚體重을 10倍로 增重시키는데 必要한 期間은 136日, 137日, 145日, 147日로써 對照區의 132日과 비교했을 때 大豆粕粉 添加에 의한 成長率 지연 문제는 그다지 심각하지 않음을 알 수 있었다.

그러므로, 이번의 實驗結果에서 成長速度에는 큰 差異가 없어 魚粉의 代替用으로 大豆粕粉을 20% 代替하는 것이 가장 經濟的인 結果로 나타났다.