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COMPLEMENTARY EFFECTS OF FISH MEAL WITH SOYABEAN MEAL REPLACERS IN BROILER DIETS

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SUMMARY AND CONCLUSIONS

Protein rich vegetable feeds used as soyabean meal replacers generally contain less metabolisable energy and protein than soyabean meal, and their amino acid content is less well suited to meet the bird's requirements for essential amino acids. However, it has been reported that soyabean meal replacers such as rapeseed meal, sunflower meal and maize gluten meal can be used to partially replace soyabean meal with little, if any, reduction in growth if fish meal is present in the diet.

In the present trials, inclusion of low glucosinolate rapeseed meal of European origin in low energy unpelleted diets reduced feed intake and growth rate of chicks to three weeks of age. In contrast, inclusion of the same rapeseed meal in high energy diets increased intake and growth rates. Inclusion of 5% fish meal further improved performance both under isoenergetic conditions but particularly when inclusion also resulted in an increased energy density of the diets.

It is recommended that in replacing soyabean meal with soyabean meal replacers in broiler diets, the following dietary changes should be made:-

1. Part, but not all, of the soyabean meal should be replaced; it can be beneficial to combine proteins.

2. The diet should include 5% fish meal to improve amino acid supply.

3. The replacement should be done in high energy diets taking care to maintain energy concentration, or even increase it, although the soyabean meal replacers will generally increase dietary fibre content.

Making the above changes, it should be possible to introduce soyabean replacers into the diet, which will generally reduce diet cost, yet maintain broiler performance.

CONTENTS

SOYABEAN MEAL REPLACERS

Soyabean meal replacers denote certain vegetable, protein-rich feeds other than soyabean meal. The term is an anachronism since these feedstuffs in many parts of the world have been used as the main protein supplements in diets for man and animals from time immemorial. Soyabean meal replacers is a relatively new term that came into use when, from economical and agropolitical reasons, it became desirable to replace part of the soyabean meal, which most countries import, by other vegetable protein sources produced locally.

NUTRIENT CONTENT OF SOYABEAN MEAL REPLACERS

The most common soyabean meal replacers used in poultry diets are rapeseed meal, sunflowerseed meal, maize gluten meal, maize gluten feed, groundnut meal and sesame meal. Within each source there are different types depending on plant breed and method of manufacturing. Thus, there is the old type of rapeseed meal high in glucosinolates and erucic acid, and the new cultivars with reduced content of these compounds, so called 'double zero', some of which also have less fibre.

Sunflower seed meal is used for poultry mainly dehulled (12% crude fibre); with hulls it contains 32% crude fibre. Groundnut meal may be produced by mechanical extraction of fat (7% fat content) or by solvent extraction (1% fat content).

Table 1 shows the content of metabolisable energy, protein and amino acids in some soyabean meal replacers in comparison with that of soyabean meal and South American fish meal.

Except for maize gluten meal, which is higher, the soyabean meal replacers have a lower content of metabolisable energy than soyabean meal, and some of them also have a somewhat lower protein content, though rapeseed meal is similar to soyabean meal in this respect. The proteins in the soyabean meal replacers other than rapeseed are lower in lysine and in certain other amino acids than is that of soyabean meal. When soyabean meal replacers are combined with fish meal they should equal or exceed soyabean meal in these respects. The effect of so doing on the nutritional value has been studied, and the work reported is reviewed below.

TABLE 1

Nutrient Composition of some Soyabean Meal Replacers in Comparison with that of Soyabean Meal and South American Fish Meal[1]

(From UK Tables of Nutritive Value and Chemical Composition of Feedstuffs, MAFF 1990)

			Soyabean meal replacers											
	Soyabean meal (dehulled)		Groundnut meal (solv.extr.)		Sunflower seed meal[3]		Rapeseed meal (solv.extr.)		Sesame meal (expeller)		Maize-gluten meal		Fish meal Anchovy	
Metabolisable energy, MJ/kg[2]	9.8		10.7		6.8		7.4		10.5		15.2		13.7	
Protein (6.25xN), %	48.5		47.3		34.5		36.1		46.4		60.5		64.6	
Amino acids, g/kg product[4]	T	D	T	D	T	D	T	D	T	D	T	D	T	D
Arginine	37.5	34.5	55.5	51.1	27.9	26.3	19.3	17.6	60.7	46.7	16.4	14.9	35.6	31.0
Glycine	20.1	17.2	30.5	24.8	19.0	14.3	16.3	13.2	22.3	N/A	16.3	12.4	39.0	30.4
Serine	25.4	22.7	24.0	22.3	15.9	13.5	14.1	11.3	20.6	N/A	29.8	26.2	24.2	19.6
Histidine	15.1	13.5	11.1	9.6	8.3	7.2	10.1	8.4	13.9	9.9	15.0	13.7	24.2	19.8
Isoleucine	24.4	21.9	17.6	15.8	15.2	13.7	13.3	11.0	17.5	12.6	25.3	23.0	27.3	23.5
Leucine	38.8	34.6	32.3	29.1	22.4	21.0	22.6	19.7	30.5	22.3	97.6	92.7	41.1	36.6
Lysine	32.0	28.3	16.6	13.4	11.7	9.9	19.7	14.4	10.6	6.2	10.4	8.4	50.7	43.1
Methionine	6.7	6.1	4.6	4.1	7.6	7.2	6.5	5.8	12.2	9.3	15.4	14.6	16.7	15.0
Cystine	6.9	5.6	7.1[3]	5.7	5.9	4.5	10.9	7.6	10.5	8.5	11.8	10.3	6.7	5.3
Phenylanine	25.5	22.9	23.1	21.1	15.5	14.3	13.8	12.0	20.7	15.3	37.7	35.0	25.0	22.0
Tyrosine	17.6	16.0	17.6	16.4	9.0	8.2	10.4	8.5	15.4	N/A	32.0	29.8	20.3	17.5
Threonine	19.6	17.1	12.9	10.9	12.4	10.3	14.8	11.1	16.2	9.7	21.1	17.3	27.8	23.6
Tryptophan	6.3[3]	N/A[5]	5.4[3]	N/A	4.8	N/A	4.3[3]	N/A	6.0[3]	N/A	3.8[3]	N/A	7.9[3]	N/A
Valine	26.0	22.6	20.3	18.1	17.2	14.6	16.8	13.1	21.4	15.6	28.9	25.4	33.2	27.0

[1] On 'as received' basis

[2] From 'European Table of Energy Values for Poultry Feedstuffs', European Federation of Branches of the World's Poultry Science Association, 3rd Edt. 1989.

[3] From 'Feeding Values for Poultry' 1979, Spelderholt Institute, Beekbergen, The Netherlands.

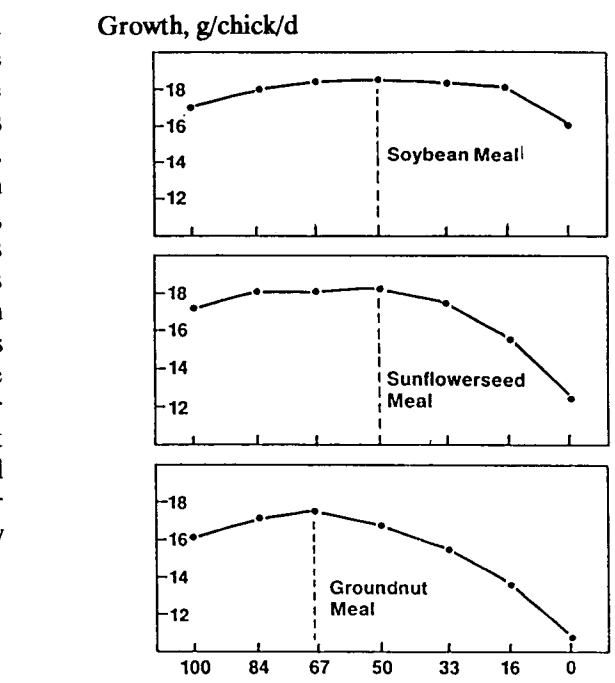
[4] T- total, D - digestible - calculated from total using true digestibility figures from "Nutrition Guide - Feed Formulation with Digestible Amino Acids" 1989 Rhone-Poulenc 92165 Anthony Cedex, France.

[5] N/A - Not available.

SUBSTITUTION OF SOYABEAN MEAL WITH SOYABEAN MEAL REPLACERS WITH AND WITHOUT FISH MEAL - EFFECT ON FEEDING VALUE TO BROILERS

The complementary effects of different proteins to meet the protein requirement of animals have long been realized, and were clearly demonstrated by *Woodham and Dean (1977)* for fish meal and different vegetable proteins (Figure 1). The authors combined different animal and vegetable proteins. In most cases mixtures of two proteins gave better growth in broilers than either alone. This was most marked where a good protein, such as fish meal, was combined with a poorer protein, such as sunflower meal - maximum growth was achieved with equal parts of fish meal protein plus sunflower seed meal protein and fish meal protein plus soyabean meal protein. However, growth was drastically retarded when less than two thirds of the protein came from fish meal and the remainder from groundnut meal. It was concluded that combining good quality protein such as fish meal with a poor quality protein such as groundnut or meat and bone meal was advantageous, especially if the latter was the major constituent.

FIGURE 1
Complementary Effects of Fish Meal with Soybean Meal, Sunflowerseed Meal and Groundnut Meal when Fed as Supplementary Protein (12%) to cereal (barley and wheat) protein (6%) in chicken diets.
(Woodham & Dean, 1977)



Singh and Prasad (1979) conducted extensive studies on the proximate composition and amino acid profiles of different varieties of sunflowerseed grown in India. Sunflowerseed meal and groundnut meal, alone or combined in equal portions, were used with different levels of fish meal as protein sources in maize based diets for broiler chickens. The results are shown in Figures 2 and 3.

FIGURE 2

Effects of level of Fish Meal (FM) addition to broiler diets based on Groundnut Meal + Sunflowerseed Meal (SFM) and SFM alone
(Sing and Prasad, 1979)

Body weight, g

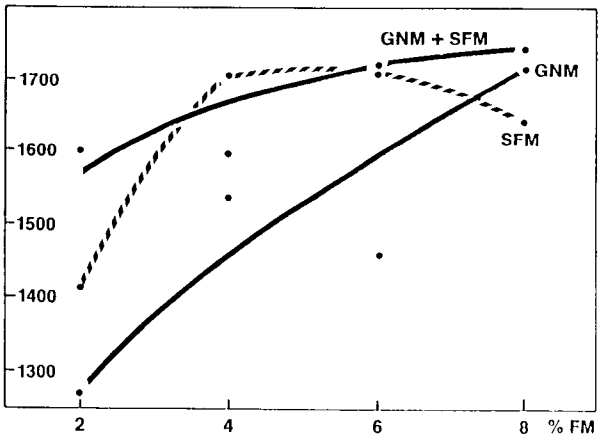
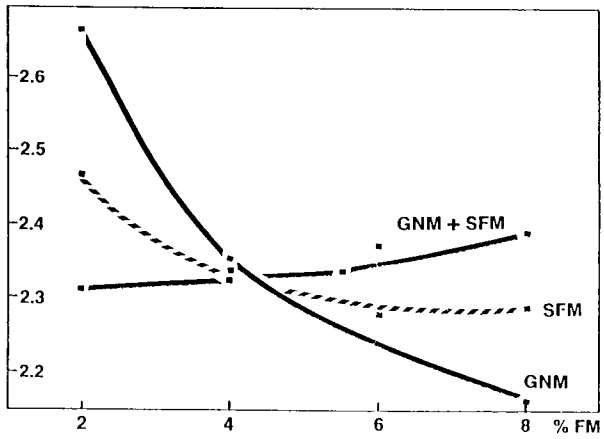


FIGURE 3

Effects of level of Fish Meal (FM) addition to broiler diets based on Groundnut Meal (GNM) alone, Groundnut Meal + Sunflowerseed Meal (SFM) and SFM alone
(Sing and Prasad, 1979)

Feed conversion

g feed/g body weight gain



The authors concluded that only 4% of fish meal in diets with sunflowerseed meal was needed to achieve maximum growth and feed efficiency, while similar results with groundnut meal diets demanded 8% fish meal. It is of interest that their equal mixture of sunflowerseed meal and groundnut meal gave almost the same results as did sunflowerseed meal alone.

The question whether the combination of different sources of plant proteins or the addition of lysine and methionine can reduce the demand for fish meal in chicken diets was addressed in Indian experiments by *Rao et al (1983)*. In experiment 1 (Table 2) groundnut meal or a combination of 75% groundnut meal + 25% sesame meal, 75% groundnut meal + 25% maize gluten meal or 50% groundnut meal + 25% sesame meal + 25% maize gluten meal replaced all the fish meal (10%) in the control diets.

The exclusion of the fish meal caused a marked reduction in growth and feed conversion. When lysine and methionine were added to all diets to meet the requirement for these amino acids (experiment 2 - see Table 3), exclusion of the fish meal caused no dramatic effects on the performance. However, when the level of protein in the diet was increased to the optimum 24% in experiment 3, maximum growth and feed conversion could not be maintained without fish meal addition (Table 4). Assuming the fish meal used was produced locally, it may have been sun dried.

TABLE 2

Complementary effects of fish meal and different soyabean meal replacers in broiler diets
(Rao et al. 1983)

Experiment 1 (22% dietary protein[1])			
	Weight gain g	**Feed consumption g**	**Feed conversion[2]**
GNM + FM	379	801	2.11
GNM	255	584	2.28
GNM 75% + SSM 25%	273	668	2.51
GNM 75% + MGM 25%	227	580	2.56
GNM 50% + SSM 25% + MGM 25%	225	569	2.52

[1] GNM: ground nut meal. FM: fish meal. SSM: sesame meal. MGM: maize gluten meal

[2] g feed per g weight gain.

TABLE 3

Complementary effects of fish meal and different soyabean meal replacers in broiler diets
(Rao et al 1983)

Experiment 2 (22% dietary protein[1], addition of lysine and methionine to meet requirements)			
	Weight gain g	**Feed consumption g**	**Feed conversion[2]**
GNM + FM	509	875	1.71
GNM	499	868	1.73
GNM 75% + SSM 25%	533	897	1.68
GNM 75% + MGM 25%	471	802	1.70
GNM 50% + SSM 25% + MGM 25%	516	901	1.74

[1] GNM: ground nut meal. FM: fish meal.SSM: sesame meal. MGM: maize gluten meal.

[2] g feed per g weight gain.

TABLE 4

Complementary effects of fish meal and different soyabean meal replacers in broiler diets
(Rao et al. 1983)

Experiment 3 (24% dietary protein[1], addition of lysine and methionine to meet requirements)			
	Weight gain g	Feed consumption g	Feed conversion[2]
GNM + FM	501	884	1.76
GNM	418	765	1.83
GNM 75% + SSM 25%	450	782	1.73
GNM 75% + MGM 25%	318	610	1.81
GNM 50% + SSM 25% + MGM 25%	394	729	1.84

[1] GNM: ground nut meal. FM: fish meal.SSM: sesame meal. MGM: maize gluten meal.

[2] g feed per g weight gain.

"Tower" and "Candle" are two of the new varieties of rapeseed developed in Canada. Both are low in erucic acid and glucosinolates and the latter also in fibre. *Hulan & Proudfoot (1981)* studied the gradual replacement of soyabean meal with these new varieties of rapeseed meal in broiler diets, when increasing levels of fish meal and added fat were used to balance for energy, protein and amino acids. There was a trend to reduction in body weight gain but an improvement in feed conversion as increasing levels of rapeseed meal replaced soyabean meal. The authors concluded that all the soyabean meal can be replaced by rapeseed meal provided the differences in energy, protein and amino acids are compensated, for which fish meal is an excellent source.

The new Canadian variety of rapeseed meal "Candle", was also tested in turkey starter diets *(Salmon, 1982)*. Graded levels of rapeseed meal and fish meal replaced soyabean meal in a completely randomized factorial design comprising of four levels of rapeseed meal (0, 150, 300 and 450g per kg) and three levels of fish meal (0, 60 and 120g per kg) (see Appendix Table 1). Replacement of 50% of the soyabean meal by rapeseed meal had no negative effect on growth rate but impaired feed conversion. Fish meal at 6% and 12% inclusion improved growth rate and feed conversion, but the growth response resulting from increasing the fish meal level from 6 to 12% was small (see Table 5). There was no interaction between fish meal and level of rapeseed meal. Thus, there was no indication that fish meal was of more value in rapeseed meal-based compared with soyabean meal-based diets.

TABLE 5

Liveweight and feed efficiency of turkeys to 42 days of age
(Salmon, 1982)

Fish Meal (g/kg)	Canola meal (g/kg)				
	0	150	300	450	Mean
	Liveweight (kg)				
0	1.79	1.79	1.76	1.81	1.79
60	1.87	1.80	1.98	1.85	1.88
120	1.87	1.89	1.86	1.94	1.89
Mean	1.84	1.83	1.87	1.87	1.85
	Feed conversion (gain/feed intake)				
0	0.66	0.64	0.63	0.63	0.64
60	0.67	0.65	0.63	0.63	0.64
120	0.66	0.67	0.66	0.63	0.65
Mean	0.66	0.65	0.64	0.63	0.65

The new, low glucosinolate varieties developed in Sweden have been tested by *Elwinger and Saterby (1986)*. Graded levels of rapeseed meal, up to 18%, with and without the addition of fish meal were used to replace part of the soyabean meal in broiler chicken diets. Their results are shown in Table 6. Diets with rapeseed meal gave in general equal or better performance than the control diet without rapeseed meal. The inclusion of fish meal improved feed conversion by about 4%, but had no consistent effect on growth. However, fish meal tended to increase growth when used together with high levels of rapeseed meal. The authors claimed that levels of rapeseed meal should be kept below 12% in order to avoid off-flavours in the meat, especially when the diets also contained fish meal.

A possible negative interaction of rapeseed meal with fish meal on the sensoric quality of the broiler meat was also noted by *Salmon et al. (1984)*.

Realizing that the increased use of soyabean meal replacers might have changed the need for fish meal in poultry diets, the IAFMM undertook a series of experiments at different centres with the aim to study the complementary effects of fish meal with different vegetable protein feeds. A report of the combined studies is in press . The studies used a low glucosinolate low erucic acid (double zero) variety of rapeseed meal from France. A dehulled USA produced soyabean meal was used. The other feed ingredients were of local commercial origin, produced in the localities of the trial sites.

TABLE 6
Effect of fish meal (FM) in combination with rapeseed meal (RSM) to replace soyabean meal (SBM) in broiler diets
(Elwinger and Saterby, 1986)

RSM, %	0	6		12		18	
SBM, %	20.0	15.5	20.0	10.5	20.0	6.5	20.0
FM, %	7.0	7.0	2.0	7.0	-	4.5	-
Body weight, g	1275	1305	1311	1291	1338	1334	1307
- relative	100	102	103	101	105	105	103
Feed conversion kg feed/ kg body weight gain	1.76	1.77	1.73	1.73	1.79	1.72	1.81
- relative	100	101	98	98	102	98	103

PART 1 - PARTIAL REPLACEMENT OF SOYABEAN MEAL WITH SOYABEAN MEAL REPLACERS WITH AND WITHOUT FISH MEAL IN ISOCALORIC DIETS

The first experiments, conducted in Norway[1], (SSF) studied the effect of fish meal addition to diets with soyabean meal as the sole vegetable protein and to diets in which about half of the soyabean meal protein was replaced by rapeseed meal, sunflowerseed meal or maizegluten meal. The diets were isonitrogenous and equated for total methionine plus cystine and lysine. In an attempt to make the diets isocaloric, additional wheat middlings were added to the fish meal diets and fat to the non-fish meal diets.

The results showed none of the diets containing soyabean meal replacers gave growth equal to that found on soyabean meal alone when the diets were without added fish meal. There were non-significant interactions between fish meal addition and source of vegetable protein, but the addition of fish meal increased growth rate on all diets except that containing maize gluten meal. In diets with fish meal the growth was equal on soyabean meal rapeseed meal and sunflower meal. Despite the fact that fish meal addition increased growth rate, there were no effects of fish meal addition on feed conversion.

The finding that fish meal increased growth without improving feed conversion in the Norwegian study was unexpected. It was felt that the reason for the results may have been due to wheat middlings being added to the diets containing fish meal in order to balance the energy content. The extra fibre in these diets from the additional wheat middlings may have depressed energy content more than expected.

Consequently a further experiment was carried out at three centres (SSF, FIRI[2] and Cambridge) using rapeseed meal as the soyabean meal replacer, with the aim to test the effect of different ways of balancing for the energy content in fish meal.

PART 2 - PARTIAL REPLACEMENT OF SOYABEAN MEAL WITH LOW GLUCOSINOLATE RAPESEED MEAL WITH AND WITHOUT FISH MEAL IN ISOCALORIC AND NON-ISOCALORIC DIETS

Diets based on soyabean meal alone or on a combination of soyabean meal and rapeseed meal were produced with or without added fish meal. The various diets were either:

(i) not balanced with regard to energy content, or

(ii) balanced by the addition of fibre (wheat middlings) to the diets with fish meal, or

(iii) with the addition of extra fat to the diets without fish meal.

Diet composition is given in Table 7. The apparent metabolisable energy content of the diets was determined at one centre (Cambridge).

[1] Norwegian Herring Oil and Meal Industry Research Institute (SSF), Bergen.

[2] Fisheries Industry Research Institute (FIRI), Cape Town.

TABLE 7

Diet Composition
Complementary Effects of Fish Meal in Broiler Diets based on Soyabean Meal (SBM) and Rapeseed Meal (RSM)

Diets	1	2	3	4	5	6	7	8
Fish Meal	-	5	-	5	-	5	-	5
Soybean Meal	31	22	31	22	23	14	23	14
Rapeseed Meal	-	-	-	-	15	15	15	15
Wheat middlings	1	1	1	10	1	1	1	10
Fat	6	4	4	4	9	7	7	7
Common ingredients	---------- To 100% ----------							
Metabolisable energy, MJ/kg	12.7	12.7	12.3	12.3	12.7	12.7	12.3	12.3

At each centre inclusion of rapeseed meal increased growth rate (liveweight gain) by an average of 3.7% in high energy diets but decreased it by an average of 3.4% in low energy diets. Inclusion of rapeseed meal had no effect on feed conversion (Figure 4).

Inclusion of fish meal (Figure 5) increased growth rate by an average of 2.9% and improved feed conversion by an average of 3.3%, these effects being similar in the presence and absence of rapeseed meal at both energy levels. The effect of fish meal was significant at the Norwegian and South African centres, but not at the Cambridge centre.

The apparent metabolisable energy contents (AME) of the low and high energy diets, determined at Cambridge, were 14.3 and 15.0 MJ per kg diet dry-matter.

Inclusion of 5% fish meal, replacing soyabean meal on an iso-nitrogenous basis, but with a consequent increase in energy from the low to the high level, improved feed conversion by an average of 6.8% in the presence and 4.6% in the absence of rapeseed meal. The response in the presence of rapeseed meal was significant at all three centres; the response in its absence was similar at all three centres but significant only at the Norwegian centre.

The trials show that in replacing soyabean meal with soyabean meal replacers, the performance of broilers will be improved by including fish meal and doing the replacement in high energy diets. These can be achieved by the use of additional fat to offset the energy lowering effect of the additional fibre from the soyabean meal replacers.

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FIGURE 4

EFFECT OF SUBSTITUTING RAPESEED MEAL FOR SOYABEAN MEAL ON PERFORMANCE OF BROILERS

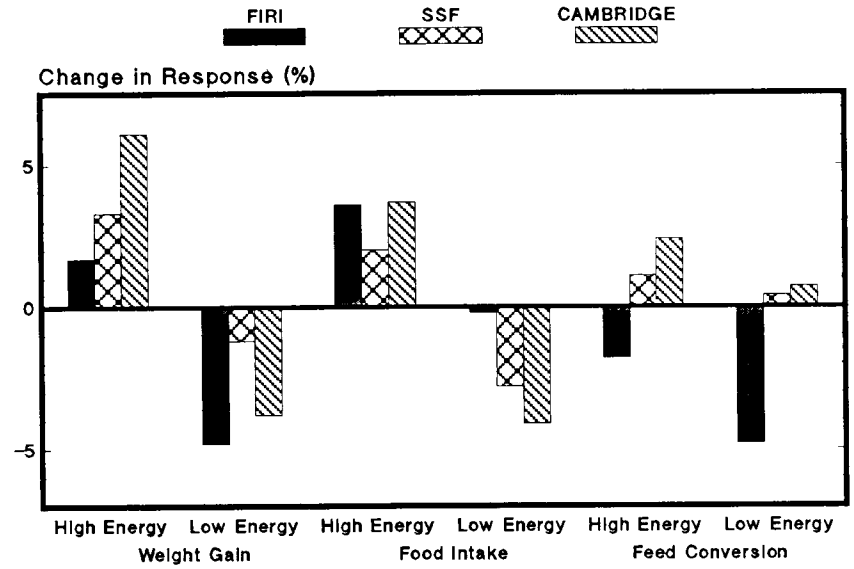
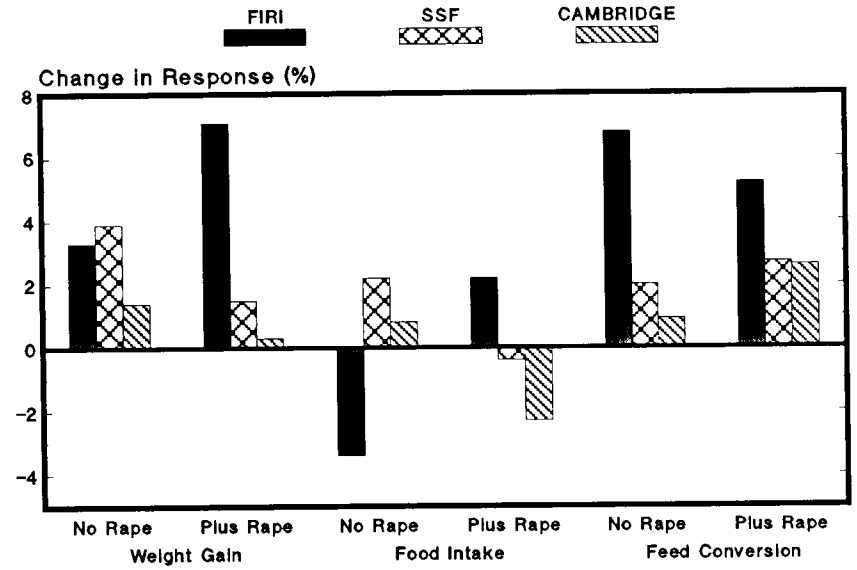


FIGURE 5

EFFECT OF SUBSTITUTING FISH MEAL FOR SOYABEAN MEAL* ON PERFORMANCE OF BROILERS



*(In diets with and without rapeseed meal)

APPENDIX TABLE 1

Composition of diets[1]

Canola meal:	Nil	Nil	High	High
Fish meal:	Nil	High	Nil	High
		-------- (g/kg) --------		
Ingredient				
Wheat (15.3% protein)	377	542	132	297
Soybean meal (46% protein)	511	279	251	19
Canola meal (36% protein)	-	-	450	450
Herring fish meal (69% protein)	-	120	-	120
Dicalcium phosphate	32.2	20.8	29.5	18.1
Calcium carbonate	9.6	10.8	5.6	6.9
Salt, iodized	2.5	2.5	2.5	2.5
Fat, stabilized animal	61.1	19.4	123.3	81.5
Vitamin-mineral premix	4.80	4.80	4.80	4.80
DL-Methionine	2.48	1.05	2.05	0.62
Calculated analysis/kg				
Crude protein, g	295	295	295	295
TME Mcal	3.00	3.00	3.00	3.00
TME, MJ	12.6	12.6	12.6	12.6
Calcium, g	12.5	12.5	12.5	12.5
Phosphorus, available, g	8.00	8.00	8.00	8.00
Methionine, g	6.76	7.12	6.71	7.06
Methionine + cystine, g	12.3	12.7	12.8	13.3
Lysine, g	17.3	18.2	17.5	18.4

[1]Diets containing intermediate levels of fish meal and canola meal - ingredient composition given by interpolation.

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