TECHNOLOGICAL STUDIES OF THE STARFISH

PART III-VALUE OF STARFISH MEAL--PROTEIN SUPPLEMENT FOR GROWTH OF RATS AND CHICKS AND FOR EGG PRODUCTION

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INTRODUCTION

This is the third paper in a series of six technological studies of the starfish (Asterias forbesi). The first discussed its ecological relation to the oyster in Long Island Sound, the necessity for starfish control by the oyster industry, and the control methods used. The second paper reviewed data on chemical composition of the starfish. The work of Dr. W. Bergmann on the sterols of starfish was also discussed briefly. The present paper is concerned with the utilization of starfish meal in starting and laying mashes for poultry and in diets for growing rats.

REVIEW OF LITERATURE

Although efforts to exterminate starfish have been carried out by oystermen on Long Island Sound for nearly 100 years, almost no effort has been made towards the utilization of starfish so taken in these control efforts.

After the first World War, in 1919, Kole reported the utilization in Germany of starfish for feed as well as for fertilizer, but it seems to have been used chiefly to adulterate the more valuable shrimp meal. Vachon (1920) suggested that starfish might be used as a fertilizer in Canada if a sufficient supply of raw material were available, and Gibbs (1941) reported that the raw starfish which were brought in for payment of bounty in Rhode Island in 1941 were used locally by farmers and by State institutions as fertilizer.

However, it remained for the period of World War II, with its accompanying shortage of protein feeds, to cause an extensive investigation of the possible use of starfish meal in feed mixtures. In recent years, the use of commercially mixed poultry mashes and other feedstuffs has increased rapidly. Fish meals have proven of exceptional value as sources of proteins of a type not found in any vegetable source and the established fish meal industries using menhaden, herring, pilchard, and the so-called "whitefish" fillet scrap have been unable

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Part II, "Chemical Composition," appeared in the February 1948 issue, pp. 11-18. Also available as Sep. No. 196.

to keep pace with the increased demand. All of these factors have accelerated the search for other sources of marine, high-protein meals for use in feeds.

There have been 6 papers published since 1944 by different groups of investigators dealing with the use of starfish meal as a protein supplement for the feeding of newly-hatched chicks. All but one of these reports presented results of work instigated by a group at the Bingham Oceanographic Laboratory which has been interested in the development of unutilized marine resources of southern New England. These reports will be briefly summarized. Bird (1944) fed poultry 3 and 6 percent starfish meal in a basal mash adjusted to maintain so far as possible the calcium:phosphorus ratio and protein content at the same levels as the control diet which contained 4 percent of fish meal. Growth was substantially equal with all three diets. The differences of 3 and 4 percent, respectively, lower mean gain in liveweight of the groups fed 3 and 6 percent starfish meal were not significant. Shank color was not bleached when the starfish meal was fed.

Heuser and McGinnis (1946) also fed to chicks diets containing 3, 6, and 12 percent starfish meal. Growth with the former diet was equal to that of the control group fed a diet containing 3 percent fish meal. There was about a 7 percent decrease in the mean gains of liveweight of the group fed the 6 percent level as compared with the control group. Chicks receiving a 12 percent level of starfish meal showed 16 percent mortality and significantly poorer growth. The gain in liveweight was only 61 percent of that of the control group. The diets contained equal quantities of protein so it was concluded that the excess calcium was responsible for the poor results obtained at the 12 percent level of starfish meal in the diet. It was concluded that the 6 percent level was the largest amount that could be fed with reasonable success.

Ringrose (1946) compared diets containing 13 and 18.5 percent levels of crude protein when fed to chicks. Mashes with the 13 percent protein content contained either 9 percent starfish meal, 4 percent rosefish meal, or 5 percent meat scrap, respectively, while those with 18.5 percent protein contained double these quantities and each diet also included 10 percent soybean oilmeal.

Growth was poor with all diets at the 13 percent level of crude protein. The diets containing starfish produced 83 percent of the gain in liveweight of that produced by the diet containing rosefish meal. With the high-protein diets, the chicks fed the 18 percent level of starfish meal averaged only one-third the gain in liveweight of the control group, and also showed a 50 percent mortality. Again the poor results are attributed by the author to the large calcium:phosphorus ratio, the high calcium content, or both.

Stuart and Hart (1946) fed chicks a diet containing starfish meal at a level of 4 percent supplemented with 4 percent meat scrap and 4.5 percent fish meal. The control group received a diet containing 7 percent fish meal and 4 percent meat scrap. Over a 12-week test period, rates of growth with the two mashes were approximately equal. Analyses of the tibia showed a higher calcium and ash content in the bones of the group which had received starfish meal than in those of the control group.

Whitson and Titus (1946) fed 3 series of chicks to make a more critical study of the quality of the protein of starfish meal. In the first series, 4 and 8 percent; in the second series, 4, 8, and 12 percent; and in the third series, 2.5 and 7.5 percent of starfish meal were included in the diets. In every case, starfish meal was the sole source of animal protein. Sardine meal was used similarly in the various control mashes, and varying amounts of ground limestone, soybean oilmeal, and wheat were replaced by these fish meals to balance the nutrients. Growth rates of the chicks fed mashes containing the lower levels of starfish meal were as good as, or better than, those obtained with the control mashes, but the rates were lower for the groups fed the 8 and 12 percent levels of starfish meal. The mean gain in liveweight of the group fed the 12 percent level of starfish meal was only 60 percent that of the control group. It was concluded that the starfish meal could be used to supply all of the calcium and some of the animal protein, it having the same growth-stimulating qualities as sardine meal protein. The calcium content limited the amount of starfish meal which could be used.

Morse, et al, (1944) carried out their study with starfish meal with an experimental lot of about one ton of meal produced in commercial scale operations. The starfish meal was included in diets at 4 and 8 percent levels and compared with those containing a 4 percent level of crab meal and a 2.5 percent level of fish meal. The protein level and calcium:phosphorus ratio were approximately balanced. There were no significant differences in mean gains of liveweight between any of the four groups of chicks after 8 weeks. Smaller groups were continued on experiment and fed the diets containing 2.5 percent fish meal and 8 percent starfish meal until the 14th week. At this time, the two groups were still about equal in size and feathering. At this level, the starfish meal plus dicalcium phosphate adequately replaced both the fish meal and meat scrap.

Although the tests varied somewhat in detail of experiment, all of these investigators have used newly-hatched chicks. Their conclusions agree in substance; namely, that small amounts of starfish meal can replace other animal proteins as a source of supplementary protein permitting approximately equal growth on an equal-protein basis. When several levels were fed, poorer growth usually resulted when more than 6 percent starfish meal was included in the diets. It was generally concluded that this effect was due to the resultant high levels of calcium, to the unbalanced calcium:phosphorus ratio, or to both factors.

STARFISH MEAL FOR GROWTH OF RATS

The work reported herein antedates the 6 papers just discussed, having been carried out in the summer and fall of 1942. This fact is mentioned in explanation of the inclusion in these tests of certain preliminary studies exploring the possible effects of the high levels of calcium in starfish meals.

The method of preparation of the meals used in these feeding tests has been described in Part II of this series dealing with chemical composition. In brief, starfish drained of free liquid which had separated in shipping were dried in ovens heated by steam coils at about a temperature of 60° C. Most of the foreign matter was removed before drying. In the first rat and chick tests, the extracted meal referred to was that remaining after the starfish oil was extracted. A quantity of this meal was available and it was fed in amounts equivalent to the protein in the diet containing the highest level of starfish meal fed to find out whether the oil had an adverse dietary effect which had to be considered in producing feeding meals.

As a preliminary to the feeding tests, the nutritive quality of the protein was determined by a nitrogen metabolism study. Six adult male rats were fed a protein-free diet during a preliminary and following period of 10 days, and the starfish protein to be tested was then fed during a middle 4-day period according to the method of Mitchell (1924). Feces and urine were collected for each period.

A determination of the nitrogen excreted at known intake levels permitted calculation of the digestibility and biological value of the protein fed. The average value for digestibility was 76.4 percent, while the average biological value, indicative of the availability of the protein, was 83.9 percent. These values compare favorably with similar data on other types of fish meals.

In the first series of feeding tests, rats and chicks were started at the same time with similar diets. The composition of these diets is given in Table 1 (see page 12). Corn, wheat middlings, and pilchard meal levels were varied with the starfish meal so as to equalize the calculated crude protein content in all diets. The nitrogen content was later determined by the standard Kjeldahl method, the results of which agreed with the calculated values quite closely. No attempt was made in either of the test series to compensate for the high level of calcium and the highly unbalanced calcium:phosphorus ratio, since it was desired to determine the extent of the tolerance for the calcium of the starfish meal which was unavoidably included along with the more sought-after protein. The calcium and phosphorus content of the diets has been calculated (Table 1) and the calcium:phosphorus ratios for the highest levels of starfish meal fed were found to be about 24 to 1 for the diets fed to rats, and 11 to 1 for those fed to chicks.

Ten rats weighing 48 to 55 grams each, evenly divided as to sex, were used in each of the 5 groups. The tests continued for 6 weeks, and the liveweight and feed consumption of each rat were recorded weekly. The results showed that the groups receiving 12 and 24 percent starfish meal had a lower growth rate than the control group while those receiving 48 percent starfish meal and 43 percent extracted starfish meal showed a net loss of from 8 to 12 grams from the initial weight. The surprising fact is that only 4 of the 20 rats in these 2 groups died. These deaths did not occur until the 6th week, and the remaining rats, while extremely emaciated, were quite lively and showed no other gross symptoms of damage. There were no deaths for the groups fed the 12 and 24 percent levels of starfish meal, although mean gain in liveweight in these groups was only 58 and 27 percent, respectively, of that of the control group.

Early in the test, it was observed that the rats tended to sort out and leave the starfish meal. This was corrected after the second week by grinding all meals very finely in a ball mill. It is interesting to note that, at this degree of fineness, the meal was so hygroscopic that the diets caked in the feed cups. The constituent responsible for this property is not known. The caking did not seem to affect the feed consumption, which remained at a fairly even level throughout the test period.

Feces were collected from 3 rats in each group during the last 3 days on tests and analyzed for total nitrogen. The mean values for the apparent digestibility of the protein in the diet indicated by these analyses were as follows: for the control group, 86.3 percent; 12 percent starfish meal level, 80.6 percent; 24 percent starfish meal level, 80.9 percent; 48 percent starfish meal level, 79.2 percent; and for the rats fed the high level of extracted meal, 81.7 percent. This high and relatively uniform degree of digestibility at all levels would seem to indicate that the poor growth was not a result of interference with protein metabolism.

Presence of thiaminase, the thiamine destroying enzyme, had previously been demonstrated in fresh starfish, and the results of the chick growth tests indicated that some of this substance still remained in the meal. However, there was little or no improvement in either weight or condition of the rats with the addition of

Table 1 - Composition of Diets in First Series of Growth Tests

Ingredients	DIETS FOR RATS					DIETS FOR CHICKS				
	Pilchard Meal	STARFISH				Pilchard Meal	STARFISH			
		Meal 1	Meal 2	Meal 3	Meal 4		Meal 1	Meal 2	Meal 3	Meal 4
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Ground yellow corn	63.4	55.0	46.7	30.0	35.0	33.0	27.4	21.0	8.8	13.5
Wheat bran	-	-	-	-	-	15.0	15.0	15.0	15.0	15.0
Wheat middlings	15.0	15.0	15.0	15.0	15.0	20.0	20.0	21.0	22.2	20.0
Corn gluten meal	-	-	-	-	-	5.0	5.0	5.0	5.0	5.0
Soybean oilmeal	-	-	-	-	-	5.0	5.0	5.0	5.0	5.0
Alfalfa meal	5.0	5.0	5.0	5.0	5.0	6.0	6.0	6.0	6.0	6.0
Dried skim milk	-	-	-	-	-	5.0	5.0	5.0	5.0	5.0
Pilchard meal	14.6	11.0	7.3	-	-	10.0	7.6	5.0	-	-
Starfish meal	-	12.0	24.0	48.0	-	-	8.0	16.0	32.0	-
Extracted starfish meal	-	-	-	-	43.0	-	-	-	-	29.5
Cod liver oil	2.0	2.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0
Salt ($MnSO_4$ added)	-	-	-	-	-	0.03	0.03	0.03	0.03	0.03
Crude protein, calculated	20.0	20.0	20.0	20.0	20.0	23.2	23.2	23.2	23.2	23.2
Protein, (Nx6.25)	20.1	20.0	19.6	19.4	19.9	22.8	22.9	22.8	22.8	23.5
Calcium, calculated	6.1	3.12	5.63	10.7	10.4	.57	2.24	3.91	7.25	7.29
Phosphorus, calculated	.63	.59	.54	.44	.45	.78	.75	.72	.66	.66
Calcium:phosphorus ratio	0.97	5.3	10.4	24.3	23.1	0.73	3.0	5.4	11.0	11.0

Table 2 - Composition of Mashes for Second Series of Growth Tests with Chicks & For Both First & Second Series of Laying Tests

Ingredients	SECOND SERIES WITH CHICKS				LAYING TEST I		LAYING TEST II	
	Pilchard Meal	STARFISH			MEAL		MEAL	
		Meal 1	Meal 2	Meal 3	Pilchard	Starfish	Pilchard	Starfish
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Ground yellow corn	24.0	24.4	24.1	23.8	33.0	33.0	37.5	37.5
Wheat bran	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Wheat middlings	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Ground oats	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Soybean oilmeal	24.6	24.5	24.6	24.7	10.0	10.0	12.0	12.0
Corn gluten meal	-	-	-	-	7.0	7.0	-	-
Alfalfa meal	6.0	6.0	6.0	6.0	7.0	7.0	7.0	7.0
Distiller's concentrate	3.0	3.0	3.0	3.0	2.0	2.0	2.0	2.0
Bone meal (steamed)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ground oyster shell	5.0	3.0	1.5	-	3.7	-	4.83	-
Starfish meal	-	3.0	6.0	9.0	-	7.5	-	8.5
Pilchard meal	3.9	2.6	1.3	-	3.3	-	3.67	-
Cod liver oil	1.0	1.0	1.0	1.0	1.0	1.0	0.5	0.5
Lard	-	-	-	-	0.5	0.5	-	-
Salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Crude protein, calculated	21.1	21.1	21.1	21.1	18.5	18.5	17.0	17.0
Calcium, calculated	2.86	2.71	2.76	2.80	2.31	2.44	2.75	2.66
Phosphorus, calculated	.86	.85	.83	.82	.80	.77	.81	.76
Calcium:phosphorus ratio	3.3	3.2	3.3	3.4	2.9	3.2	3.4	3.5

one microgram of thiamine per gram of diet. In this series, the poor growth was apparently not due primarily to a thiamine deficiency.

The carbohydrate contents of the diets containing starfish meal were lower than that of the control diet but hardly to an extent which would account for the extremely large differences observed. In fact, the only explanation for the poor results of feeding starfish meal to rats appears to be that the rat will not tolerate the serious imbalance of the calcium:phosphorus ratio which resulted from the large excess of acid-soluble calcium contained in the starfish meal.

STARFISH MEAL FOR GROWTH OF CHICKS

It was evident from the tests with rats that this animal is not satisfactory for assaying diets containing high levels of calcium. Results obtained from a series of feeding tests with chicks were much more satisfactory and have the further advantage of being directly applicable to commercial practice. The poultry feed industry is probably the largest single user of high protein meals. Chicks and hens were therefore used in all subsequent feeding tests.

All chicks were a Rhode Island Red-New Hampshire cross, purchased from a nearby hatchery. Chicks were housed by groups in batteries in a room in which the temperature was maintained at 78°-82° F. Birds were distributed between the groups at random, although an effort was made to have initial weights of the groups about equal. Size of groups was limited to 10 chicks each by the small size and limited number of batteries available. Birds were weighed individually at weekly intervals and group feed-consumption records were kept. These data are not highly significant, since there was some wastage in scattered feed.

The same starfish meal was used for the first series of rat and chick tests and similar levels were fed. Bran, soybean oilmeal, and dried skim milk supplied additional phosphorus to reduce the calcium:phosphorus ratios materially below those of the diets containing comparable levels of starfish meal which were fed to the rats. The composition of the mashes is presented in Table 1. The crude protein was maintained at a 23.5 percent level, primarily by the adjustment in the amount of pilchard meal. Starfish meal was fed at 8, 16, and 32 percent levels. These are really abnormally high levels and were fed with the sole intention of determining the tolerance of the chick for excessive calcium content with no compensating sources of phosphorus. The amounts of calcium and phosphorus, calculated from tables of feed analyses and the calcium:phosphorus ratios are presented in this table also.

A second series of chicks was fed in the same manner as the first, with diets modified on the basis of the results obtained in the first test. In this second series, starfish meal was fed at 3, 6, and 9 percent levels in order to determine the level which permitted optimum growth. The composition of these diets is given in Table 2 (see page 12).

In the first series with chicks, the control group made rather poor growth, for reasons to be explained later. The group fed the lowest level of starfish meal is used as a basis of comparison in this case. It was difficult also to find a basis of comparison by which the two groups fed the highest levels could be included, because only one-half of these groups survived, and these would have died except for supplementary thiamine supplied after 3 weeks. These chicks made small gains in weight during the first 3 weeks, but in the third week, half of the group died. Thiamine deficiency was considered to be the probable cause of death, since the presence of a thiamine destructive substance in raw starfish had previously been demonstrated. This will be described in detail in the next paper of this series. The diet was therefore supplemented with one microgram of thiamine per gram of diet, which resulted in a marked improvement in the condition of the chicks. Only one more death occurred, so the comparison made in Table 3 is based on the weight of the surviving chicks after 5 weeks of feeding of the supplementary thiamine.

Table 3 - Individual and Average Gains in Liveweight, and Food Consumed Per Gram for the Two Series of Growth Tests with Chicks1/

Diet Designation	Gains in Liveweight for Individual Chicks										Average Gain in Liveweight	Food Consumed Per Gram Gain
Series I	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Grams	Grams
Pilchard meal	182	225	325	322	203	224	449	408	152	361	285.1	3.32
8% starfish meal ...	538	373	743	383	491	713	565	663	640	*	567.3	2.66
16% " " ...	265	494	374	389	307	341	373	387	372	312	361.4	3.42
29% extracted starfish meal 1st to 3rd wks.	40	36*	38*	22*	55	35	10*	20*	29	41	40.0	5.03
Same plus thiamine 3rd to 8th wks.2/..	157	-	-	-	247	206	-	-	190	110	182	4.59
32% starfish meal 1st to 3rd wks. ...	12*	45	34	6*	7*	23*	43	22	38	11*	37.0	6.29
Same plus thiamine 3rd to 8th wks.2/..	-	97	2**	-	-	-	115	177	152	-	135.2	6.05
Series II												
Pilchard meal	970	887	903	873	739	712	696	773	807	967	832.7	3.04
3% starfish meal ...	818	662	837	743	847	859	659	707	757	*	765.4	2.89
6% " " ...	722	906	898	748	735	721	678	805	693	790	769.6	2.90
9% " " ...	604	596	547	707	666	715	613	687	752	-	654.1	2.86

*Dead. **Dead in 8 days.

1/Duration of tests is 8 weeks unless otherwise indicated.

2/100 micrograms of thiamine added per 100 grams of diet.

The data for individual gains, mean group gains in liveweight, and food consumed per gram gain in weight are shown in Table 3. It is evident that there is a large degree of individual variation in the early stages of growth of the chicks. The data on food required per gram gain in liveweight are about what may be expected for groups showing poor growth. The efficiency of utilization of food is almost invariably below normal for such groups.

In the second series of growth tests, the groups receiving 3 and 6 percent levels of starfish meal showed identical rates of growth, being 8 percent less than that of the group fed pilchard meal. The group receiving 9 percent starfish meal made only 78 percent of the gain in liveweight of the control group. A number of changes were made in the composition of the mash used in this series (Table 2). With the large reduction in maximum level of starfish meal in the diets, the amount of pilchard meal in the control mash was reduced to 3.9 percent of the diet. Soybean oilmeal in all diets was increased to compensate for the fish meal protein that was removed. The adjustments between the mashes were small so that the amount of corn could be kept almost constant in all four mashes. Ground oyster shell was added to the control and to the diets containing 3 and 6 percent starfish meal to balance, approximately, the calcium carbonate in the diet containing 9 percent starfish meal. The range of the calcium:phosphorus ratios was reduced by the addition of 2 percent bonemeal and 3 percent of a distiller's concentrate which was used instead of the dried skim milk as a source of riboflavin.

It seems certain that the poor growth of the control group in Series 1 was due to a deficiency of riboflavin. The better performance of the groups fed 8 and

16 percent starfish meal in the diets may be explained by bacterial synthesis of riboflavin, and possibly other factors, during the early stages of the drying operation in making the meal. The same effect had been noted by Lanham and Nilson (1942) in a study of the possible toxicity of artificially spoiled pilchard meal. In this case also, the diet containing the spoiled meal showed much better results than the diet containing the commercial meal. Further work identified riboflavin as one of the substances that stimulated growth which had been produced during the spoilage of the meal.

In the second series, the control group fed the pilchard meal showed very much greater growth, although they received less than half as much pilchard meal, and 2 percent less crude protein. This was the result of the adequate supply of riboflavin. The relative nutritive values of the pilchard and starfish meal proteins then may be evaluated with the proper prospective.

The sharp decrease in gain in liveweight from 92 to 78.5 percent of that of the control group, which occurred when the starfish meal in the mash was increased from 6 to 9 percent, must be explained on some other basis than as a riboflavin deficiency. The much-depended-upon explanation that the decrease is due to excess calcium or an unbalanced calcium:phosphorus ratio does not appear valid. Five percent of oyster shell was added to the control diet and lesser amounts to the others so as to give all 4 diets a practically identical calcium content. The range was only 2.71 to 2.86 percent calcium, making the range in calcium:phosphorus ratios from 3.2:1 to 3.4:1. The control group and the groups fed diets containing 3 and 6 percent starfish meal made very good growth, with a mean gain in liveweight of 833, 765, and 770 grams, respectively, at the end of 8 weeks.

The extraordinary tolerance of chicks for large amounts of calcium is also evidenced by the surviving chickens fed the high levels of starfish meal in Series 1. With mashes containing 32 percent starfish meal, the diet contained almost 18 percent calcium carbonate with no compensating source of phosphorus (calcium: phosphorus ratio of 11 to 1). Yet these chicks lived and more than doubled their weight in 5 weeks after the thiamine supplementation was started.

There are two other possible explanations for the sharply decreased rate of growth when increased amounts of starfish meal were included in the feed: either the poor quality of the protein or the presence of some other substance carried by the starfish that is detrimental, above certain levels.

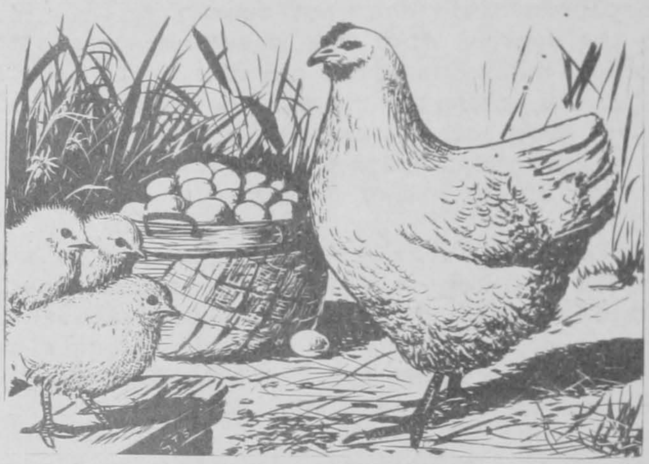
All evidence indicates that the starfish protein is very nearly equal to any other marine protein supplement in biological value, when the amount used does not exceed 6 percent. It is suggested that the major factor in the interference with growth of chicks fed levels of starfish meal ranging from 6 to 18 percent, is the presence of thiaminase, the thiamine-destructive enzyme, in starfish meal which has been dried at a low temperature.

The hypothesis is advanced that the thiaminase content of the diet explains the results of the present test, as well as the similar results noted by Heuser and McGinnis (1946) who fed 6 and 12 percent levels of starfish meal, by Ringrose (1946) who fed 9 and 18 percent levels, and by Whitson and Titus (1946) who fed a 12 percent level of starfish meal. It is notable that a sun-dried meal was used by all these investigators. The one series in which a meal was fed that had been dried in commercial drying equipment (Morse, et al, 1944) resulted in better growth with the 8 percent than with the 4 percent level of starfish meal. This result was obtained with a meal containing only 27.5 percent crude protein as compared to 30.5 and 34 percent in the sun-dried meal. This would explain why the poor results with sun-dried meals at higher levels are directly due to thiaminase which was destroyed by the heat to which the commercial meal had been subjected during drying.

It is still probable that very high levels of calcium will adversely affect the rate of growth of chicks, but this evidence indicates that as much as 12 percent of starfish meal can be included in the diet and produce good growth if the meal used is entirely free of thiaminase. Thiaminase is not a factor in the use of commercially-dried starfish meals because it is easily destroyed by heat. The probable presence of thiamine should be considered in any starfish meal dried at temperatures of less than 75° C., as it is capable of adversely affecting growth by rendering inactive considerable quantities of dietary thiamine.

STARFISH MEAL IN LAYING MASHES FOR EGG PRODUCTION

The value of starfish meal as a source of protein for growing chicks had been demonstrated, and it was thought advisable to determine its value in egg production. Commercial laying mash feed contains added sources of lime for egg shell formation. The high calcium content of starfish meal would appear to be a desirable feature in this type of mash, rather than a source of possible trouble.



Since only limited facilities were available for egg production studies, the groups used were smaller than would be necessary to give the desired significance to differences in the results. The only available laying battery consisted of 12 units, permitting only 6 hens each for a control group and an experimental group.

In the first series of tests, one hen in each group was unproductive or died early in test, so that the final results are based on 5 hens in each group. The hens had been raised from the first series of experimental chicks, the 12 best pullets being chosen from all of the groups. They were fed a stock mash until 6½ months old. At this time all were laying. Hens from all 5 of the original experimental groups were represented, and there was no indication whatever that the retarded early growth on the high-calcium diets had any affect on the future rate of egg production. The composition of the mashes fed during the experimental period is shown in Table 2.

Starfish meal was fed the first group of hens at a 7.5 percent level, being replaced in the control mash by 3.3 percent pilchard meal, 3.7 percent ground oyster shell, and 0.5 percent lard to provide amounts of protein, calcium carbonate, and fat essentially equal in amount to the three chief nutrients of starfish meal.

The results of the first series of laying tests were checked with those of a second series of pullets raised from the chicks of the second series of growth studies. The composition of these mashes is also shown in Table 2. There were only minor modifications in the formula. Starfish meal was increased to 8.5 percent, with pilchard meal and oyster shell in the control diet increased to 3.67 and 4.83 percent, respectively, to balance the additional starfish meal. Lard was omitted. Soybean oilmeal and corn were increased to compensate for corn gluten meal which was no longer available.

The first laying test favored the mash containing starfish meal in number and gross weight of eggs produced. The mean egg weights were almost identical for the two groups, being 52.1 grams for the group fed pilchard meal and 51.5 for the group fed starfish meal.

Those fed starfish meal laid 435 eggs while the control hens laid 379 eggs; however, one hen of the latter group did not lay for long periods so that on a productivity basis (eggs per day x 100) the groups were nearly identical, being 70.8 for the hens fed starfish meal as compared to 69.7 for the group fed pilchard

Table 4 - Egg Laying Records

Group	Wing Band Numbers	Total Eggs Laid		Total Egg Weight		Average Egg Weight		Productivity - Eggs Per Day x 100	
Series I		Number		Kilograms		Grams			
7.5% starfish meal	252	89		4.60		51.7			
	226	75		3.84		51.1			
	221	86		4.44		51.6			
	239	104		4.57		43.9			
	242	81		4.79		59.2			
Group Total		435		22.24		-			
Average		87		4.45		51.5		70.8	
3.3% pilchard meal	212	75		4.09		54.5			
	250	77		4.20		54.6			
	225	96		4.99		52.0			
	280	74		3.80		51.4			
	299	57		2.73		47.9			
Group Total		379		19.81		-			
Average		75.8		3.96		52.1		69.7	
Series II		A	B	A	B	A	B	A	B
1. Pilchard meal for period A and starfish meal for period B[1]	283	39	35	1.95	1.82	50.0	52.0		
	289	49	41	2.56	2.24	52.2	54.6		
	357	36	17	2.02	0.97	56.0	56.8		
	332	39	40	1.91	2.23	50.8	55.6		
	346	48	42	2.32	2.12	48.4	50.4		
	242	41	35	2.50	21.3	61.0	60.8		
Group Total		252	210	13.33	11.51	-	-		
Average		42.0	35.0	2.22	1.92	53.1	55.0	66.8	58.8
2. Starfish meal for period A and pilchard meal for period B	317	38	42	1.96	2.12	51.6	50.4		
	294	33	24	1.67	1.18	50.7	49.2		
	354	14	23	0.77	1.49	55.3	64.6		
	329	42	43	2.07	2.34	49.4	54.4		
	335	42	40	1.88	1.97	44.9	49.4		
	225	42	32	2.23	1.80	55.2	56.2		
Group Total		211	204	9.77	10.90	-	-		
Average		35.2	34.0	1.63	1.82	51.2	54.0	56.4	57.3

1/ The diets contained 8.5 percent starfish meal and 4.83 percent pilchard meal.

meal over a 4-month period. The individual data for these hens are summarized in Table 4. It is evident that there is a high degree of intra-group variation in both egg size and productivity, so that none of the differences is significant.

The second egg-laying test series was designed to eliminate, to a large extent, the undesirable effect of the individual variation in the hens upon the significance of the results. The design of the test was as follows:

Randomly selected groups, after laying had been well established, were fed mashes containing pilchard and starfish meals, as in Series 1, for 2 months. At the end of this period, the group that had been receiving the mash containing pilchard meal was shifted to that containing starfish meal, and vice versa. Egg records were then kept for a second 2-month period. In this way, the individual differences in egg weight and productivity characteristics of the hens in each group were made to apply to each diet for a like period. The individual records of these hens are shown in Table 4, and the results are summarized in Table 5.

Table 5 - Summary of Data for Laying Test Series II

Item	GROUP I		GROUP II	
	Feeding Period		Feeding Period	
	First	Second	First	Second
	Pilchard meal	Starfish meal	Starfish meal	Pilchard meal
Total no. eggs	252	210	211	204
Total egg weight, kg.	2.22	1.92	1.63	1.82
Average egg weight, gm.	53.1	55.0	51.2	54.0
Productivity	68.8	58.8	56.4	57.3

As was expected, there are considerable variations for both individual hens and groups. Those hens originally allotted to the group fed the pilchard meal diet produced both larger eggs and more eggs per hen than the group originally fed the starfish meal diet. After the shift at the end of 2 months, this group still produced more and larger eggs on the starfish meal diet, but the magnitude of the difference was reduced due to the slightly greater nutritive value of the pilchard meal protein. During the second period, there was a decrease for both groups in the number of eggs laid, but an appreciable increase in egg weight, both factors being related to the increased age of the hens. As a combined result of both factors, the total weight of the eggs was almost the same in both periods. Small net differences remained in favor of the group fed the diet containing pilchard meal, both as to number of eggs laid and mean egg weight. The total differences amounted to 35 eggs, and 0.9 gram per egg. The hens receiving starfish meal laid 7.7 percent fewer eggs and the eggs laid were 1.67 percent smaller than those laid by the group fed pilchard meal. The mean productivity was 57.6 for the group fed starfish meal or 7.2 percent less than that of the control group which had a productivity of 62.1.

The data indicate that pilchard meal has a slightly greater stimulating effect than starfish meal on the rate of egg production. The size of eggs laid is almost unaffected by the source of protein in the diet, this factor being apparently hereditary and little influenced by changes in diet. For practical purposes, starfish meal can be rated as a very good source of protein for laying hens, supplying, in addition, all of the calcium needed for shell formation.

CONCLUSIONS

Starfish meal has been fed to newly-hatched chicks at levels varying from 3 to 32 percent of the diet. The starfish meal is only slightly less effective when fed at the lower levels as a source of protein for growth of chicks than is a high-grade pilchard meal. Intermediate levels of starfish had a retarding effect on growth. This effect is thought to be primarily due to the presence of a thiamine-destructive enzyme in meal dried at a low temperature. The excess calcium and unbalanced ratio of calcium to phosphorus may be secondary factors affecting growth, particularly with diets containing more than 10 to 12 percent starfish meal.

Severely retarded growth resulted when chicks were fed diets containing very high levels of starfish meal. Any deaths, however, were due to thiamine deficiency, which also accounted for much of the adverse effect upon growth.

The rat is not a suitable animal for testing growth when fed diets containing much calcium. It has a relatively low tolerance for excess calcium compared with the chick.

Starfish meal compares favorably with pilchard meal as a protein supplement when used in laying mash. It also supplies calcium in place of the ground oyster shell or the limestone which is usually added. The rate of egg production of the group fed starfish meal was 7.2 percent less than for the group fed pilchard meal. This difference, however, is not statistically significant.

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