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The Utilization of Food Elements by Growing Chicks. II. A Comparison of Protein Concentrates from Single and Multiple Sources

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SUMMARY

1. The effect of adding to a basal ration a protein concentrate consisting of meat scraps alone was compared with one made up of a mixture of meat scraps, fish meal, and dried buttermilk by means of growth and body-analysis experiments.

2. The percentages of nitrogen, calcium, and phosphorus contained in the chicks of the lot fed the mixture of three proteins were slightly higher than those found in the lot fed meat scraps as the concentrate.

3. The percentage rate of gain and the gain per gram of nitrogen fed were greater in the lot fed the mixture of proteins as the concentrate.

4. The retention of nitrogen, calcium, and phosphorus was greater by the chicks of the lot fed the mixture of meat scraps, fish meal, and dried buttermilk.

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The cost relationships among cereal by-products and protein concentrates of various kinds govern the choice of the concentrate as well as the amount to be included in a chick ration. The lower initial cost as well as the local availability of the cereals and their by-products indicates that they will form the basis for chick rations until radical changes occur in their costs. Numerous investigators have demonstrated that the inclusion of a high-protein concentrate is an economical addition to a growing mash. Their work has shown that up to six or eight weeks of age the plane of protein should be adjusted to a level of roughly twenty per cent, and that thereafter the plane of protein intake may be profitably reduced. The choice of the concentrate is based upon a consideration of the unit cost and the quality of the protein. It was found early that there were differences in the quality of the various products used and that proteins of animal origin produced more favorable responses than did those of vegetable origin.

A list of concentrates of vegetable origin includes soybean meal, cottonseed meal, linseed oil meal, and corn gluten meal. The animal protein concentrates include the various forms of meat meals and tankages, fish meal, cod-liver meal, cracklings, blood meal, dry milk solids, casein, and albumins. Economy in the use of any of these products entails a knowledge of their efficiency in promoting chick growth. While these feed materials have been studied intensively with rats and to a lesser extent by means of digestion trials with domestic animals, information of a general nature only has been secured with respect to poultry.

Work on the kind and quantity of protein to be fed to growing chicks has been carried on by Swift, Black, Voris, and Funk (1), Milne (2), Tomhave and Mumford (3), Mussehl and Ackerson (4,5), as well as by a large number of other workers. Methods of determining the nutritive values of proteins for chicks have been presented by Heller, Morris, and Shirley (6), St. John, Johnson, Carver, and Moore (7), Plimmer, Rosedale, Raymond, and Lowndes (8) and Almquist, Stokstad, and Halbrook (9). These papers contain lists of references as well as general discussions of the problems of protein metabolism of poultry. With regard to the mineral metabolism and requirements of poultry the reader is referred to a recent review of this field by Mitchell and McClure (10).

The object of the experiment to be reported in this paper was to compare the retentions of nitrogen, calcium, and phosphorus by growing chicks on two rations differing in the nature of the protein concentrate. The concentrate in one ration was limited to a single source of animal protein, while in the second it was derived from a mixture of three animal proteins. The set-up of the experiment was the same as in previous work

at this station (11, 12, 13). Retentions of the elements were calculated from the amounts present in the feed and in the body at the conclusion of the experiment. The chicks were brooded in electrically heated metal brooders in a room where the temperature seldom dropped to 70° F. The chicks were hand-fed the pelleted rations so that exact intake records were available for all chicks.

PREPARATION OF THE RATIONS

The base of the two rations was identical in this experiment and was also the same as the one used in earlier work (13). A quantity of the base was prepared and divided into two portions. Then to one portion was added a mixture of 12 pounds of meat scraps and 3 pounds of starch (protein content of mixture 55.6 per cent). To the other portion of the base was added a mixture of 5 pounds each of meat scraps, fish meal, and dried buttermilk (protein content of mixture 55.6 per cent). The rations were mixed as follows:

Ingredients	Ration 1-X	Ration 3-X
	Lbs.	*Lbs.*
Yellow corn meal	32	32
Shorts	20	20
Bran	10	10
Pulverized oats	10	10
Alfalfa meal	10	10
Meat scraps	12	5
Fish meal	0	5
Dried buttermilk	0	5
Corn starch	3	0
Pulverized calcium carbonate	2	2
Sodium chloride	1	1

The protein content of the base was 15 per cent and that of the finished rations 21 per cent. The base furnished 60 per cent of the total protein and the concentrate 40 per cent. The experimental variable was thus the source of the protein concentrate of the two rations. After the base and concentrate of each ration had been thoroughly mixed the mixtures were pelleted, using a 5/32-inch die. The mixtures were called 1-X and 3-X to designate the ration containing meat scraps alone and the one with meat scraps, fish meal, and dried buttermilk as the concentrate, respectively. The composition of the rations is given in Table 1.

TABLE 1.—*Analyses of the rations.*

Ration	Water	Ash	Nitrogen	Calcium	Phosphorus
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1-X	8.9	7.2	3.36	1.416	0.754
3-X	9.4	7.5	3.35	1.535	0.799

Ration	Crude fat	Crude fiber	Protein	N-free extract	Ratio Ca:P
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	
1-X	4.4	6.7	21.0	51.8	1.88
3-X	4.3	6.5	20.9	51.4	1.92

EXPERIMENTAL FEEDING

Single Comb White Leghorn chicks, selected in a weight range of 35 to 39 grams at hatching time, were divided into two lots of 18 each. Seven chicks were lost during the first three days but these losses were a direct result of the forced feeding. There were no further losses during the experiment. This group of chicks was fed during January and February. The identity of each chick was retained by the use of leg bands. The chicks were all fed identical amounts of the rations daily. The use of the pelleted feed, hand-fed as described in earlier work (13), afforded quantitative intake records of the feed used by each chick during the experiment. Cod-liver oil was fed individually from a burette at a level of 0.6 per cent of the ration. The rations were analyzed at intervals during the feeding period so that the data of Table 1 represent averages of different samples of the pellets. No tendency for the analysis of the pelleted rations to vary within the batch was noted.

Growth data and analysis of the entire chicks at the conclusion of the feeding period constitute the basis for the conclusions reached in this paper. The initial nitrogen, calcium, and phosphorus contents of the chicks were estimated from data obtained in earlier work (11), which in an analysis involving 127 chicks placed the amounts at 0.95, 0.15, and 0.11 gram of each respectively. Subsequent analysis of 21 chicks gave results agreeing closely with those of the first group. In addition a calculation of the data in Table 2 of a paper by Buckner, Martin, and Peter (14) showed the weighted average of calcium and phosphorus of 76 newly hatched chicks to be 0.146 and 0.108 gram respectively. Thus the figures used in the estimation of the initial content represent group averages of 224 chicks in the case of calcium and phosphorus and 148 for nitrogen.

At the end of the respective feeding periods the chicks were killed by ether anesthesia after food had been withheld for 16 hours. The intestinal tract was removed and emptied after the chicks had been chilled sufficiently to prevent loss of blood during the operation. The nitrogen in the contents of the proventriculus and gizzard was determined and deducted from the amount of nitrogen fed each chick. The sex of each chick was confirmed at this time. The chicks were analyzed in groups of two or three of like sex from each lot. The records of the experiment included the initial and final weights, net body weights and interval weights during the experiment, and the food intake. The amounts of nitrogen, calcium, and phosphorus in the chicks were thus determined analytically and from the estimated initial contents of these elements the percentage of retention during the feeding period calculated. The rates of gain of chicks, calculated from the interval weights, are given in Table 2.

TABLE 2.—*Rates of gain of chicks.*

RATES OF GAIN ON SUCCESSIVE INCREMENTS OF DRY MATTER						
Age of chicks (*days*)	15	23	27	32	37	40
Dry matter increment (*g.*)	110	163	124	149	137	91
LOT 1-X						
8 males—rate of gain (*p. ct.*)	56	51	56	33	27	36
6 females—rate of gain (*p. ct.*)	55	48	56	32	21	43
LOT 3-X						
8 males—rate of gain (*p. ct.*)	57	55	55	43	24	37
7 females—rate of gain (*p. ct.*)	57	57	50	36	25	40
RATES OF GAIN OF CHICKS, CALCULATED AT ATTAINED WEIGHT ON GAIN OVER INITIAL WEIGHT						
Total dry matter fed (*g.*)	110	273	397	546	683	774
LOT 1-X						
8 males—rate of gain (*p. ct.*)	56	53	54	48	44	43[1]
6 females—rate of gain (*p. ct.*)	55	51	53	47	42	42[1]
LOT 3-X						
8 males—rate of gain (*p. ct.*)	57	56	55	52	46	45[1]
7 females—rate of gain (*p. ct.*)	57	57	55	50	45	44[1]

[1] These values differ from the ones in Table 5, since the latter are based on the net weight and these on the live weight figures.

The growth of the chicks was very uniform in the lots, there being a maximum variation of but 10 per cent of the net body weight among chicks of like sex on one ration. This is shown by the low standard errors found in Table 3.

TABLE 3.—*Mean net weights*[1] *at slaughter and their standard errors.*

Lot	Males	Females	Males and females (unweighted mean)
	g.	*g.*	*g.*
1-X	347.00±3.90	337.33±4.50	342.16±2.98
3-X	365.25±3.90	354.71±4.17	359.98±2.86

[1] The net weight is the weight of the chick after removal of the contents of the digestive tract.

TABLE 4.—*Analysis of the body weights: effect of sex and diet.*

Sources of variation	Degrees of freedom	Sum of squares	Mean square	Standard deviation
Diet	1	2,268.88	2,268.88	....
Sex	1	729.26	729.26	....
Interaction	1	0.10	0.10	....
Error	25	3,044.26	121.77	11.03

The standard errors of the means noted in Table 3 indicate that the variations between lots and among the chicks of the same sex in both lots were low. The difference between the means of the sexes on the two rations

was about 18 grams in each case. In view of the low coefficient of variation found in the experiment the significance of these differences was tested by the method of weighted squares of means. The results of this analysis are given in Table 4.

The value of 'F' for diet is 18.6, and since the one per cent point is 7.77 there is a highly significant difference between the mean weights of the chicks on the two diets. The value of 'F' for sex is 5.99, with a five per cent point of 4.24, which indicates that there is a significant difference between the sexes on the same diet. However, there is no significant interaction between sex and diet or, in other words, both sexes responded to the diet in a similar manner. The coefficient of variation, which is the standard deviation divided by the mean net weight, is 3.15 per cent showing that the error of the experiment is small.

The growth data and the analytical data were handled as in a previous report (13) with one exception. In Research Bulletin 90 the intakes and the gains of the elements were given in Table 4 on the lot basis. In Table 5 below all the data have been reduced to the basis of individual averages for the sexes in both lots.

TABLE 5.—*Summary of growth and analytical data on chicks.*

Item	1-X Ration		3-X Ration	
	Male	Female	Male	Female
Number of chicks	8	6	8	7
Net weight (*g.*)	347	337	365	355
Gain in weight (*g.*)	310	300	328	318
Dry matter fed (*g.*)	774	774	774	774
Rate of gain (*p. ct.*)	40.0	38.8	42.6	41.3
Gain per gram nitrogen fed (*g.*)	10.9	10.5	11.5	11.2
Nitrogen in chicks (*p. ct.*)	3.34	3.20	3.44	3.31
Calcium in chicks (*p. ct.*)	0.83	0.71	0.89	0.86
Phosphorus in chicks (*p. ct.*)	0.57	0.50	0.59	0.58
Ratio, Ca:P in chicks	1.46	1.42	1.51	1.48
Nitrogen in gain (*p. ct.*)	3.43	3.28	3.53	3.40
Calicum in gain (*p. ct.*)	0.88	0.75	0.94	0.91
Phosphorus in gain (*p. ct.*)	0.61	0.53	0.62	0.61
Ratio, Ca:P in gain	1.44	1.41	1.52	1.49
Ether extract (*p. ct.*)	7.6	11.1	5.8	8.2
Nitrogen intake (*g.*)	28.56	28.54	28.46	28.48
Nitrogen in gain (*g.*)	10.62	9.85	11.60	10.81
Nitrogen retained (*p. ct.*)	**37.2**	**34.4**	**40.8**	**38.00**
Calcium intake (*g.*)	12.04	12.04	13.05	13.05
Calcium in gain (*g.*)	2.74	2.25	3.09	2.90
Calcium retained (*p. ct*)	**22.8**	**18.7**	**23.7**	**22.2**
Phosphorus intake (*g.*)	6.41	6.41	6.79	6.79
Phosphorus in gain (*g.*)	1.88	1.60	2.04	1.94
Phosphorus retained (*p. ct*)	**29.3**	**24.9**	**30.0**	**28.5**

CONCLUSIONS

The rate of gain (gain in weight divided by the weight of the dry matter fed) of the chicks of the lot fed a mixture of three protein concentrates was greater than in a comparable lot fed meat scraps alone as the concentrate.

The mean net weight of the chicks fed the mixture of meat scraps, fish meal, and dried buttermilk was higher than that of the chicks fed meat scraps as the concentrate. This difference was found to be highly significant statistically.

Within the lots a significant difference was found between the sexes.

The average retention of nitrogen, calcium, and phosphorus was greater in the case of the lot fed the mixture of three concentrates.

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