IMPROVEMENTS OF CORN - SOYBEAN OIL MEAL CHICK STARTER DIETS

By

Saleem Saleem Sa'd-Akrabawi

A Thesis Submitted to the Graduate

Faculty of the School of Agriculture in Partial Fulfillment of

the Requirements for the Degree of

MASTER OF SCIENCE IN AGRICULTURE

Split Major: Poultry Nutrition - Animal Science

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American University of Beirut

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Studies on Corn-Soya Diets

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ABSTRACT

Three experiments were conducted at the American University of Beirut farm with day-old Rhode Island Red x Barred Plymouth Rock chicks. The objectives of these experiments were to establish the proper level of dried skimmilk and methionine hydroxy analogue supplementation of corn-soybean oil meal chick starter diets, and to study possible interactions of these two ingredients.

The results of the first experiment showed that the best live weight gain and feed efficiency were attained by chicks receiving 2.0 percent dried skimmilk supplemented diets that had 0.2 percent MHA added to them. The results of the second experiment showed that, among different levels used, 0.1 percent MHA in diets containing 2.0 percent dried skimmilk produced the highest live weight gain and feed efficiency. The results of the third experiment showed that the supplementation of diets with either 2.0 percent dried skimmilk or 0.1 percent MHA did not effectuate an improvement in live weight gain and feed efficiency. Live weight gain and feed efficiency were improved only when both supplements were added together. This indicated a definite interaction between the two supplements.

It is concluded that the supplementation of all-plant corn-soybean oil meal diets with a combination of 2.0 percent dried skimmilk and 0.1 percent methionine hydroxy analogue produces optimum live weight gain and feed efficiency of chicks.

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INTRODUCTION

It has been the purpose of many research workers to establish a chick starter diet free of animal proteins. This has definite values for the poultry industry because animal proteins are scarce and expensive in this part of the world. The scarcity of animal protein sources is due to the combination of the effects of climate, soil, management and absence of certain agricultural industries. Plant proteins are either available locally or can be imported at reasonable prices.

Rations based on yellow corn and soybean oil meal have been found to meet most of the dietary requirements of growing chicks. However, the addition of a small amount of animal protein has been found to improve growth and feed utilization obtained from such diets. This is in addition to the great improvement encountered in most of the cases with the incorporation of methionine.

The present work is an attempt to establish the proper level of dried skimmilk and methionine hydroxy analogue supplementation of corn-soybean oil meal diets. It included three experiments. The first experiment dealt with dried skimmilk supplementation, the second with methionine hydroxy analogue supplementation and the third with the interaction of these two supplements.

REVIEW OF LITERATURE

Dried Skimmilk in Chick Starter Diets

During the last twenty years very little has been reported in the literature about the use of dried skimmilk in poultry diets. This is probably due to the increased use of this product for human consumption. According to Ewing (1951), dried skimmilk contains 50 percent lactose, 34 percent protein, 1.35 percent calcium and 0.98 percent phosphorus. It contains an adequate amount of all essential amino acids except arginine and glycine and it is very rich in water-soluble vitamins.

Roberts _et al_. (1933) observed that when day-old Barred Plymouth Rock chicks were given a ration containing 20 percent of a combination of meat and bone scraps and dried skimmilk in the proportions of 3:1, 1:1 and 1:3 respectively, there was no difference in rate of growth or mortality during the first 10 weeks of life. Ott _et al_. (1939) conducted an experiment to study the effect of the incorporation of 7 graded levels of dried skimmilk in a diet containing 13 percent animal protein on the growth and feed efficiency of day-old Single Comb White Leghorn chicks. The levels used ranged from 1.25 to 8.75 percent. Adjustments were made to keep protein, calcium and phosphorus contents equal. They found that the greatest weight gains were obtained by groups receiving 1.25 and 2.50 percent dried skimmilk. Christiansen _et al_. (1940) found that the addition of 8 percent dried skimmilk to a diet containing 8 percent meat scraps produced the best growth of chicks receiving different kinds of animal-protein supplemented diets. They also found that the addition of 3 percent dried skimmilk to an all-plant starter diet was more effective in promoting growth than the addition of 3 percent of either meat scraps or casein. Hammond and Titus (1944) stated that the incorporation of 3-5 percent of dried skimmilk in a diet composed mainly of ground wheat, soybean oil meal and alfalfa meal improved growth of Rhode Island Red chicks to an extent that might allow its use when available at a reasonable price

Methionine Supplementation of Chick Starter Diets

Almquist et al. (1942) were among the first to work on methionine supplementation of chick starter diets. They observed that the addition of 0.05 percent DL-methionine improved growth of Single Comb White Leghorn chicks. They also concluded that heated soybean protein was slightly deficient in methionine at the 20 percent level, but was complete in all other amino acids required by the chick. Evans and McGinnis (1946) studied the effect of different heat treatments and supplementation of different kinds of soybean oil meal (SBOM) on the growth and feed efficiency of day-old New Hampshire chicks. Autoclaving at 100°-120° C. was found to increase the nutritive value and availability of sulfur amino acids in the meal. The increase was less when the meals were autoclaved at higher temperatures. Adding 0.2 percent DL-methionine to all diets increased growth and feed efficiency of chicks.

Gordon and Sizer (1955) indicated that calcium 2-hydroxy, 4-methyl thio-butyrate (MHA) appeared to be more active than DL-methionine and as active as L-methionine in promoting growth. Machlin and Gordon (1959) found that the addition of either methionine hydroxy analogue (MHA) or DL-methionine to diets containing 12 or 14 percent isolated soybean protein resulted in equivalent growth response of day-old New Hampshire cockerels and straight run chicks produced from the mating of New Hampshire males to Single Comb White Leghorn females.

Almquist and Grau (1945) conducted an experiment in which the level of cystine was increased gradually to a maximum sulfur amino acids content of 1.0 to 1.1 percent in diets deficient in methionine and cystine and adequately supplemented with choline. The growth obtained with these diets was about 4 percent a day. However, substituting part of cystine with methionine so that the total methionine content of the diet was raised to 0.55 percent gave 6 percent gains per day. Marvel et al. (1944) fed day-old Barred Plymouth Rock male chicks corn-soybean oil meal diets supplemented with 0.15 and 0.50 percent choline chloride and 0.12 percent DL-methionine. The supplemented diets were compared to a non-supplemented and a control commercial diet. It was concluded that the growth produced with any of the supplemented diets was comparable to that produced by the control diets. Bird and Mattingly (1945) fed day-old chicks of different breeds and crosses two different diets. The first was based on corn, oats, wheat bran, wheat middlings, soybean oil meal and bone scraps, while the second was based on the same ingredients but with no meat and bone scraps. They concluded that the addition of 0.2 percent DL-methionine significantly improved growth of chicks fed on the second diet only. Addition of 0.15 percent choline or a combination of 0.15 percent choline and 0.30 percent nicotinic acid did not add to the nutritive value of these diets. Gerry et al. (1948) observed that when levels of 30, 35 and 40 percent of soybean oil meal were fed with the addition of 0.20, 0.25 and 0.30 percent of either methionine or choline chloride to day-old Barred Plymouth Rock female chicks, the lower levels of soybean oil meal with the higher levels of either supplements gave the best results with one exception. The addition of methionine was more effective than choline chloride. None of the simple diets produced a growth that was comparable to chicks fed on control diets. Briggs et al. (1950) found that methionine could completely replace vitamin B_{12} requirement of day-old White Leghorn chicks getting corn-soybean oil meal diets. Normal chicks could be raised to 16 weeks of age on all-vegetable 0.05 percent methionine supplemented corn-soybean oil meal diets. Machlin et al. (1952) stated that the addition of 0.3 percent DL-methionine and 0.1 percent vitamin B_{12} to an animal protein-free corn-soybean oil meal diet produced maximum growth response of day-old Rhode Island Red chicks hatched out from eggs of vitamin B_{12} depleted hens. Douglas et al. (1958) also observed that the incorporation of 0.20 percent glycine in addition to 0.15 percent methionine hydroxy analogue in corn-soybean oil meal diets improved growth of male broiler chicks significantly.

Rosenberg et al. (1955 a.) observed a slight improvement in the growth of day-old New Hampshire chicks when 0.05 percent DL-methionine was added to a corn-soybean oil meal diet. Also supplementation of the diet with 3 or 6 percent vegetable or animal fat brought about considerable improvement in growth and feed efficiency of chicks. When both fat and methionine were added, a still greater improvement was observed. Baldini and Rosenberg (1955) fed day-old New Hampshire chicks six different corn-soybean oil meal diets; three of them averaged 20.4 percent protein and 837, 893 and 982 Calories of productive energy per pound respectively and the other three averaged 21.3 percent protein and 798, 900 and 1002 Calories of productive energy per pound. All the diets were supplemented with graded levels of 0.000 to 0.294 percent methionine. The authors concluded that the methionine requirement expressed as percentage of the diet increased as productive energy level increased. In 1957 the same workers stated that when sufficient energy from non-protein sources was available to permit full utilization of protein, the methionine requirement as percentage of the diet increased as the protein level increased. If there was not sufficient energy from non-protein sources, an increase in protein percentage did not initiate a corresponding increase in methionine requirement. Baldini (1961) found that the ability of birds to utilise the metabolizable energy of the diet for productive purposes was impaired by a methionine deficiency. The metabolized energy that was not put to productive use was given off as heat as evidenced by oxygen consumption. The deficient diets proved to have more metabolizable calories per pound than the supplemented diets.

Milligan et al. (1951) observed that the methionine requirement of Rhode Island Red chicks fed practical diets with soybean oil meal as the only protein supplement to six weeks of age was not higher than 0.42 percent. The chicks required a total of only 0.70 percent methionine plus cystine in their diets. The maternal diet did not affect growth of chicks or their requirement for methionine. Nelson et al. (1960)conducted 7 experiments in order to determine the total sulfur amino acids requirement of the chick. They used Vantress x New Hampshire, Rhode Island x Barred Plymouth Rock and White Plymouth Rock chicks. The results of adding graded levels of methionine to semi-synthetic and corn-soybean oil meal diets showed that the requirement for sulfur amino acids was

3.510 ± .025 percent of the protein. The results were the same with all protein and energy levels tested.

Menge et al. (1953) fed day-old New Hampshire chicks practical corn-soybean oil meal diets averaging 22.4 percent protein for the first six weeks at two different experimental stations. From the sixth to the tenth week of age the protein levels ranged from 15.8 to 22.4 percent. During the first 6 weeks the addition of 0.05 percent DL-methionine improved growth and feed efficiency. Between the sixth and tenth week period, methionine supplementation failed to produce any response at one of the two experimental stations. The value of methionine supplementation was unaffected by the protein level. Titus et al. (1955) reported a failure to improve feed efficiency of male and female New Hampshire chicks by supplementing two corn-soybean oil meal diets averaging 25.0 and 21.5 percent protein with 0.05 percent DL-methionine. Moreover, a decrease in the weights of female chicks was detected as a result of methionine supplementation. In a second experiment, the same workers found that the addition of 0.05 percent DL-methionine had no effect on growth or feed efficiency of chicks.

Methionine-Animal Protein Interrelationships in Chick Starter Diets

Matterson et al. (1953) fed practical corn-soybean oil meal diets to day-old New Hampshire chicks at four different experimental stations. The diets were fortified with four levels of methionine and three levels of fish meal. The levels of methionine were 0.000, 0.0500, 0.0625 and 0.0750 percent while the levels of fish meal were 0.0, 2.5 and 5.0 percent. The results showed that the absolute weights attained by birds at different stations varied significantly but the relative growth responses to different treatments were the same. The addition of methionine significantly improved efficiency of feed utilization but the growth response was variable. Increasing the level of fish meal to 2.5 percent markedly improved both growth and feed efficiency. Methionine supplementation also improved rations with fish meal. Rosenberg et al. (1955 b.) fed day-old New Hampshire cockerels three simple corn-soybean oil meal diets similar in energy and protein content. Fish meal was added to the diets at the rate of 0, 5 and 15 percent and they were fed with or without the supplementation of 0.05 percent DL-methionine. The addition of fish meal did not improve growth of chicks significantly while methionine did. The interaction between fish meal and methionine was found to be significant. Reed et al. (1954) showed that feeding 0.05 percent methionine produced an increase in growth and an improvement in efficiency of feed utilization of day-old New Hampshire chicks and Columbian crosses. Best results were obtained when methionine was added to diets containing 3 percent fish meal or fish solubles. Gordon et al. (1954) fed day-old New Hampshire chicks corn-soybean oil meal diets supplemented with 0.05 percent methionine hydroxy analogue, 2.5 percent fish meal and 2.0 percent dried whey alone or in combination. All of the experimental diets analyzed 20.25 percent protein. The addition of methionine hydroxy analogue or fish meal significantly improved feed efficiency. Sunde et al. (1952) concluded that a combination of DL-methionine and torula yeast was more effective than either supplement in the improvement of rate of growth of day-old New Hampshire male x Single Comb White Leghorn female chicks.

MATERIALS AND METHODS

Three experiments were conducted at the American University of Beirut farm, between April 1962 and April 1963. The farm is located in the Beka'a Valley of Lebanon, 1000 meters above sea level. The Valley is one of the areas with the largest poultry production in Lebanon.

Birds used in all experiments were day-old Rhode Island Red x Barred Plymouth Rock sex-link chicks obtained from a flock maintained at the farm. All chicks were vaccinated with a New Castle disease water-vaccine between 3-14 days of age.

Chicks were started in wire-floored thermostatically-controlled 5-deck brooder batteries. Each deck was 1.20 m. long and 0.80 m. wide with 1.40 m. of feeding space and 0.80 m. of water space. At 4 weeks of age, the chicks were transferred to non-heated wire-floored growing batteries. Each deck was 1.80 m. long and 0.65 m. wide with 3.20 m. of feeding space and 1.06 m. of water space. The battery room temperature in all of the experimental periods ranged between a maximum of 80°F. and a minimum of 55°F. Light was distributed uniformly among different decks through the use of side-wall bulbs. Light was provided 14 hours a day.

The experimental diets were formulated according to the feed-ingredient analysis shown in table 1. Protein, fat, fiber, calcium and phosphorus contents of individual feed ingredients were analysed by the author using AOAC methods of feed analysis. Productive energy, methionine and cystine contents of feed ingredients were based on the "1962 feed ingredient analysis table" published by Nopco Chemical Company.

Methionine content of diet No. 1 used in experiment II was analysed microbiologically by the author according to the following procedure:

A sample containing approximately 50 mg. of nitrogen was transferred into a round-bottom flask connected to a reflux-condenser. Sixty ml. of 2N HCL were added to the sample and the mixture was kept at 110°C. for 8 hours. The contents of the flask were transferred to an evaporating dish and allowed to evaporate until only 3-5 ml. of the sample remained. Fifty ml. of distilled water were then added, the pH was adjusted to 4.0 and the sample was cooled. After 1 hour, the sample was filtered and pH was adjusted to 6.8. The sample was then transferred into a 200 ml. volumetric flask and brought to volume. One ml. of toluene was added and the flask was kept in a refrigerator till further use. An aliquot was then taken and diluted to get a methionine concentration of approximately 4.0 mg. per ml. 0.0, 0.2, 0.4, 0.6, 0.8 and 1.0 ml. of the diluted aliquot were each transferred into 3 test tubes. 0.3, 0.6 and 1.0 ml. of a standard 5.0 mg. of L-methionine per ml. solution were each transferred into 3 test tubes also. The sample volume in each test tube was brought up to 1.0 ml. with the addition of a corresponding volume of distilled water. The test tubes were autoclaved and 1.0 ml. of sterile methionine-free assay medium containing Leuconostoc mesenteroides P-60 ATCC = 8042 bacteria was added to each of the test tubes. The test tubes were then incubated at 37°C. After 3 days of incubation, 2.0 ml. of bromo thymol-blue indicator were added to each of the test tubes and the contents were titrated with 3N NaOH. The NaOH used for neutralization was taken as a measure of the methionine content of the aliquot. The findings were compared to a standard and the methionine content was calculated.

The bacteria-containing medium was prepared according to the following procedure: Bacteria was transferred into a liquid medium and incubated overnight. The medium was transferred into a centrifuge tube and centrifuged for 15 minutes at 3500 revolutions per second. The supernatant medium was decanted and 5.0 ml. of sterile physiological saline solution were added. The tube was shaken to bring the bacteria into solution and one drop of the bacteria-containing saline solution was added to each 5.0 ml. of the sterile methionine-free assay medium. All of the operations were done under sterile conditions.

The medium was prepared by dissolving 10.5 gm. of the solid methionine-free assay medium(Manufactured by Difco Laboratories, Detroit 1, Michigan, USA) in 100 ml. of distilled water.

The diets used in experiments I and II were mixed in 100 lb. batches in a Brower Whirl-Wind feed mixer. Diets used in experiment III were mixed in locally built 50-pound batch mixer. Salt, methionine, vitamins, and minerals were mixed with 3-5 lbs. of ground soybean oil meal and then added to the experimental diets. Water and feed were allowed _ad libitum_. Water was changed and waterers were cleaned daily. Feed was added whenever needed. Care was taken to keep feeders only half-full to avoid any wastage of feed. Sick birds were isolated. Dead chicks were post-mortem examined.

Individual chick weights were recorded at one week intervals in experiments II and III while in experiment I they were weighed at 2-week intervals. All of the experimental chicks were raised to 8 weeks of age. Feed was weighed and feed consumption of each experimental lot was recorded at the time the chicks were weighed. The 8-week body weight gains and feed efficiency figures were analyzed statistically according to the completely randomized block design discussed by Panse and Sukhatme (1961).

Table 1. Analysis of feed ingredients.

Feed Ingredient	PE[2] (Cal/lb.)	Protein[1] (%)	Fat[1] (%)	Fiber[1] (%)	Ca[1] (%)	P[1] (%)	Methionine[2] (%)	Cystine[2] (%)
Ground yellow corn	1140	8.6	2.5	2.1	0.01	0.26	0.17	0.16
Soybean oil meal	560	45.0	0.9	5.5	0.17	0.70	0.79	0.64
Dried skimmilk	525	34.0	1.4	0.0	1.20	1.05	0.86	0.43
Suncured alfalfa meal	250	17.0	2.7	26.0	1.75	0.22	0.33	0.31
Steamed bone meal	200	5.5	1.4	0.0	28.50	15.00	0.20	0.10
Ground limestone	-	-	-	-	38.50	-	-	-

[1]Analyzed by the author.

[2]"1962 feed ingredient analysis table" published by Nopco Chemical Company.

EXPERIMENTAL RESULTS

Experiment I

Purpose

This experiment was conducted to study the effect of adding graded levels of dried skimmilk to a 0.2 percent methionine hydroxy analogue (MHA)-supplemented corn-soybean oil meal diet on the growth and feed efficiency of day-old chicks raised to 8 weeks of age. The experimental period was from April 10, 1962 to June 6, 1962.

Procedure

Seventy two male and the same number of female day-old chicks were weighed individually on a sensitive to one gram scale. They were divided into 12 groups of practically equal average weights. Each group contained 6 male and 6 female chicks. A randomized block design was used with both chick groups and experimental diets randomly assigned to each pen. The composition of experimental diets is shown in table 2. Dried skimmilk was incorporated in the diets at the level of 0.0, 0.5, 1.0, 2.0, 4.0 and 6.0 percent. Each level of dried skimmilk was substituted for an equivalent level of soybean oil meal. MHA was added at the rate of 0.2 percent to bring up the methionine content of the diets to a level considered to be adequate by most workers. Feeding, management, recording of data and statistical analyses were as described in materials and methods.

Results

As it is apparent from table 3, the addition of 2.0 percent dried skimmilk improved live weight gain of chicks during practically all intervals. The poorest body weight gain was attained by birds receiving no dried skimmilk. The addition of 6.0 percent dried skimmilk had a detrimental effect on live weight gain attained by chicks during all intervals. However, the addition of 4.0 percent dried skimmilk could not support live weight gain equal to that produced by 2.0 percent dried skimmilk during the last 2-week period. The addition of 0.5 and 1.0 percent dried skimmilk improved live weight gain during all intervals but not to the extent obtained by the addition of 2.0 percent dried skimmilk.

The ability of different levels of dried skimmilk to improve feed efficiency was variable during different intervals. However, as shown in table 4, the 0-8-week feed efficiency was best when 1.0 or 2.0 percent dried skimmilk was added. Table 4 shows also that the best 0-8-week live weight gain was attained with groups receiving 2.0 percent dried skimmilk. The male and female responses to dried skimmilk supplementation were similar.

The data on 0-8-week live weight gain and feed efficiency was analyzed statistically. The results are shown in table 5. No statistical differences were found to exist among the 0-8-week live weight gain and feed efficiency of chicks receiving different levels of dried skimmilk. The author, however, feels that if not for the great differences encountered between replicates (table 4), the differences among the 0-8-week live weight gain of chicks receiving different levels of dried skimmilk would have been significant. Furthermore, a statistical analysis was made on individual bird basis. Significant statistical differences at the one percent level were found to exist among treatments. The interaction between treatments and pens was found to be statistically significant at the 5 percent level.

Table 2. Composition of experimental diets - Experiment I.

Ingredients	Experimental diets (%)					
	1	2	3	4	5	6
Ground yellow corn	62.30	62.30	62.30	62.30	62.30	62.30
Soybean oil meal	33.50	33.00	32.50	31.50	29.50	27.50
Dried skimmilk	-	.50	1.00	2.00	4.00	6.00
Steamed bone meal	3.00	3.00	3.00	3.00	3.00	3.00
Ground limestone	.50	.50	.50	.50	.50	.50
Salt	.25	.25	.25	.25	.25	.25
Vitamin & mineral mixture[1]	.25	.25	.25	.25	.25	.25
Methionine hydroxy analogue[2]	.20	.20	.20	.20	.20	.20
Calculated composition (%)[3]						
Protein	20.80	20.74	20.68	20.58	20.36	20.14
Fat	1.90	1.90	1.90	1.93	1.93	1.93
Fiber	3.15	3.12	3.10	3.04	2.93	2.82
Calcium	1.11	1.12	1.12	1.12	1.15	1.17
Phosphorus	.84	.84	.85	.85	.86	.86
Methionine	.57	.57	.57	.58	.58	.58
Cystine	.31	.31	.31	.31	.31	.30
Productive energy (Cal./kg.)	1989	1987	1987	1984	1984	1984

[1]The vitamin and mineral premix was obtained from Nopco Chemical Company as Nopcosol M-5. It furnishes the following per lb. of diet: vitamin A, 1750 U.S.P. units; vitamin D_3, 500 I.C.U.; vitamin E, 0.5 I.U.; riboflavin, 1.5 mg.; niacin, 10 mg.; d-pantothenic acid, 2.5 mg.; choline chloride, 100 mg.; vitamin B_{12}, 2.5 mcg.; manganese, 27.2 mg.; zinc, 12.5 mg.; iodine, 0.5 mg.; iron, 9.1 mg.; copper, 0.9 mg.; cobalt, 90.8 mcg.; zinc bacitracin, 2.0 mg.; butylated hydroxy toluene, 56.0 mg.

[2]Methionine hydroxy analogue calcium (90%) was obtained from E.I. Du Pont de Nemours and Co., Inc. under the name of Hydan.

[3]Figures are based on the analysis of individual feed ingredients used in the formulation of experimental diets (see table 1).

Table 3. Effect of different levels of dried skimmilk on average 2-week interval live weight gain and feed/gain - Experiment I.

Period (week)	Skimmilk (%)	Average live weight gain (grams)		Mixed average		
		Males	Females	Weight gain (grams)	Feed consumption (grams)	Feed/gain
0-2	0.0	69	70	70	125	1.8
	0.5	72	64	68	191	2.9
	1.0	76	73	74	183	2.6
	2.0	80	76	78	183	2.4
	4.0	75	66	70	175	2.5
	6.0	67	76	72	125	1.7
2-4	0.0	168	157	162	375	2.5
	0.5	203	162	182	361	2.0
	1.0	180	163	172	375	2.2
	2.0	211	168	190	417	2.2
	4.0	205	174	190	346	1.8
	6.0	180	178	179	350	2.0
4-6	0.0	263	213	238	600	2.6
	0.5	241	194	218	656	3.0
	1.0	244	213	228	550	2.4
	2.0	286	232	259	517	2.2
	4.0	286	236	261	642	2.4
	6.0	271	225	248	612	2.5
6-8	0.0	277	212	244	873	3.5
	0.5	325	241	283	813	2.9
	1.0	312	254	283	833	2.9
	2.0	323	265	294	936	3.2
	4.0	298	202	250	858	3.4
	6.0	290	232	261	888	3.4

Table 4. Effect of different levels of dried skimmilk on 0-8-week average live weight gain and feed/gain - Experiment I.

Skimmilk (%)	Live weight gain (grams)						Mixed average			Mortality[1]
	Males			Females			Weight gain (grams)	Feed consumption (grams)	Feed/gain	
	Rep.1	Rep.2	Ave.	Rep.1	Rep.2	Ave.				
0.0	734	820	777	618	683	650	714	1973	2.82	2
0.5	807	873	840	672	647	660	750	2022	2.68	1
1.0	842	780	811	757	646	702	756	1942	2.58	0
2.0	908	888	898	766	714	740	819	2053	2.58	2
4.0	901	826	864	652	702	677	770	2021	2.62	0
6.0	811	802	806	752	666	709	758	1975	2.60	0

[1] Mortality figures refer to the number of individuals that died out of 24 chicks started per treatment.

Table 5. Analyses of variance of 0-8-week average live weight gain and feed/gain - Experiment I

Source of variation	d.f.	0-8-week live weight gain M. S.	Feed/gain M. S.
Replication[1]	1	630.75	0.0161
Treatment	5	2,321.55	0.0168
Error	5	1,622.75	0.0221

[1] In each replicate there were 6 male and 6 female chicks making a total of 24 chicks per treatment.

Experiment II

Purpose

This experiment was conducted to study the effect of adding graded levels of methionine hydroxy analogue (MHA) to a corn-soybean oil meal diet containing 2.0 percent dried skimmilk on the growth and feed efficiency of day-old chicks raised to 8 weeks of age. The experimental period was from November 21, 1962 to January 16, 1963.

Procedure

One hundred male and the same number of female day-old chicks were weighed individually on a sensitive to one gram scale. They were divided into 10 groups of practically equal average weights. Each group contained 10 male and 10 female chicks. A randomized block design was used with both chick groups and experimental diets randomly assigned to each pen. The composition of experimental diets is shown in table 6. MHA was incorporated in the diets at the rate of 0.00, 0.05, 0.10, 0.15 and 0.20 percent. Each level of MHA was substituted for an equivalent level of soybean oil meal. Feeding, management, recording of data and statistical analyses were as described in materials and methods.

Results

The effect of different levels of MHA on the 2-week interval live weight gain and feed efficiency is shown in table 7. The responses of chicks to different treatments were variable during different intervals. However, as it is shown in table 8, addition of 0.10 percent MHA gave the best live weight gain and feed efficiency among treatments tested. The poorest live weight gain and feed efficiency were obtained by birds receiving 0.20 percent MHA. Addition of 0.05 and 0.15 percent MHA slightly reduced live weight gain as compared to that obtained by chicks receiving no MHA. Also, the addition of 0.15 percent MHA slightly increased feed efficiency of chicks as compared to that attained with no MHA added. The male and female responses to MHA supplementation were practically similar.

Table 9 shows that the addition of MHA failed to improve significantly live weight gain and feed efficiency of day-old chicks raised to 8 weeks of age. These findings are contrary to expectation since experimental diet No. 1 contained sub-optimum (0.39 percent) level of methionine according to calculation. An explanation of these findings will be presented in the general discussion.

Table 6. Composition of experimental diets - Experiment II.

Ingredients	Experimental diets (%)				
	1	2	3	4	5
Ground yellow corn	60.00	60.00	60.00	60.00	60.00
Soybean oil meal	32.00	31.95	31.90	31.85	31.80
Dried skimmilk	2.00	2.00	2.00	2.00	2.00
Suncured alfalfa meal	2.00	2.00	2.00	2.00	2.00
Steamed bone meal	3.00	3.00	3.00	3.00	3.00
Ground limestone	.50	.50	.50	.50	.50
Salt	.25	.25	.25	.25	.25
Vitamin & mineral mixture[1]	.25	.25	.25	.25	.25
Methionine hydroxy analogue[2]	.00	.05	.10	.15	.20
Calculated composition (%)[3]					
Protein	20.74	20.77	20.80	20.82	20.85
Fat	1.87	1.87	1.87	1.87	1.87
Fiber	3.54	3.54	3.54	3.54	3.54
Calcium	1.16	1.16	1.16	1.16	1.16
Phosphorus	.85	.85	.85	.85	.85
Methionine	.39	.42	.49	.54	.59
Cystine	.32	.32	.32	.32	.32
Productive energy (Cal./kg.)	1947	1947	1945	1945	1945

[1]The vitamin and mineral premix was obtained from Nopco Chemical Company as Nopcosol M-5. It furnishes the following per lb. of diet: vitamin A, 1750 U.S.P. units; vitamin D_3,500 I.C.U.; vitamin E, 0.5 I.U.; riboflavin, 1.5 mg.; niacin, 10 mg.; d-pantothenic acid, 2.5 mg.; choline chloride, 100 mg.; vitamin B_{12}, 2.5 mcg.; manganese, 27.2 mg.; zinc, 12.5 mg.; iodine, 0.5 mg.; iron, 9.1 mg.; copper, 0.9 mg.; cobalt, 90.8 mcg.; zinc bacitracin, 2.0 mg.; butylated hydroxy toluene, 56.0 mg.

[2]Methionine hydroxy analogue calcium (90%) was obtained from E.I. Du Pont de Nemours and Co., Inc. under the name of Hydan.

[3]Figures are based on the analysis of individual feed ingredients used in the formulation of experimental diets (see table 1).

Table 7. Effect of different levels of methionine hydroxy analogue on average 2-week interval live weight gain and feed/gain - Experiment II.

Period (week)	MHA[1] (%)	Average live weight gain (grams)		Mixed average		
		Males	Females	Weight gain (grams)	Feed consumption (grams)	Feed/gain
0-2	.00	74	70	72	153	2.14
	.05	70	64	67	136	2.04
	.10	76	74	75	159	2.12
	.15	72	68	70	142	2.02
	.20	70	64	67	136	2.02
2-4	.00	182	154	168	369	2.20
	.05	183	140	162	358	2.22
	.10	178	158	168	386	2.30
	.15	179	142	160	392	2.44
	.20	178	152	165	363	2.21
4-6	.00	278	222	250	602	2.40
	.05	275	225	250	613	2.46
	.10	269	224	246	568	2.30
	.15	294	210	252	602	2.39
	.20	273	219	246	585	2.38
6-8	.00	366	272	319	1022	2.92
	.05	346	270	308	982	2.89
	.10	370	296	333	1022	2.80
	.15	364	260	312	993	2.89
	.20	316	259	288	986	3.22

[1]Methionine hydroxy analogue calcium (90%).

Table 8. Effect of different levels of methionine hydroxy analogue on 0-8-week average live weight gain and feed/gain - Experiment II.

MHA (%)	Live weight gain (grams)						Mixed average			Mortality[1]
	Males			Females			Weight gain (grams)	Feed consumption (grams)	Feed/gain	
	Rep.1	Rep.2	Ave.	Rep.1	Rep.2	Ave.				
.00	918	879	898	715	721	718	808	2145	2.56	0
.05	867	882	874	700	698	699	786	2088	2.55	0
.10	933	854	894	749	756	752	823	2134	2.50	0
.15	936	883	910	635	723	679	794	2128	2.58	0
.20	834	843	838	693	694	694	766	2070	2.63	2

[1] Mortality figures refer to the number of individuals that died out of a total of 40 chicks started per treatment.

Table 9. Analyses of variance of 0-8-week average live weight gain and feed/gain - Experiment II.

Source of variation	d. f.	0-8-week live weight gain M. S.	Feed/gain M. S.
Replication[1]	1	62.50	.0079
Treatment	4	927.90	.0044
Error	4	221.00	.0039

[1] In each replicate there were 10 male and 10 female chicks making a total of 40 chicks per treatment.

Experiment III

Purpose

This experiment was conducted to study the effects of adding 2.0 percent dried skimmilk and 0.1 percent MHA singly or in combination to an all-plant corn-soybean oil meal diet on the growth and feed efficiency of chicks from day-old to 8 weeks of age. The experimental period was from February 20, 1963 to April 17, 1963.

Procedure

Ninety six day-old male chicks were weighed individually on a sensitive to one gram scale. They were divided into 8 groups of equal average weight. Each group contained 12 chicks. A randomized block design was used with both chick groups and experimental diets randomly assigned to each pen. The composition of experimental diets is shown in table 10. Two percent dried skimmilk was incorporated in diets 3 and 4. MHA was incorporated at the rate of 0.1 percent in diets 2 and 4. Experimental diet No. 1 did not contain any supplement. Feeding, management, recording of data and statistical analyses were as described in materials and methods.

Results

The effect of dried skimmilk and MHA on live weight gain obtained during the 2-4 and 4-6 week of age period is shown in table 11. During the two intervals, the addition of either 2.0 percent dried skimmilk or

0.1 percent MHA did not affect live weight gain appreciably, but the addition of both supplements increased live weight gain during these periods. The efficiency of feed utilization of chicks receiving different treatments was inconsistent during the 0-2 and 2-4 week intervals. During the 4-6 and 6-8 week intervals, however, the addition of 0.1 percent MHA improved feed efficiency.

Table 12 shows the 0-8-week live weight gain and feed efficiency of chicks receiving different treatments. Addition of both dried skimmilk and MHA produced the best gain. Addition of 2.0 percent dried skimmilk improved live weight gain slightly while the addition of 0.1 percent MHA did not have any effect. The incorporation of dried skimmilk and MHA singly or in combination improved feed efficiency slightly.

The data on 0-8-week live weight gain and feed efficiency was analyzed statistically. The results are shown in table 13. No statistically significant differences were found to exist among the 0-8-week live weight gain and feed efficiency of chicks receiving different treatments.

Table 10. Composition of experimental diets - Experiment III.

Ingredients	Experimental diets (%)			
	1	2	3	4
Ground yellow corn	62.00	62.00	62.00	62.00
Soybean oil meal	33.00	32.90	31.00	30.90
Suncured alfalfa meal	1.00	1.00	1.00	1.00
Dried skimmilk	-	-	2.00	2.00
Steamed bone meal	3.00	3.00	3.00	3.00
Ground limestone	.50	.50	.50	.50
Salt	.25	.25	.25	.25
Vitamin & mineral mixture[1]	.25	.25	.25	.25
Methionine hydroxy analogue[2]	-	.10	-	.10
Calculated composition (%)[3]				
Protein	20.51	20.56	20.29	20.34
Fat	1.92	1.92	1.93	1.93
Fiber	3.38	3.37	3.26	3.26
Calcium	1.12	1.12	1.13	1.13
Phosphorus	.84	.84	.85	.85
Methionine	.37	.47	.37	.47
Cystine	.31	.31	.31	.31
Productive energy (Cal./kg.)	1980	1980	1978	1978

[1]The vitamin and mineral premix was obtained from Nopco Chemical Company as Nopcosol M-5. It furnishes the following per lb. of diet: vitamin A, 1750 U.S.P. units; vitamin D_3, 500 I.C.U.; vitamin E, 0.5 I.U.; riboflavin, 1.5 mg.; niacin, 10 mg.; d-pantothenic acid, 2.5 mg.; choline chloride, 100 mg.; vitamin B_{12}, 2.5 mcg.; manganese, 27.2 mg.; zinc, 12.5 mg.; iodine, 0.5 mg.; iron, 9.1 mg.; copper, 0.9 mg.; cobalt, 90.8 mcg.; zinc bacitracin, 2.0 mg.; butylated hydroxy toluene, 56.0 mg.

[2]Methionine hydroxy analogue calcium (90%) was obtained from E.I. Du Pont de Nemours and Co., Inc. under the name of Hydan.

[3]Figures are based on the analysis of individual feed ingredients used in the formulation of experimental diets (see table 1).

Table 11. Effect of the interaction of dried skimmilk and methionine hydroxy analogue on average 2-week interval live weight gain and feed/gain - Experiment III.

Period (week)	Dried skimmilk (%)	MHA[1] (%)	Average live weight gain (grams)		Mixed average		
			Rep. 1	Rep. 2	Weight gain (grams)	Feed consumption (grams)	Feed/gain
0-2	0.0	0.0	58	61	60	166	2.77
	0.0	0.1	53	52	52	175	3.32
	2.0	0.0	64	66	65	175	2.71
	2.0	0.1	60	63	62	170	2.78
2-4	0.0	0.0	196	196	196	326	1.66
	0.0	0.1	173	179	176	345	1.96
	2.0	0.0	194	194	194	345	1.78
	2.0	0.1	204	203	204	374	1.84
4-6	0.0	0.0	278	270	274	695	2.54
	0.0	0.1	264	274	269	624	2.32
	2.0	0.0	276	258	269	662	2.49
	2.0	0.1	286	295	290	681	2.44
6-8	0.0	0.0	345	300	322	993	3.09
	0.0	0.1	338	357	348	984	2.83
	2.0	0.0	342	351	346	1017	2.94
	2.0	0.1	317	344	330	982	2.98

[1] Methionine hydroxy analogue calcium (90%).

Table 12. Effect of the interaction of dried skimmilk and methionine hydroxy analogue on 0-8-week average live weight gain and feed/gain - Experiment III.

Dried skimmilk (%)	MHA (%)	Live weight gain (grams)		Mixed average			Mortality[1]
		Rep. 1	Rep. 2	Weight gain (grams)	Feed consumption (grams)	Feed/gain	
0.0	0.0	818	767	792	2180	2.75	0
0.0	0.1	775	810	792	2128	2.68	0
2.0	0.0	812	803	808	2199	2.72	0
2.0	0.1	807	841	824	2207	2.72	1

[1] Mortality figures refer to the number of individuals that died out of a total of 24 chicks started per treatment.

Table 13. Analyses of variance of 0-8-week average live weight gain and feed/gain - Experiment III.

Source of variation	d. f.	0-8-week live weight gain M. S.	Feed/gain M. S.
Replication[1]	1	10.13	.0078
Treatment	3	451.13	.0020
Error	3	840.46	.0232

[1] In each replicate there were 12 male chicks making a total of 24 chicks per treatment.

GENERAL DISCUSSION

Dried Skimmilk in Chick Starter Diets

The effect of different levels of dried skimmilk on 2-week interval live weight gain and feed efficiency is shown in table 3. Chicks receiving 2.0 percent dried skimmilk had the highest live weight gain during all intervals except the 4-6-week interval. Live weight gain of chicks receiving 4.0 percent dried skimmilk compared favorably with those receiving 2.0 percent, except during the last 6-8-week interval. Addition of 0.5 and 1.0 percent dried skimmilk improved live weight gain over that attained by chicks receiving no dried skimmilk. The incorporation of 6.0 percent dried skimmilk decreased live weight gain as compared to what was attained by chicks receiving 2.0 and 4.0 percent dried skimmilk. The same trends were observed with the 0-8-week live weight gain shown in table 4. Table 4 shows also that feed efficiency was best when 1.0 or 2.0 percent dried skimmilk was added.

Similar results have been obtained by Ott _et al._ (1939) who found that among different levels of dried skimmilk used in rations containing 13 percent animal protein, the largest live weight gain was attained by chicks receiving 1.25 and 2.50 percent dried skimmilk. The work of Hammond and Titus (1944), who found that the incorporation of 3.0 to 5.0 percent dried skimmilk in all-plant diets improved growth of day-old chicks, can be considered as further support for these results.

The effect of dried skimmilk on live weight gain and feed efficiency is not only due to essential amino acids, water soluble vitamins and possibly unidentified growth factors, but also partly due to its improvement of the palatability of corn-soybean oil meal diets. The depression in the live weight gain of chicks receiving 6.0 percent dried skimmilk was probably due to the increased dustiness of the diets which caused a reduced feed intake. The smaller amount of feed consumed by chicks receiving 6.0 percent dried skimmilk was utilized practically as efficiently as the feed consumed by chicks receiving 1.0, 2.0 and 4.0 percent of the same supplement.

MHA Supplementation of Chick Starter Diets

The effect of different levels of MHA on the 2-week interval live weight gain and feed efficiency is shown in table 7. The responses of chicks to different treatments were variable during the different intervals. However, the 0-8-week live weight gain and feed efficiency, which are shown in table 8, followed a certain trend. The highest live weight gain and the best feed efficiency were attained by chicks receiving 0.10 percent MHA. The poorest live weight gain and feed efficiency were attained by chicks receiving 0.20 percent MHA. Addition of 0.05 and 0.15 percent MHA slightly reduced live weight gain as compared to that attained by chicks receiving no MHA. These results are contrary to the work of most workers.

The failure to increase significantly live weight gain with the addition of different levels of MHA lead the author to determine the actual methionine content of diet No. 1 shown in table 6. Using the procedure explained in materials and methods, the methionine content of the diet was found to be 0.44 percent. This level, if added to the amount of cystine found in the diet, brings up the total sulfur-containing amino acids to 0.76 percent of the diet which Milligan <u>et al</u>. (1951) and Nelson <u>et al</u>.(1960) considered adequate for chick growth. The differences in the 0-8-week live weight gain and feed efficiency may therefore be attributed to normal non-treatment variations usually encountered in animal experimentation. However, in agreement with NRC standard, the author tends to consider 0.80 percent sulfur-containing amino acids as the required level in chick starter diets. On this basis the results can be explained as follows:

Addition of 0.05 percent MHA brings the total sulfur-containing amino acids up to 0.81 percent. No appreciable improvement in growth can be expected with this addition. This is in agreement with the work done by Titus <u>et al</u>.(1955) who reported that the addition of 0.05 percent DL-methionine failed to improve feed efficiency of male and female chicks and that it reduced the weight of female chicks. In a second experiment, the same workers found that the addition of 0.05 percent DL-methionine had no effect on growth and feed efficiency. The incorporation of 0.10 percent MHA brings the sulfur-containing amino acids content up to 0.86 percent which is adequate, thus improving live weight gain and feed efficiency in the present experiments. This is in agreement with the work of Almquist and Grau (1945) who found that substituting a part of cystine with methionine so that the total methionine content of the diet was 0.55 percent improved live weight gain. The incorporation of 0.15 percent MHA produced an amino acid imbalance which caused a slight depression of live weight gain and feed efficiency. The addition of 0.20 percent MHA produced a severe amino acid imbalance which manifested itself by the lowest live weight gain and feed efficiency of all experimental groups. The imbalance was probably also a result of marginal levels of both lysine and glycine.

Dried Skimmilk-MHA Interaction in Chick Starter Diets

The effects of the interaction between dried skimmilk and MHA on live weight gain during the 2-4 and 4-6 week periods is shown in table 11. The highest live weight gain was attained by chicks receiving a combination of 2.0 percent dried skimmilk and 0.1 percent MHA. During the 0-2-week period and the 6-8-week period, the effect of the interaction on live weight gain of chicks was not clear. Feed efficiency during different periods was inconsistent. Table 12 shows that the addition of both supplements produced the highest 0-8-week live weight gain. The addition of 2.0 percent dried skimmilk improved live weight gain slightly, while the incorporation of 0.1 percent MHA did not have any effect. Table 12 shows that the addition of dried skimmilk and MHA singly or in combination improved feed efficiency slightly.

The author did not find any literature on the interaction between dried skimmilk and MHA in chick starter diets. However, a few experiments where methionine was found to interact with fish meal in promoting growth and improving feed efficiency were conducted by Rosenberg _et al._ (1955 b.) and Reed _et al._ (1954). Dried skimmilk, aside from its deficiency in arginine and glycine, compares favorably with fish meal. The absence of interaction between dried skimmilk and MHA during the last 6-8-week period suggests decreasing requirements with increase in age.

The failure of chicks to respond to 0.1 percent MHA supplementation as far as the total 0-8-week live weight gain is concerned was due to the absence of dried skimmilk in the diets which resulted in low feed intake, and hence a low methionine consumption. The failure of chicks to respond to 2.0 percent dried skimmilk supplementation during the same period was due to low methionine content of the diet which prevented maximum growth inspite of the palatability imparted by dried skimmilk. The same reasoning applies to the trends encountered in the 2-4 and 4-6 week interval live weight gain shown in table 12.

SUMMARY AND CONCLUSION

Three experiments with day-old Rhode Island Red x Barred Plymouth Rock chicks were conducted at the American University of Beirut farm. The first experiment tested the effect of 0.0, 0.5, 1.0, 2.0, 4.0 and 6.0 percent dried skimmilk on live weight gain and feed efficiency of chicks raised to 8 weeks of age when incorporated in a corn-soybean oil meal diet supplemented with 0.2 percent MHA. The second experiment was designed to study the effect of .00, .05, .10, .15 and .20 percent MHA in a corn-soybean oil meal diet containing 2.0 percent dried skimmilk. The third experiment was conducted to study possible interactions between 2.0 percent dried skimmilk and 0.1 percent MHA both added to an all-plant corn-soybean diet.

The results of the first experiment showed that among the different levels of dried skimmilk tested, 2.0 percent produced the highest live weight gain and most efficient feed utilization. The second experiment proved that the incorporation of 0.1 percent MHA produced the best live weight gain and feed efficiency. The third experiment indicated a possible interaction between 2.0 percent dried skimmilk and 0.1 percent MHA in promoting growth and improving feed efficiency.

It is concluded that among all dietary treatments studied, a combination of 2.0 percent dried skimmilk and 0.1 percent MHA produces the best live weight gain and most efficient feed utilization of RIR x BPR day-old chicks raised to 8 weeks of age on an all-plant corn-soybean oil meal diet.

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