EVALUATION OF SESAME MEAL AS A SOURCE OF PROTEIN FOR BROILERS

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A THESIS

Submitted to the
AMERICAN UNIVERSITY OF BEIRUT

In partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE IN
AGRICULTURE
June 1966

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Date Thesis is presented: June 1, 1966.

SESAME MEAL FOR BROILERS

ULLAH

ACKNOWLEDGEMENTS

The author is grateful to the advisor and members of the committee as well as the poultry staff at A.R.E.C. for their encouragement and cooperation.

AN ABSTRACT OF THE THESIS OF

Mohammad Fahim Ullah for M.S. in Poultry Production

Title: Evaluation of sesame meal as a source of protein for broilers.

Protein supplements make up about 30 percent of a broiler ration and are very expensive compared to other ingredients of the ration. Any successful attempt to reduce the cost of protein supplements will reduce the cost of broiler production. Sesame meal is a rich source of protein and is available at a relatively low cost in the Middle East, but there is no information available concerning the nutritive value of sesame meal produced in this area.

The objective of this work was to determine the nutritive value of Middle Eastern sesame meal and its possible use in practical broiler rations. Five feeding experiments were conducted using sesame meal either as the sole source of protein in a semi-purified chick diet or as a protein supplement in a practical broiler ration. The economic phase of the study consisted of determining net returns per broiler over feed cost. The proximate composition of the meals including calcium and phosphorous was also determined.

The results of these experiments indicate that lysine is the most limiting amino acid in sesame meal. Supplementation of a sesame meal semi-purified diet with DL-methionine, L-histidine, L-leucine, DL-phenylalanine, DL-threonine, and DL-valine singly did not affect growth but improved feed efficiency. It was found that sesame meal can replace 50 percent of the soybean meal in a practical broiler ration. Supplementation of an all-sesame meal ration with L-lysine HCl improved growth significantly. Rations containing equal amounts of soybean meal and sesame meal gave maximum net returns per broiler over feed cost.

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I. INTRODUCTION

Sesame (*Sesamum indicum*) also known as benne, gingili and til or teel, is used for the production of oil and protein foods and feeds. It is believed to have originated in the East. The leading countries in the production of sesame are India, Iraq, Egypt and Pakistan. Sesame meal or cake is the by-product of the production of oil from sesame seeds which can be either black or white.

Feed constitutes about 68 percent of the total cost of broiler production in Lebanon (Ward and Fuleihan, 1962). Protein supplements make up about 30 percent of a broiler ration and they are generally the most expensive part of the ration. Protein supplements vary in price, however, so if a high priced supplement can be replaced by a lower priced supplement the cost of broiler production is thereby reduced.

Sesame meal is a protein-rich feed available at a relatively low price in several countries of the Middle East. Most of this meal in Lebanon is imported from Iraq. Sesame meal is known to be high in methionine but deficient in lysine. Hence it cannot be fed as the sole protein supplement in a broiler ration.

Many investigations have been made to determine the nutritive value of sesame meal and the extent to which it can replace soybean meal in poultry rations. No research has been done however, to evaluate sesame meal as a source of protein for broilers in the Middle East.

The objective of the present work was to evaluate the nutritive value of Iraqi produced sesame meal as a source of protein for broilers. Sesame meal samples were analyzed for proximate composition including calcium and phosphorous. Feeding experiments were conducted in both battery cages and floor pens. In the practical floor pen feeding experiments the possibility of replacing soybean meal partially or completely with sesame meal was studied along with lysine supplementation of this meal. Amino acid limitations of sesame meal fed in a semi-purified diet at 10 and 20 percent protein levels were also studied.

II. REVIEW OF LITERATURE

Several research papers have been published on the nutritive value of sesame meal and the extent to which it can replace soybean meal in practical poultry rations.

Grau and Almquist (1944) stated that chicks fed a basal diet containing 20 percent protein supplied from the sesame meal showed poor chick growth. When the basal diet was supplemented with 10 percent casein or 0.50 percent lysine, optimal growth was obtained. According to the above workers, the chick requirement of lysine is 0.9 percent, only half of this amount is provided by 20 percent sesame protein in the ration. Almquist and Grau (1944) in another experiment showed mutual supplementary effect of sesame meal and soybean meal. Soybean meal, sesame meal and a combination of the two were fed to White Leghorn chicks to supply 20 percent protein. The results showed that best gains were obtained at the sesame-soybean protein ratio of 7:13. Chicks fed on sesame meal alone as a source of protein showed poor growth. Sesame meal contains about 1.4 percent methionine as compared with 0.78 percent in soybean meal. The requirement of the sulfur containing amino acids by the chick for optimal growth is 0.8 percent.

Patrick (1953) observed increased growth rate of chicks by the supplementation of 30 percent sesame meal diet with lysine and vitamin B_{12}. The growth rate, however, was not as high as that of the soybean meal or milk albumin diets. It was observed that soybean meal produced better growth rate and feather development than any of the groups fed sesame meal. It was also noted that sesame meal, aside from lysine, is also lacking in some other factors which are found in soybean meal and milk albumin. Patrick (1953) further showed that these factors which are present in soybean meal are water soluble, unstable to acid treatment and are destroyed by prolonged enzymic treatment.

Kick and Marinus (1960) conducted growth and metabolism experiments with young rats by feeding them diets composed of fat-extracted sesame seed and meal with and without supplementation of lysine, threonine and vitamin B_{12}. Addition of lysine, lysine and threonine and buffalo fish improved growth and protein utilization of sesame seed and sesame meal. Lysine and threonine raised the biological value and net utilization of sesame seed. Vitamin B_{12} did not improve the lysine and threonine supplemented rations. The results of these experiments indicate that the proteins of commercial sesame seed and meal can be further improved by supplementation with lysine, threonine and buffalo fish. The addition of lysine was in agreement with reports by Grau and Almquist (1944) who found optimal chick growth when 0.5 percent L-lysine HCl was added to an all-sesame protein ration.

Squibb and Braham (1955) used blood meal as a source of lysine to supplement sesame meal diets in chick experiments. Blood meal being a poor quality protein is a good lysine supplement in all-plant protein rations for chicks. Feed conversion was highest in the chick groups fed either 2 or 4 percent blood meal. In another experiment, it was observed that 3 percent dried blood meal was necessary for optimum growth on a ration containing 35 to 40 percent sesame meal.

Lease _et al_. (1960) showed a decrease in biological availability of zinc when the chicks were fed sesame meal. Chicks fed a sesame meal ration showed poor growth rate and developed leg deformities similar to those reported in zinc deficiency even though they received added zinc in the salt mixture. Chicks fed autoclaved sesame meal diets having 30 p.p.m. of added zinc showed a significant gain in weight and reduction in leg deformities as compared with non-treated sesame meal. The addition of a chelating agent ethylenediamine tetraacetic acid (EDTA) to the sesame meal diet resulted in an increase in growth rate and reduction in leg deformities comparable with the addition of 60 to 120 p.p.m. of zinc. Since the sesame meal in the diet contained 45 p.p.m. of zinc, sufficient quantities of EDTA was capable of releasing the zinc from its sesame meal bond. The addition of zinc to the isolated soybean meal diet did not result in a significant improvement in growth. It was observed that not only the zinc present in sesame meal but also added zinc is of low availability to chicks.

III. MATERIALS AND METHODS

Experimental Animals

Nine hundred and two, day-old male broiler type chicks (Cornish male x Plymouth Rock female) used in these studies were obtained from a commercial hatchery. Sixty three chicks were used in experiment I and 189 chicks were used in experiment II. In experiments III and IV 225 chicks were used in each while 200 chicks were used in experiment V.

Methods of Feeding and Management

In experiments I and II chicks were started on wire floored, thermostatically controlled 5-deck electric battery brooders. Each deck was divided into 2 equal parts and each part was designated as 1 pen. The room temperature ranged between 60°F and 80°F and light was distributed uniformally among different decks through the use of vertical side wall bulbs for 24 hours daily. In experiment I chicks were divided into 9 groups of equal average weight, while in experiment II they were divided into 27 groups with 7 chicks in each group.

All the chicks in experiments III, IV and V were raised in floor pens using a completely randomized design.

The house was divided into 10 pens, 9 of which were used in experiments III and IV while 10 pens were used in experiment V. Chicks were brooded with infra-red lamps for 4 weeks and kept in the same pen till 8 weeks of age. Light was provided for 24 hours using ceiling light bulbs. Chicks were randomly divided on approximately equal weight basis in triplicate groups of 25 chicks each in experiments III and IV, and in duplicate groups of 20 chicks each in experiment V.

In all experiments, chicks were weighed and wing-banded individually and vaccinated against Newcastle disease with a water vaccine at 2 weeks of age. Feed and water were provided <u>ad libitum</u>. Semi-purified diets were used in experiments I and II having sesame meal as the only source of protein, while the rations for experiments III, IV and V were prepared from natural feeds.

Proximate Analysis

Sesame meal was obtained from Iraq in 2 consignments. Calcium and phosphorous were determined using the methods described by the Association of Official Agricultural Chemists (1960). For the nitrogen determination, Kjeldahl method was used and crude protein was calculated by multiplying percent nitrogen by 6.25. The nitrogen free extract (NFE) was calculated by using the following formula:

% NFE = 100 - (% water + % ether extract + % crude fiber +

% crude protein + % ash).

Records and Experimental Data

At one week intervals, individual chick weights were recorded and pen feed consumption calculated. Daily mortality records were kept for each pen. The chick groups and experimental diets were assigned randomly to each pen. Data of all experiments were statistically analyzed according to Snedecor (1956). Multiple comparisons were made using the method of Duncan (1955).

Experimental Rations

Experimental diets were formulated using the feed composition tables compiled by Hubbell (1963). Composition of the rations used in experiments I and II are shown in Tables 1 and 2 while those used in experiments III, IV and V are shown in Tables 3, 4 and 5, respectively.

In experiment I, a semi-purified diet having approximately 20 percent protein from sesame meal was supplemented with L-lysine HCl or L-histidine in order to bring the levels of these amino acids up to the chick's requirement as recommended by the National Research Council (NRC, 1960) In experiment II, a similar diet containing 10 percent protein from sesame meal was supplemented with L-lysine HCl, DL-methionine, L-histidine, L-leucine, DL-phenylalanine, DL-threonine and DL-valine singly and in combination to make the particular amino acid content equal to that of the chick's requirement.

In experiment III, 0, 33 and 100 percent of the soybean meal was replaced by 0, 10 and 30 percent sesame meal, respectively. The ration containing 30 percent sesame meal was supplemented with 0.50 percent L-lysine HCl in order to raise the level of lysine to that of the chick's requirement. In experiment IV, 50, 66 and 100 percent of the soybean meal was replaced by 15, 20 and 30 percent sesame meal, respectively; while in experiment V, 0, 15, 15, 20 and 30 percent of the soybean meal was replaced by corresponding percentages of sesame meal. Three of the last mentioned rations, namely 15, 20 and 30, were supplemented with 0.46, 0.64 and 1.00 percent lyamine, respectively. Lyamine is a commercial "Merck" product containing 50 percent pure L-lysine HCl.

Table 1 - Composition of experimental diets (%) - Experiment I.

Ingredients	Diet number		
	1	2	3
Sesame meal	50.00	50.00	50.00
Dextrose	41.46	41.00	41.40
Mineral mixture[1]	5.30	5.30	5.30
Vitamin mixture[2]	1.00	1.00	1.00
Choline chloride	0.25	0.25	0.25
Corn oil	2.00	2.00	2.00
L-lysine-HCl	-	0.35	-
L-histidine	-	-	0.04

[1] The mineral mixture provided the following per kg. of diet: Ca, 11.0 gm; P, 4.18 gm; Mn, 111 mg; I_2, 2.5 mg; Fe, 40.6 mg; Cu, 3.8 mg; Zn, 0.24 mg; Co, 0.37 mg; K, 0.04 mg; Mg, 657.8 mg.

[2] The vitamin mixture provided the following per kg. of diet: Vitamin A, 9988 IU; vitamin D_3, 1498 ICU; vitamin E, 22 mg; menadione, 4.4 mg; PABA, 66 mg; inositol, 132 mg; folic acid, 3.3 mg; biotin, 220 mcg; thiamine, 4.4 mg; niacin, 88 mg; pantothenate, 22 mg; vitamin B_{12}, 22 mcg; pyridoxine, 4.4 mg; ascorbic acid, 220 mg.

Table 2 - Composition of experimental diets (%) - Experiment II.

Ingredients	Diet number								
	1	2	3	4	5	6	7	8	9
Sesame meal	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Dextrose	66.45	63.43	65.77	66.00	66.25	65.82	65.90	66.22	66.17
Mineral mixture[1]	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30
Vitamin mixture[2]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Choline chloride	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Corn oil	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
L-lysine-HCl	-	0.68	0.68	-	-	-	-	-	-
DL-methionine	-	0.45	-	0.45	-	-	-	-	-
L-histidine	-	0.20	-	-	0.20	-	-	-	-
L-leucine	-	0.63	-	-	-	0.63	-	-	-
DL-phenylalanine	-	0.55	-	-	-	-	0.55	-	-
DL-threonine	-	0.23	-	-	-	-	-	0.23	-
DL-valine	-	0.28	-	-	-	-	-	-	0.28

1 For composition see footnote in Table 1.

2 For composition see footnote in Table 1.

Table 3 - Composition of experimental diets (%) - Experiment III.

Ingredients	Diet number 1	2	3
Yellow corn	62.25	63.00	64.00
Soybean meal (44% protein)	30.00	20.00	-
Sesame meal	-	10.00	30.00
Fish meal (65% protein)	2.00	2.00	2.00
Alfalfa meal (17% protein)	2.00	2.00	2.00
Steamed bone meal	2.25	1.25	-
Limestone	1.00	1.25	1.00
Salt	0.25	0.25	0.25
Vitamin and mineral mixture[1]	0.25	0.25	0.25
L-lysine-HCl	-	-	0.50
Calculated composition[2] (%)			
Protein	20.30	19.96	19.27
Methionine	0.39	0.45	0.57
Cystine	0.36	0.36	0.36
Lysine	1.10	0.94	1.10
Productive energy (Cal./kg.)	1998	2046	2088

1 Vitamin and mineral mixture was obtained from Nopco Chemical Company as Nopcosol M-5. It furnishes the following per kg. of diet: Vitamin A, 3850 USP; vitamin D_3, 1100 ICU; vitamin E, 1.1 IU; riboflavin, 3.3 mg; niacin, 22 mg; pantothenic acid, 5.5 mg; choline chloride, 220 mg; vitamin B_{12}, 5.5 mcg; manganese, 59.8 mg; zinc, 27.5 mg; iodine, 1.1 mg; Fe, 20.0 mg; Cu, 1.98 mg; Co, 199.76 mcg; zinc bacitracin, 4.4 mg; BHT, 123.2 mg.

2 Figures are based on the feed composition tables provided by Hubbell (1963).

Table 4 - Composition of experimental diets (%) - Experiment IV.

Ingredients	Diet number 1	2	3
Yellow corn	63.00	63.00	64.50
Soybean meal (44% protein)	15.00	10.00	-
Sesame meal	15.00	20.00	30.00
Fish meal (65% protein)	2.00	2.00	2.00
Alfalfa meal (17% protein)	2.00	2.00	2.00
Steamed bone meal	1.50	1.50	-
Limestone	1.00	1.00	1.00
Salt	0.25	0.25	0.25
Vitamin and mineral mixture[1]	0.25	0.25	0.25
Calculated composition[2] (%)			
Protein	19.76	19.56	19.31
Methionine	0.48	0.51	0.57
Cystine	0.37	0.37	0.36
Lysine	0.87	0.78	0.62
Productive energy (Cal./kg.)	2059	2072	2090

[1] For composition see footnote in Table 3.

[2] See footnote in Table 3.

Table 5 - Composition of experimental diets (%) - Experiment V.

Ingredients	Rations				
	I	II	III	IV	V
Yellow corn	62.25	63.00	62.54	62.36	63.50
Soybean meal	30.00	15.00	15.00	10.00	-
Sesame meal	-	15.00	15.00	20.00	30.00
Fish meal (65% protein)	2.00	2.00	2.00	2.00	2.00
Alfalfa meal (17% protein)	2.00	2.00	2.00	2.00	2.00
Steamed bone meal	2.25	1.50	1.50	1.50	-
Limestone	1.00	1.00	1.00	1.00	1.00
Salt	0.25	0.25	0.25	0.25	0.25
Vitamin and mineral mixture[1]	0.25	0.25	0.25	0.25	0.25
Lyamine	-	-	0.46	0.64	1.00
Calculated composition[2] (%)					
Protein	20.30	19.76	19.76	19.56	19.27
Methionine	0.39	0.48	0.48	0.51	0.57
Cystine	0.36	0.37	0.37	0.37	0.36
Lysine	1.10	0.87	1.10	1.10	1.10
Productive energy (Cal./kg.)	1998	2059	2059	2072	2088

1 For composition see footnote in Table 3.

2 See footnote in Table 3.

IV. RESULTS AND DISCUSSION

Chemical Composition

The data presented in Table 6 shows the chemical composition of the 2 Iraqi sesame meal samples and 1 soybean meal sample from the U.S.A. When compared with soybean meal sesame meal is lower in protein and higher in ether extract, crude fiber, calcium and phosphorous. The sesame meal samples varied in protein from 37.93 to 39.24 percent and in crude fiber from 6.90 to 8.15 percent. Differences in composition may be attributed to different condition in processing. Table 6 shows that sesame meal produced in U.S.A. is higher in protein as compared with that produced in India and Iraq. Sesame meal from India and U.S.A. is high in fat while that produced in Iraq and U.S.A. is higher in fiber.

Experiment I

The experiment was designed to study the effect of supplementing sesame meal furnishing 20 percent protein to a semi-purified diet with L-lysine HCl and L-histidine on chick performance.

The composition of the experimental diets used is shown in Table 1. Body weights, feed consumption, feed

Table 6 - Chemical composition of sesame meals and soybean meal.

Reference and source	Name of meal	Moisture (%)	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	Calcium (%)	Phosphorous (%)	Nitrogen free extract (%)
Morrison (1957) (USA)	Sesame meal	6.30	43.30	9.00	6.20	11.60	2.02	1.61	23.60
Subrahmanyan (1957) (India)	Sesame meal	10.30	37.20	12.50	4.20	7.20	2.30	0.66	28.60
Author (Iraq)	Sesame meal I	9.16	37.93	4.11	8.15	13.97	2.07	1.05	26.68
Author (Iraq)	Sesame meal II	7.92	39.24	4.80	6.90	14.17	2.90	1.06	26.97
Author (USA)	Soybean meal	9.64	44.60	0.76	6.12	6.28	0.31	0.60	32.60

efficiency and mortality for the different diets are presented in Table 7. Body weights and feed intake of the chicks fed the lysine supplemented diet were higher than those of the unsupplemented group. The histidine supplemented diet depressed the body weights and feed intake. The statistical analysis of the data on body weight and feed efficiency are shown in Table 8. Significant differences were found among treatments in both body weight and feed efficiency. The significant differences between means were tested using Duncan's multiple range test as shown in Table 9. Chicks receiving a diet supplemented with 0.35 percent L-lysine HCl differed significantly in body weights and feed efficiency from those fed unsupplemented or histidine supplemented diets. There was no significant difference between those receiving the unsupplemented or the histidine supplemented sesame meal diets. Body weights at weekly intervals demonstrate that the nutritive value of sesame meal is improved with lysine supplementation. The supplementation of histidine to a 20 percent protein sesame meal semi-purified diet depressed chicks' growth possibly due to amino acid imbalance.

Table 7 - Body weights, feed consumption, feed efficiency and mortality of chicks fed 20 percent protein sesame meal diets - Experiment I.

	Dietary treatments		
	SM[1]	SM + lysine[2]	SM + histidine[3]
Body weight (gms) at			
0 weeks	40	40	40
1 week	68	85	65
2 weeks	108	180	99
3 weeks	161	314	140
Feed consumption (gms)	287	519	303
Feed efficiency[4]	2.37	1.89	3.03
Mortality[5]	1/21	0/21	0/21

1 Sesame meal - 50% of the diet.

2 Sesame meal 50% + 0.35% L-lysine HCl.

3 Sesame meal 50% + 0.04% histidine.

4 Feed efficiency = $\frac{\text{Feed consumed}}{\text{Body weight gain}}$

5 Chicks dead at 3 weeks out of 21 started.

Table 8 - Analysis of variance of body weights and feed efficiency - Experiment I.

Source of variance	d.f.	M.S. Body weights	M.S. Feed efficiency
Treatment	2	27131**	0.9435**
Error	6	61.5	0.0352

** Significant at 1% level of probability.

Table 9 - Separation of means by Duncan's multiple range test[1] - Experiment I.

Body weights (gms)

Treatments	SM[2] + histidine	SM	SM + lysine
Means	140	161	314

Feed efficiency

Treatments	SM + lysine	SM	SM + histidine
Means	1.89	2.37	3.03

[1] Means not underlined by the same continuous line are significantly different at 5% level of probability.

[2] Sesame meal.

Experiment II

This experiment was designed to study the effect of supplementing sesame meal protein with L-lysine HCl, DL-methionine, L-histidine, L-leucine, DL-phenylalanine, DL-threonine and DL-valine singly and in combination on chick performance.

The composition of the experimental rations is presented in Table 2. All the diets contained 10 percent protein coming from sesame meal and the above mentioned 7 amino acids were supplemented in order to make the amino acid content equal to that of the chick's requirement as stated by NRC. The average body weights, feed consumption, feed efficiency and mortality are presented in Table 10. Lysine supplementation increased body weights and feed intake. The supplementation of all the above mentioned 7 amino acids together also improved body weights and feed efficiency. The statistical analysis of the data are shown in Table 11. Significant differences were found in body weights and feed efficiency. The means of body weights and feed efficiency are tested by Duncan's multiple range test and shown in Table 12. Sesame meal fed at 10 percent protein supplemented with 0.68 percent lysine differed significantly in body weights from all other treatments. There was no significant difference between those receiving the unsupplemented sesame meal diet and the diets supplemented with methionine, histidine, leucine, phenylalanine, threonine and valine, respectively. The data demonstrate that a 10 percent protein, sesame meal semi-purified diet supplemented with 0.68 percent L-lysine HCl significantly improved chick growth. The supplementation of the same diet with methionine, histidine, leucine, phenylalanine, threonine and valine together also improved growth but not to the same extent as that supplemented with lysine alone. These data further support that the nutritive value of sesame meal can be improved by supplementation with lysine. Furthermore, it indicates that no other amino acid of those studied is limiting in a 10 percent sesame meal protein diet, since the combination of all amino acids did not give superior growth to that of the diet supplemented with lysine alone.

Table 10 - Body weights, feed consumption, feed efficiency and mortality of chicks fed 10 percent protein sesame meal diets - Experiment II.

Dietary treatments	Body weights[2] (gms)	Feed consumption (gms)	Feed efficiency[3]	Mortality[4]
1. 25% sesame meal	69	101	7.21	1/21
2. 25% sesame meal + 7 amino acids[1]	118	182	2.89	1/21
3. 25% sesame meal + 0.68% L-lysine-HCl	130	205	2.73	0/21
4. 25% sesame meal + 0.45% DL-methionine	68	76	5.85	0/21
5. 25% sesame meal + 0.20% L-histidine	69	86	6.14	0/21
6. 25% sesame meal + 0.63% L-leucine	67	88	7.33	1/21
7. 25% sesame meal + 0.55% DL-phenylalanine	66	90	8.18	1/21
8. 25% sesame meal + 0.23% DL-threonine	70	87	5.80	0/21
9. 25% sesame meal + 0.28% DL-valine	69	97	6.93	0/21

[1] L-lysine HCl + DL-methionine + L-histidine + L-leucine + DL-phenylalanine + DL-threonine + DL-valine.

[2] Average chick weight at start of experiment in each group was 55 grams.

[3] See footnote 4 in Table 7.

[4] Chicks dead out of 21 started.

Table 11 - Analysis of variance of body weights and feed efficiency - Experiment II.

Source of variance	d.f.	M.S.	
		Body weights	Feed efficiency
Treatments	8	1822**	13.5545**
Error	18	16	2.4365

** Significant at 1% level of probability.

Table 12 - Separation of means by Duncan's multiple range test[1] - Experiment II.

Body weights (gms)									
Treatments[2]	7	6	4	5	9	1	8	2	3
Means	66	67	68	69	69	69	70	118	130

Feed efficiency									
Treatments	3	2	8	4	5	9	1	6	7
Mean	2.73	2.89	5.80	5.85	6.14	6.93	7.21	7.33	8.18

[1] Means not underlined by the same continuous line are significantly different at 5% level of probability.

[2] See Table 10 for details of treatments.

Experiment III

This experiment was designed to study the effects of replacing 33 or 100 percent of the soybean meal with sesame meal in a practical broiler ration and the supplementation of an all-sesame meal ration with 0.50 percent L-lysine HCl on body weights, feed efficiency and mortality of broilers up to 8 weeks of age. The results of this experiment are shown in Table 13. Chicks receiving a corn-soybean meal diet and those receiving a combination of soybean meal and sesame meal diet (3:1) had higher body weights than the group receiving all-sesame meal diet supplemented with 0.50 percent L-lysine HCl. The differences however were not statistically significant. The statistical analysis of the data is shown in Table 14. The supplementation of 0.50 percent L-lysine HCl to a sesame meal diet improved body weights and made them nearly equal to those fed a corn-soybean meal diet. Similar results have been reported by Grau and Almquist (1944). They stated that the basal diet containing 20 percent protein supplied from sesame meal when supplemented with 10 percent casein or 0.50 percent lysine gave optimal chick growth. Patrick (1953) showed increased growth rate of chicks by supplementation of a 30 percent sesame meal diet with lysine and vitamin B_{12}, but the growth rate was not as high as on a soybean meal or milk albumin diet. It was observed that a soybean meal diet not only produced better growth but also better feather development.

There were no significant differences in feed efficiency between corn-soybean meal diet, corn-soybean-sesame meal diet and the sesame meal diet supplemented with lysine. Feed intake was decreased with an increase of sesame meal in the diet.

Table 13 - Effect of different levels of sesame meal on body weights, feed efficiency and mortality - Experiment III.

	Sesame meal added (%)		
	0	10	30 + L-lysine-HCl
Body weight (gms) (0-56 days)	1384	1359	1299
Feed consumption (gms)	3245	3285	3206
Feed efficiency	2.36	2.38	2.47
Mortality[1]	2/75	2/75	3/75

[1] Chicks dead at 8 weeks out of 75 started.

Table 14 - Analysis of variance of 8 weeks body weights and feed efficiency - Experiment III.

Source of variance	d.f.	M.S.	
		Body weights	Feed efficiency
Treatments	2	5750	0.01
Error	6	2061	0.0033

Experiment IV

This experiment was designed to study the effects of replacing 50, 66 or 100 percent of soybean meal with sesame meal in a practical broiler ration on body weights, feed efficiency and mortality of broiler chicks raised to 8 weeks of age. The results shown in Table 15 indicate that as the level of sesame meal in the ration was increased, body weights at 8 weeks decreased from 1469 to 595 grams. Feed efficiency also dropped with increasing levels of sesame meal in the ration. The statistical analysis of the data on body weights and feed efficiency are shown in Table 16. Chicks receiving 15, 20 and 30 percent sesame meal differed significantly in body weights as shown by Duncan's multiple range test in Table 17. Chicks receiving 15 and 20 percent sesame meal did not differ significantly in feed efficiency but there was a significant difference in body weights between those receiving a combination of soybean meal and sesame meal and those receiving all-sesame meal diet. Almquist and Grau (1944) also reported mutual supplementary effect of soybean meal and sesame meal protein in the ratio of 3:1. They observed that sesame meal could replace 33 percent of the soybean meal without any significant effect on growth.

Body weights at weekly intervals are presented in Table 18. Differences in body weights began to appear at

1 week of age and continued to the end of the experiment. This indicates that increasing the level of sesame meal in the ration depresses appetite or reduces the efficiency of utilization of the ration. Both factors may contribute to lower performance with high levels of sesame meal in the ration.

Table 15 - Effect of different levels of sesame meal on body weights, feed efficiency and mortality - Experiment IV.

	Sesame meal added (%)		
	15	20	30
Body weight (gms) (0-56 days)	1469	1338	595
Feed consumption (gms)	3236	3183	1814
Feed efficiency	2.20	2.38	3.05
Mortality[1]	1/75	1/75	4/75

[1] Chicks dead at 8 weeks out of 75 started.

Table 16 - Analysis of variance of 8 weeks body weights and feed efficiency - Experiment IV.

Source of variance	d.f.	M.S.	
		Body weights	Feed efficiency
Treatments	2	668402**	0.600*
Error	6	1729	0.012

** Significant at 1% level of probability.
* Significant at 5% level of probability.

Table 17 - Separation of means by Duncan's multiple range test[1] - Experiment IV.

	Body weights (gms)		
Treatments	SM[2] 30%	SM 20%	SM 15%
Means	595	1338	1469
	Feed efficiency		
Treatments	SM 15%	SM 20%	SM 30%
Means	2.20	2.38	3.05

1 Means not underlined by the same continuous line are significantly different at 5% level of probability

2 Sesame meal.

Table 18 - Effect of different levels of sesame meal on average body weights (gms) at weekly intervals - Experiment IV.

Sesame meal added (%)	Age in weeks								
	0	1	2	3	4	5	6	7	8
15.00	35	87	170	294	457	645	918	1188	1469
20.00	35	80	154	256	398	573	815	1061	1338
30.00	35	63	97	146	203	270	360	469	595

Experiment V

This experiment was designed to study the effects of partial and complete replacement of soybean meal with sesame meal in a practical broiler ration along with lysine supplementation of such rations.

Results of body weights, feed efficiency and mortality are shown in Table 19. The statistical analysis of the data on body weights and feed efficiency are presented in Tables 20 and 21, respectively. Diets containing a combination of soybean meal and sesame meal produced higher body weights than either soybean meal or sesame meal alone. This supports the work of Grau and Almquist (1944) who have previously shown similar supplementary effects of soybean meal and sesame meal. Chicks receiving a combination of soybean meal and sesame meal (1:2) supplemented with 0.32 percent lysine had significantly higher body weights than those receiving corn-soybean meal as shown in Table 22. The means were separated using Duncan's multiple range test. The addition of 0.23 percent lysine to the diet containing ½ soybean meal and ½ sesame meal did not result in significant improvement in body weights when compared with the unsupplemented diet. Combination of soybean meal and sesame meal (1:1) significantly improved body weights and made it practically equal to that of soybean meal alone. No significant differences, however, were found in feed

Table 19 - Effect of different levels of sesame meal and lysine supplementation on body weights, feed consumption, feed efficiency and mortality - Experiment V.

Dietary treatments	Body weights (gms) (0-56 days)	Feed consumption (gms)	Feed efficiency	Mortality[1]
1. No sesame meal	1475	3993	2.70	1/40
2. 15% sesame meal	1496	4132	2.75	1/40
3. 15% sesame meal + 0.23% L-lysine-HCl	1523	4051	2.66	1/40
4. 20% sesame meal + 0.32% L-lysine-HCl	1555	4342	2.79	1/40
5. 30% sesame meal + 0.50% L-lysine-HCl	1398	4047	2.89	6/40

[1] Chicks dead out of 40 started.

Table 20 - Analysis of variance of body weights - Experiment V.

Source of variance	d.f.	M.S.
Between treatments	4	124521*
Within treatments	185	24509
Between pens within treatments	5	27569
Within pens within treatments	180	24427

* Significant difference between treatments at 5% level of probability.

Table 21 - Analysis of variance of feed efficiency - Experiment V.

Source of variance	d.f.	M.S.
Treatments	4	0.0159
Error	5	0.01066

Table 22 - Separation of means by Duncan's multiple range test[1] - Experiment V.

	Body weights (gms)				
Treatments	5	1	2	3	4
Means	1398	1475	1496	1523	1555

1 See Table 19 for details of treatments.

efficiency among the all-sesame meal lyamine supplemented diet, the diet containing a combination of soybean meal and sesame meal with or without lyamine supplementation or the sorn-soybean meal diet. Regression of feed efficiency of all the treatments used in this experiment at different ages is shown in Figure 1. This indicates an inverse relationship between age and feed efficiency. The increase in feed required per pound of gain amounted to 0.2776 pound per week increase in age. Feed efficiency decreases with age because more feed is needed for every additional unit increase in gain.

Net returns and market age.

In experiment V, the net returns over feed cost were calculated for the different treatments at 6, 7 and 8 weeks of age. The net returns were obtained by subtracting feed cost from the value of the broiler. The price per kilogram for the different rations was calculated using Table 23 which shows cost of ingredients. The net returns shown in Table 24 are mainly determined by rate of gain and the cost of ration. The ration containing equal amounts of soybean meal and sesame meal gave maximum net returns per broiler, although this ration did not give the best growth response. Ration containing 10 percent soybean meal and 20 percent sesame meal supplemented with 0.32 percent L-lysine HCl produced highest body weights but it was not the most profitable which is due to the high cost of the rations.

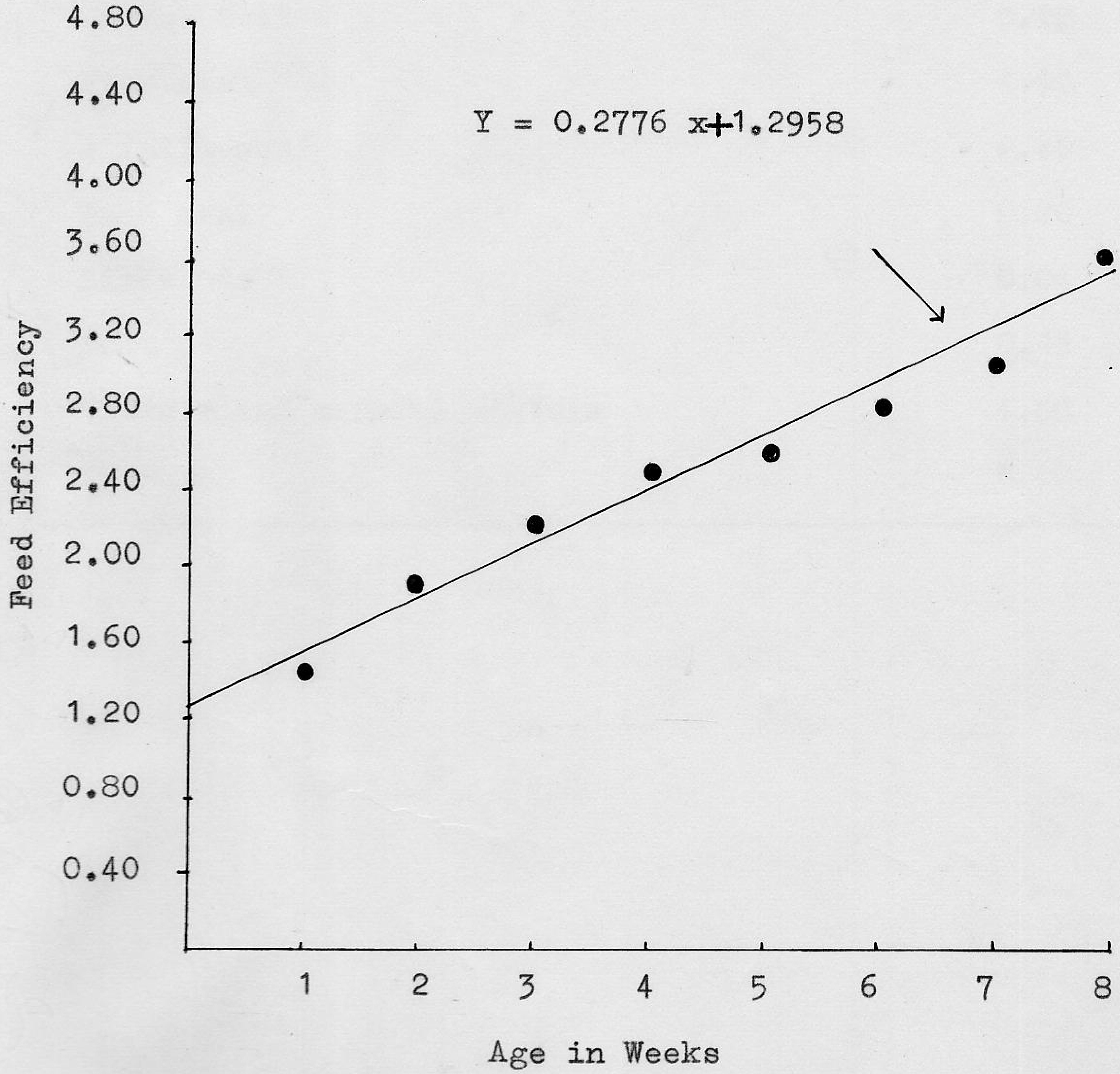

Figure 1 - Regression of feed efficiency on age - Experiment V.

Table 23 - Cost of ingredients - Experiment V.

Ingredients	Price/kg. L.P.
Yellow corn	0.24
Soybean meal	0.40
Sesame meal	0.28
Fish meal	1.00
Alfalfa meal	0.40
Bone meal	0.20
Limestone	0.04
Salt	0.13
Vitamin and mineral mixture	4.00
Lyamine	6.00

Table 24 - Net returns per broiler at 6, 7 and 8 weeks of age - Experiment V.

	Rations[1]				
	I	II	III	IV	V
Price/kg. (L.P.)	31.26	29.49	31.23	31.68	33.51
Live weight/broiler (gms)					
6 weeks	935	983	992	1050	868
7 weeks	1192	1266	1260	1311	1125
8 weeks	1475	1496	1523	1555	1398
Value/live broiler[2] (L.L.)					
6 weeks	1.40	1.47	1.49	1.58	1.30
7 weeks	1.79	1.90	1.89	1.97	1.69
8 weeks	2.21	2.25	2.28	2.33	2.10
Feed consumed/broiler (gms)					
6 weeks	2216	2327	2285	2443	2091
7 weeks	3008	3216	3118	3220	3129
8 weeks	3993	4132	4051	4342	4047
Feed cost/broiler (L.L.)					
6 weeks	0.69	0.69	0.71	0.80	0.70
7 weeks	0.94	0.95	0.97	1.05	1.05
8 weeks	1.25	1.22	1.26	1.42	1.36
Net returns over feed cost/broiler (L.L.)					
6 weeks	0.71	0.78	0.78	0.78	0.60
7 weeks	0.80	0.95	0.92	0.92	0.64
8 weeks	0.96	1.03	1.02	0.91	0.74

[1] For composition of rations I, II, III, IV and V see Table 5.

[2] Assuming selling price at L.L. 1.50 per kilogram of live weight.

In general the best growth producing ration is the most profitable. In cases where the price per unit output is low, maximum returns are reduced unless there is a consistant reduction in feed cost. The ration containing all-sesame meal supplemented with lysine produced both lowest body weights and net returns over feed cost. This shows that the use of lysine in large amounts in practical broiler rations at this stage is not economical due to its high price.

V. SUMMARY AND CONCLUSIONS

Five experiments utilizing a total of 902 chicks were conducted at the Agricultural Research and Education Center of the American University of Beirut to evaluate sesame meal as a source of protein for broilers. Two Iraqi sesame meal samples and 1 American soybean meal sample were analyzed for proximate composition including calcium and phosphorous. Sesame meal samples were higher in fiber, ether extract, calcium and phosphorous and lower in protein than that of soybean meal. The 2 sesame meal samples varied in protein from 37.93 to 39.24 percent and in crude fiber from 6.90 to 8.15 percent.

Out of the 5 experiments, 2 were conducted in electric battery brooders. These were designed to study the effect of amino acid supplementation when sesame meal was used as the sole source of protein in a semi-purified diet. L-lysine HCl, DL-methionine, L-histidine, L-leucine, DL-phenylalanine, DL-threonine and DL-valine were supplemented in order to make the amino acid content equal to the chick's requirement as specified by NRC. The rations were adjusted to 20 percent protein level in experiment I and 10 percent protein level in experiment II and the chicks were kept on experiment for 21 days. The supplementation of sesame meal with L-lysine HCl resulted in a significant improvement in live weight gain and feed efficiency. This leads to the conclusion that one reason for the poor nutritive value of sesame meal is due to its low lysine content.

The other three feeding experiments were conducted to establish levels of sesame meal which can be used with or without L-lysine HCl supplementation in practical broiler rations. Experiment III was conducted to study the effects of replacing 1/3 of the soybean meal with sesame meal and all the soybean meal with sesame meal when the diet was supplemented with 0.50 percent L-lysine HCl on live weight, feed efficiency and mortality of broiler chicks raised to 8 weeks of age. Experiment IV was conducted to study the effects of replacing 66 and 100 percent of the soybean meal with corresponding percentages of sesame meal, while experiment V was designed to study the effects of replacing 0, 50, 50, 66 and 100 percent of the soybean meal with corresponding percentages of sesame meal. The 50 percent and the 66 percent sesame meal rations were supplemented with 0.23 and 0.32 percent L-lysine HCl, respectively. The same criteria as those of experiment III were used. The results of these experiments indicate that sesame meal may replace up to 50 percent of the soybean meal in broiler rations supplemented with 2 percent fish meal without significant reduction in weight gains or feed efficiency. Lysine was found to be the most limiting amino acid in a diet containing sesame meal as the sole source of protein. Supplementation of a corn-sesame meal ration with 0.50 percent L-lysine HCl significantly improved body weights and feed efficiency. Chicks receiving a combination of soybean meal and sesame meal in the proportion of 1:2 supplemented with 0.32 percent lysine had significantly higher body weights than those receiving a corn-soybean meal diet or those receiving an all-sesame meal diet supplemented with 0.50 percent lysine. This shows a supplementary action between soybean meal and sesame meal. It further indicates that sesame meal is not only deficient in lysine but also lacking in some unknown factors which are present in soybean meal.

The economic phase of this study consisted of determining net returns per broiler over feed cost in experiment V at different ages. The ration containing equal amounts of soybean meal and sesame meal gave maximum net returns per broiler over feed cost although it did not produce the best growth response. This shows that the most economical ration is not always the one that gives the fastest growth. An all-sesame meal ration supplemented with L-lysine HCl was not economical due to the high cost of the amino acid.

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