PRACTICAL-TYPE RAW, UNEXTRACTED SOYBEAN MEAL DIETS FOR EGG-TYPE PULLETS

by

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INTRODUCTION

Poultry feeds account for two-thirds or more of the cost of producing eggs and meat. In countries such as Nigeria where protein sources for poultry rations are very scarce because they are mostly imported, poultry feed ingredients often cost twice their United States' value.

Soybean meal has contributed immensely to the growth of United States' poultry industry as a primary source of protein in poultry diets. The economics of soybean oil production has been changing in recent years so that the meal is becoming more valuable. This trend has prompted many nutritionists to intensify their research on feeding cooked and raw whole soybeans to poultry.

Presently Nigeria exports all the soybean she produces since there is no facility for processing the meal for use in livestock feeds. If it would be possible to feed raw soybeans directly to chickens without adversely affecting their laying house performance, then a more beneficial outlet for the country's soybeans would be assured and the transportation costs involved in the importation of soybean meal would be minimized.

The primary purpose of this study was to investigate the effects of feeding egg-type pullets, during the latter part of the growing phase and early part of the laying phase, practical-type rations in which raw, unextracted soybean meal and sorghum grain (milo) were the main ingredients. It was hypothesized that feed cost would be reduced by starting the chicks on standard starting and rearing diets containing soybean meal, followed by diets containing raw, unextracted soybean meal. It was hypothesized that if raw, unextracted soybean meal depressed the growth of pullets, its effects would be similar to controlled or restricted pullet feeding programs which have little effect on subsequent performance of pullets fed normal laying diets.

REVIEW OF LITERATURE

Effects of Feeding Raw Soybeans to Poultry

It is well established that raw soybean meal, unlike properly heated meal, exhibits inhibitory properties on the growth of chicks and rats. The growth inhibition has been related to various factors such as unavailability of sulfur amino acids cystine and methionine (Mitchell and Smuts, 1932) and a trypsin inhibitor (Ham and Sandstedt, 1944). Raw soybeans contain hemagglutinins which tend to decrease protein and fat digestibility (Scott et al., 1971). Schaible (1970) reported that raw soybeans reduce the availability of some trace minerals, especially zinc due to their phytic acid composition. Liener (1966) also suggested manganese, copper and iron exist in a bound form in raw soybeans. According to Couch (1963) raw soybeans may not only interfere with the release of enzymes from the pancreas but may also cause a reduction in enzyme synthesis. Heat treatment destroys most of the inhibitory properties and renders the sulfur amino acids more available (Hayward and Hafner, 1941). It also increases the energy value of raw soybeans.

Bornstein et al. (1961) and Saxena et al. (1963b) reported that the susceptibility of chicks to the detrimental effects of raw soybean meal decreased with age. Alumot and Nitsan (1961) reported proteolytic activity in the intestines of the chicks fed raw soybean meal was almost completely inhibited up to three weeks of age but after the fourth week proteolytic activity increased, approaching that of control at 6 weeks of age. Nesheim et al. (1962) reported dietary raw soybean meal depressed fat absorption in chicks at two weeks but not at four weeks of age. They further stressed that marked effect of raw soybean meal on fat absorption was probably a true age difference and not merely an adaptation to a raw soybean meal diet. Contrary to this, Bornstein and Lipstein (1963) reported intestinal proteolysis was completely suppressed during the first eight experimental days in 8-week old birds fed raw soybean meal and that the birds recovered completely after 21 to 28 days. This suggests age does not seem to affect the sensitivity of chicks to improperly processed soybeans but tends to shorten their physiological adaptation process. They noticed this adaptive phenomenon could not adequately compensate for the initial inhibitory properties of the underprocessed soybean meal within their 4 weeks experimental periods. Fisher et al. (1957) concluded insensitivity of chicks to the growth inhibitors did not assert itself until after 14 weeks of age. Hayward and Hafner (1941) and Bornstein and Lipstein (1963) reported growth inhibition in chicks was not due to decreased feed intake.

Carver et al. (1946) reported raw soybean meal supported excellent egg production in all-mash diets containing 13 percent protein. Fisher et al. (1957) working with raw soybean meal protein exclusively in a semi-purified diet concluded raw extracted soybeans, properly supplemented with methionine and vitamin B_{12}, would support good egg production equally as well as heated meal. Griminger and Fisher (1960) concluded egg production and egg weight could be maintained on a practical diet in which the major source of protein was raw, unextracted soybeans. Other workers have reported satisfactory egg production with raw soybean diets for layers (Fisher and Griminger, 1961; Saxena et al., 1963a, b; Summers et al., 1966; and Salman and McGinnis, 1968).

In contrast, Hill and Renner (1963) observed a reduction in egg production and metabolizable energy values for raw soybeans when compared to heated soybeans for layers. Rogler and Carrick (1964) also noticed a distinct reduction in egg production and a definite pancreatic hypertrophy when ground raw soybean diets were fed to layers. They explained that lack of agreement in some results on feeding raw soybeans might be due to the fact that some workers worked with extracted soybeans while others worked with unextracted soybeans. They also observed that many of the workers with favorable results used supplemental methionine and sometimes in combination with supplemental vitamin B_{12}.

Effects of Supplemental Methionine

The importance of supplemental methionine in raw soybean diets was demonstrated by Hayward and Hafner (1941). They compared raw and cooked soybean meal in chick diets when supplemented with either cystine or methionine or a combination of the two at 0.3 percent levels and without any amino acid supplements. They concluded the raw soybean diet was deficient in available cystine and methionine and that 0.3 percent methionine supplement was effective and capable of replacing cystine in the diet while 0.3 percent cystine supplement could not replace methionine. Fisher et al. (1957) and Salman and McGinnis (1968) also noticed methionine improved the utilization of raw soybean diets for layers. Saxena et al. (1963a) reported no differences in egg production nor in pancreatic size between hens fed raw extracted soybeans supplemented with methionine and those fed heated soybean meal diets. A report from Anonymous (1972a) described an experiment in which cooked, extruded and raw soybeans supplemented with 0.5 percent methionine were compared. The highest egg production and lowest feed consumption was obtained with extruded soybean diets while the raw soybean diet with supplemental methionine gave the poorest performance. Waldroup et al. (1969) demonstrated effective utilization of raw soybeans in laying diets requires total sulfur amino acid levels (methionine-cystine) considerably higher than 0.53 percent as suggested by National Research Council (N.R.C.) (1971).

Effects of Raw Soybeans on Egg Quality and Nutritional Factors Affecting Egg Size

Saxena et al. (1963a) observed no significant differences in the albumen and yolk quality measurements but they observed a greater incidence of blood spots in eggs laid by hens receiving raw soybean meal. On the contrary, Summers et al. (1966) compared raw unextracted soybean with 44 percent protein soybean meal in 14 and 16-percent protein diets. They observed no increased incidence of blood spots by feeding raw unextracted soybeans. There were no differences in Haugh units and shell weights but they noticed a slight indication that egg weight increased in the groups fed raw unextracted soybean meal diet as the level of protein increased. Bornstein and Lipstein (1972) reported methionine was the first limiting factor in increasing egg size of corn-soybean diets followed by linoleic acid. Shutze, as quoted by Anonymous (1972b), reported the feeding program plays a vital role in egg size, both from a protein and energy standpoint since this will influence the age at which the pullet matures.

Composition of Soybeans Grown in Nigeria

Generally, great variations occur in the densities and chemical compositions of soybean seed varieties (Oyenuga, 1968). He reported protein contents of U. S. samples vary from 32.4 to 50.2 percent and the oil content from 13.9 to 23.2 percent. He also observed that climate and temperature rather than soil and varieties tended to cause variations in protein and oil content as well as in the size of seeds while the sugar content depended more on variety. Viljoen (1937) as quoted by Oyenuga calculated that for every degree rise or fall in minimum temperature, a corresponding increase or decrease of 0.44 percent of oil may be expected while for every degree fall in minimum temperature, a rise of 0.39 percent in the protein content of the seed may occur. Oyenuga also stated that Nigerian soybean samples averaged 44.1 percent protein, 19.1 percent ether extract, 5.7 percent crude fibre and 26 percent nitrogen free extract compared to 42.8, 19.6, 5.5, and 27.1 percent, respectively, for an average of 10 common varieties grown at 5 locations in the U. S.

Composition of Nigerian Sorghum Grain

Sorghum grain (milo) is the major cultivated cereal crop in Nigeria with the bulk of the production coming from the drier northern states.

Chemical composition of Nigerian sorghum grain compares favorably with U. S. samples. Nigerian sorghum grain contains on the average 9 percent protein, 2.15 percent ether extract, 2.9 percent fiber and 2.6 percent total ash compared to the average values of 9.0, 2.8, 2.5, and 1.7 percent, respectively, for U. S. samples.

Oyenuga (1958) reported West African sorghum grain, like cereal proteins in general, is low in methionine, cystine, lysine and tryptophan and of the four common varieties grown, Sorghum guineense is richer in sulfur amino acids and in histidine than any of the rest. He also reported the Short kaura variety grown at Samaru had a carotene content of the endosperm equal to that of the best yellow maize produced then in America.

Protein-Energy Ratio and Low Protein Diets

The level of protein required by growing pullets depends on several factors such as balance of amino acids in the dietary protein, energy-protein or more specifically energy-amino acid ratios, age and size of birds, stage of egg production and environmental temperatures. Experience has indicated that low protein diets usually result in greater incidences of feather pulling, tail picking and cannibalism.

Many of the programs used for delaying sexual maturity of growing pullets involve some type of feeding regimen designed to reduce the nutrient intake sometime between 8 and 20 weeks of age. Up to 8 weeks, the chicks are usually fed a good quality starting ration to get over the initial critical period of life. The idea of feeding low protein diets to pullets during the growing phase before 20 weeks is based on the assumption that the protein requirements of pullets decline very rapidly to about 12 weeks of age because more feed is needed for maintenance energy and less for growth.

Blaylock (1956) reported White Leghorn pullets need no more than 12 percent protein in their diets between 8 and 20 weeks of age. Berg and Bearse (1958) reported the protein requirements of pullets was no more than 15 percent between 8 and 12 weeks, 13 percent between 12 and 14 weeks and 12 percent between 16 and 20 weeks of age. Nesheim (1967) calculated for a grower diet containing 1375 kilo calories of metabolizable energy per pound, that White Leghorn pullets at 4 weeks of age require

21 percent protein in the diet, 13 percent at 12 weeks, and 11 percent at 16 weeks.

Waldroup and Harms (1962) demonstrated that low protein diets during the growing period delayed sexual maturity in egg production type pullets. Lillie and Denton (1966) found that the performance of pullets fed a 12 percent protein diet from 0 to 20 weeks of age was equal to that of birds subjected to several nutrient restriction regimens. Nesheim (1967) reported on a 10-year study involving restricted feeding of growing pullets. He observed that pullets restricted in feed intake had lower body weights at housing, but the weight loss was regained once they were full fed a good laying ration. The feed restriction did not result in pullets that performed poorly in the laying house. In some of his studies in which 12 percent protein diets were fed from 8 to 22 weeks of age, differences in body weight were made up by more rapid and efficient gains in the laying house compared to pullets raised on adequate protein levels. Sexual maturity was also delayed for nearly 2 weeks. Therefore, he concluded that inadequate levels of protein during certain stages of rearing are not detrimental provided the low protein diet adequately meets the critical amino acid needs for growth.

Wright et al. (1968), in 2 separate experiments, compared the performances of laying hens which had been fed low (10 percent) and normal (16 percent) protein diets, respectively, between 8 and 18 weeks of age. Both diets contained 2,068 kilo calories productive energy per kilogram. In the first experiment with an egg-type strain, they noticed a delay of sexual maturity by 5 days in low protein diet group but these birds laid at a significantly higher rate and gave a better feed efficiency than the normal protein diet group. In the second experiment with another egg-type strain, the onset of egg production was delayed for 18 days and feed conversion was inferior to the 16 percent protein group which indicated that the first pullets were more adaptable to the low protein grower diet. There were no differences in egg weight and the composition of the grower diet did not affect mortality during either the growing or laying phase.

Ceballos et al. (1970) reported on their studies with White Leghorns from 8 to 20 weeks of age, observed that a 12 percent protein diet supported growth to 20 weeks of age comparatively equal to that obtained with higher protein levels. They also stated that levels of 10 to 12 percent protein derived entirely from cereal grain sources supported lower growth than the control diets but the pullets on lower protein diets performed as layers essentially equal to the controls.

Energy needs dictate to a large degree the amount of feed a bird consumes. High energy rations tend to lower the feed intake since birds eat mainly to satisfy their energy requirements. Harms (1963) reported low protein-high energy diets which were developed at Florida Agricultural Experiment Station gave excellent results in field trials. These diets contained only 9 to 10 percent protein with high levels of corn or milo resulting in productive energy levels in excess of 1,000 kilo calories per pound. The diets gave a desirable delayed sexual maturity and some savings in the feed cost due to the cheaper rations as well as a reduced feed consumption. However, he commented the greatest drawback with this program was the poor appearance of the pullets and the necessity of debeaking to prevent cannibalism.

Holmquist and Carlson (1972) compared low protein-low energy, low protein-high energy, and high protein-high energy diets containing crude protein and metabolizable energy values of 10 percent, 1,950 Cal/Kg; 12 percent, 2,900 Cal/Kg and 16 percent, 2,900 Cal/Kg, respectively, for commercial egg-type pullets between 8 and 20 weeks of age. They observed no difference in the mortality rates between the dietary treatments. Although body weights at 20 weeks were reduced in the group that received the low protein-low energy diet, they gave the largest average egg size and the lowest hen-housed mortality.

METHODS AND PROCEDURES

Day-old female chicks of a commercial White Leghorn-type egg production strain (Babcock) were received at Kansas State University (KSU) on June 6, 1972. The chicks were dubbed and vaccinated for Marek's, infectious bronchitis, and Newcastle diseases.

The chicks were then allotted at random to 6 floor pens, 10 by 18 feet, in a combination brooding-rearing house. The chicks were fed ad libitum KSU 20 and 14.5 percent protein all-mash diets (Appendix, Table A-1) from 0 to 6 and 7 to 10 weeks, respectively. The chicks were debeaked at 7 days of age. Lighting equal to natural daylength was provided during the first 10 weeks.

At 10 weeks of age, the birds were moved into an environmentally-improved, fan ventilated, windowless house with 3 rows of stretched-wire cages. Each row consisted of back to back rows of single-deck cages. Each side of each row had sixteen 28 by 32 in. colony cages with each cage containing 13 pullets (at least two from each floor brooding-rearing pen).

The experiment was divided into 2 phases, the growing phase from 10 to 22 weeks and the laying phase from 22 to 38 weeks.

The Growing Phase--The growing diets, a 14 percent protein soybean meal diet (SBM) and a 12 percent protein raw, unextracted soybean meal-sorghum grain diet with supplemental methionine (RSM + M) and without (RSM) were fed in four dietary regimens (Table 1). The calculated analysis of the diets are shown in Table 2 and the composition of the diets in Table A-2. Calculated analysis, Table 2 shows the ingredients used in SBM and RSM growing diets resulted in diets slightly deficient in lysine, arginine and glycine and marginal in tryptophan. Sixteen pens on each side of each row were divided into 2 blocks of 8 pens, 4 blocks per row. Each dietary regimen was assigned at random to a block in each of the 3 rows. All the birds were wing banded and redebeaked at the time of housing in cages. Moderate culling was done.

Spare pullets were maintained on each of the diets to replace mortalities in the respective groups. Two trigger-type plastic cup waterers in each pen supplied water *ad libitum*. Feed was supplied *ad libitum*. Lighting was decreased during this period by reducing daylength 15 minutes

Table 1. Dietary regimens fed during growing and laying phases[1/].

	Growing regimen			Laying regimen
Age	10-14 wk.	14-22 wk.		22-38 wk.
1	SBM(14%)[2/]	SBM(14%)	1	SBM(18%)[2/]
			2	RSM+M(18%)
2	RSM+M(12%)[4/]	RSM+M(12%)	1	SBM(18%)
			2	RSM+M(18%)
3	SBM(14%)	RSM+M(12%)	1	SBM(18%)
			2	RSM+M(18%)
4	SBM(14%)	RSM(12%)[3/]	1	SBM(18%)
			2	RSM+M(18%)

1/ Figures in parenthesis show calculated levels of protein.
2/ SBM--all-mash soybean meal diets (control).
3/ RSM--all-mash raw, unextracted soybean meal diets.
4/ RSM+M--all-mash raw, unextracted soybean meal plus supplemental methionine.

every two weeks until 12 hours light per day was reached. It was kept constant at this level until 22 weeks of age.

At 10, 14, and 20 weeks of age, 26 pullets from 2 randomly selected cages within each block were weighed. Records of mortality and feed consumption were maintained.

Table 2. Calculated analyses of diets.

	Grower diets			Layer diets	
	SBM	RSM+M	RSM	SBM	RSM+M
Protein (%)	14	12	12	18	18
M.E. K.cal/lb.	1283.0	1393.0	1393.0	1177.0	1183.0
Calorie-protein ratio (C/P)	89:1	115:1	115:1	66:1	66:1
Total sulfur amino-acid (%)	0.59	0.96	0.41	0.81	0.79
Lysine (%)	0.63	0.52	0.52	1.00	0.97
Arginine (%)	0.79	0.64	0.64	1.10	1.19
Glycine (%)	0.66	0.58	0.58	0.85	0.93
Tryptophan (%)	0.18	0.14	0.14	0.23	0.24
Calcium (%)	0.90	0.80	0.80	3.13	3.15
Phosphorus (%)	0.50	0.50	0.50	0.85	0.85

The Laying Phase--As shown in Table 1, at 22 weeks of age each rearing block was subdivided into two, 4-cage blocks and the pullets in one block switched to an 18 percent protein all-mash soybean meal-sorghum grain layer diet (SBM), and the pullets in the other block to an 18 percent protein all-mash raw, unextracted soybean-sorghum grain layer diet plus supplemental methionine (RSM + M). This gave a total of 8 groups as shown in Table 1. The calculated analysis of the diets are shown in Table 2 and the composition of the diets in Appendix, Table A-2.

At this time the number of pullets in each pen was reduced to 12.

The light period was increased from 12 to 14 hours and increased 15 minutes bi-weekly thereafter. Feed and water were supplied ad libitum and mortalities were not replaced.

Records on feed consumption, egg production and mortality were maintained from 22 to 38 weeks of age. Eggs laid per cage were recorded three days each week for a total period of 16 weeks. A sample of eggs equal to 33 percent of the number of birds in each pen was randomly sampled for two consecutive days each 28-day period. The eggs were immediately weighed and candled for presence of blood spots. At 38 weeks of age 12 birds from a randomly selected cage within each block of the laying phase were weighed.

Hen-housed production was calculated on the basis of the number of pullets housed per cage. Hen-day production was calculated on the basis of number of birds present in each 3-day recording period per week for each treatment-row-cage subclass. Rate of lay was calculated from the age of sexual maturity to 34 weeks of age. Age of sexual maturity was estimated using age when 50 percent hen-day production was reached. Feed efficiency was determined from the total feed consumption and the total egg production to 38 weeks of age.

Average values for adjacent pens of the same treatment for the first three, 28-day periods of egg production were used for analysis of variance for hen-day production, hen-housed production and percent mortality. Average values from 22 to 38 weeks and from 20 to 38 weeks were used for the analysis of variance of feed efficiency and percent change in body weights, respectively. All data were analyzed by the analysis of variance (Snedecor and Cochran, 1967).

RESULTS

Growing Phase

Body Weights--Average body weights and percent changes in body weight for the various groups, at different ages during the growing period, are shown in Table 3. Analysis of variance of the percent changes in body weight data is presented in Table 4.

The data show birds fed the raw soybean meal diet, starting at 10 weeks of age (2) had a lower percent change in body weight (approached significance) at 14 weeks of age than those fed the soybean meal diet (1, 3, 4). There was no significant difference in percent change in body weight at 20 weeks of age between the birds switched to the raw soybean meal diet at 10 weeks (2) and those switched to this diet at 14 weeks of age (3). However, pullets on regimen 3 had a significantly higher percent change in body weight (96.6 vs. 88.4) than pullets fed the raw soybean meal diet without supplemental methionine (4). Average body weight at 20 weeks of age was highest for pullets fed the soybean meal diet (1) and lowest for those fed the raw soybean meal diet without supplemental methionine (4).

Mortality--Mortality data for the growing and laying phases are not shown because the rates were extremely low in all the groups and showed

Table 3. Effect of growing dietary regimens on pullets' body weight.

Dietary regimen	Age (wk.) 10	14 wt. (gm.)	20	Percent change in body wt.[1/] 10-14 wk.	14-20 wk.	10-20 wk.
1	694.7	1065.3	1433.0	53.5	34.5[a]	106.4[a]
2	710.7	991.0	1364.0	39.5	37.8[a]	92.1[bc]
3	696.8	1049.3	1368.0	51.2	30.7[ab]	96.6[b]
4	703.3	1076.3	1324.0	53.2	23.1[b]	88.4[c]

[1/] Mean values with different superscripts differ significantly at the ($P < 0.05$) level.

Table 4. Analysis of variance for percent change in body weights.

Source of variation	Degrees of freedom	Age wk. 10-14	14-20 Mean squares	10-20
Dietary regimen	3	265.26	241.70*	361.53**
Row	2	168.71	39.30	44.71
Pen within row	3	58.16	15.83	61.30
Treatment x row	6	41.00	20.40	19.85
Error	9	79.87	40.80	39.73
Total	23			

* Significant ($P < 0.05$)

** Significant ($P < 0.01$)

no relationship to the various dietary regimens.

Feed Consumption--The effect of the growing dietary regimens on feed consumption is shown in Table 5. Analysis of variance of the data show that the dietary regimens had a significant effect on feed consumption during all periods (Table 6). Feed consumption between 10 and 14 weeks of age was lowest for the birds fed the raw soybean meal (2). However, by 22 weeks of age the feed consumption of the birds on this diet was not significantly different than that of the birds on the other raw soybean meal regimens (3 and 4). A comparison of the average feed consumption for the birds in dietary regimens 3 and 4 show that whether or not supplemental methionine was added to the raw soybean meal diet had no significant effect. Birds fed the soybean meal diet (1) had significantly higher feed consumption from 10 to 22 weeks of age than those on the raw soybean meal regimens (2, 3, and 4) probably due to the lower caloric content of diet (1).

Laying Phase

Age at Sexual Maturity--Data in Table 7 show age at sexual maturity of birds on the various growing and laying dietary regimens. An analysis of variance of these data (Table 10) show that both growing and laying dietary regimens had significant ($P < 0.001$) effects on this parameter. The birds fed the soybean meal growing diet (1) matured earlier (24.7 weeks) than those fed the raw soybean growing diets (25.3, 25.1 and 26.1 weeks

Table 5. Effect of dietary regimens on feed consumption during the growing period.

Dietary regimen	Period (wk.) 10-14	14-22	10-22
	Feed consumption/bird/day (gm.)[1/]		
1	54.1[bc] [2/]	71.6[a]	65.9[a]
2	52.3[c]	67.5[b]	62.6[b]
3	57.7[ab]	65.6[c]	63.1[b]
4	58.1[a]	66.0[c]	63.5[b]

1/ Each value is composed of the average of three replicates of 96 birds each.

2/ Mean values with different superscripts differ significantly at the ($P < 0.05$) level.

Table 6. Analysis of variance of feed consumption data.

Source of variation	Degrees of freedom	Age (wk.) 10-14	14-22	10-22
		Mean squares		
Dietary regimen	3	24.45*	22.28**	6.59*
Row	2	13.72	0.71	3.09
Error	6	5.04	0.23	0.86
Total	11			

* Significant ($P < 0.05$)

** Significant ($P < 0.01$)

for 2, 3, and 4, respectively). There was no significant difference in age at sexual maturity between pullets on regimens 2 and 3. A comparison of the two means of the laying dietary regimens shows the birds fed the soybean meal laying diet (1) matured earlier than those fed the raw soybean meal diet (2).

The lack of a significant growing x laying interaction (Table 10) indicates these main effects had separate but additive effects on maturity. These data show the birds fed the soybean meal diets throughout the experiment (1-1) matured earlier (24.4 weeks) than either those switched from raw soybean meal growing diets to the soybean meal laying diets (25.0, 24.8, and 25.9 weeks for 2-1, 3-1 and 4-1, respectively) or those fed the raw soybean meal diets throughout the experiment (25.7, 25.3, and 26.3 weeks for 2-2, 3-2, and 4-2, respectively). However, in all cases the pullets switched from the raw soybean growing diets to the soybean laying diet matured earlier than those fed the raw soybean diets throughout the experiment.

Egg Production--Effect of the dietary regimens on hen-day egg production is presented in Table 8. Analysis of variance of this trait is shown in Table 10.

Both the growing and laying diets had a significant ($P < 0.001$) effect on hen-day production. As the data in Table 8 show, the pullets reared on the soybean meal diet (1) had higher percent hen-day production (64.0) than those reared on the raw soybean diets (62.6, 60.3, and 56.8 percent

Table 7. Effect of growing and laying dietary regimens on age at sexual maturity (wk.).

Growing dietary regimen	1		3		2		4	
Mean:[1/]	24.7^{a}		25.1^{b}		25.3^{b}		26.1^{c}	
Laying dietary regimen		1				2		
Mean:[1/]		25.0^{a}				25.6^{b}		
Growing x laying interaction	(1-1)	(1-2)	(2-1)	(2-2)	(3-1)	(3-2)	(4-1)	(4-2)
Means:	24.4	24.9	25.0	25.7	24.8	25.3	25.9	26.3

[1/] Means with different superscripts are significantly different at ($P < 0.05$) level.

Table 8. Effect of growing and laying dietary regimens on percent, hen-day production.

Growing dietary regimen	1		3		2		4	
Means:[1/]	64.0^{a}		62.6^{ab}		60.3^{b}		56.8^{c}	
Laying dietary regimen		1				2		
Means:[1/]		67.9^{a}				54.0^{b}		
Growing x laying interaction	(1-1)	(1-2)	(2-1)	(2-2)	(3-1)	(3-2)	(4-1)	(4-2)
Means:	70.3	57.7	68.3	52.2	69.4	55.8	63.4	50.2
Difference:	12.6		16.1		13.6		13.2	

[1/] Means with different superscripts are significantly different at ($P < 0.05$).

for regimens 3, 2, and 4, respectively). The age at which the pullets were started on the raw soybean meal diet plus supplemental methionine (2 vs. 3) did not affect hen-day production but the lack of supplemental methionine significantly depressed egg production (3 vs. 4). The hens fed the soybean meal laying diet (1) had much higher egg production than those fed the raw soybean meal laying diet (2).

As shown in Table 10, the growing x laying diets interaction was not significant. A comparison of means in Table 8 shows that in all cases birds switched from the raw soybean meal plus supplemental methionine diet to the soybean meal laying diet (2-1 and 3-1) performed nearly as well as those fed the soybean meal diet throughout the experiment (1-1). The birds fed the raw soybean meal growing diet without supplemental methionine-soybean meal laying diet combination (4-1) laid better than those maintained on the raw soybean meal diet (4-2) throughout the experiment; although their performance was not equal to their counterparts receiving the methionine supplemented diets (2-1 and 3-1).

Data on hen-housed production have not been presented due to their similarity to the hen-day data because of low and uniform mortality in all groups.

Rate of Lay--Only the laying diets had a significant ($P<0.001$) effect on rate of lay (Table 10). As the data in Table 9 show, the birds on the soybean meal diet (1) outperformed those on the raw soybean meal diet (2). As a comparison of the growing x laying interaction means shows, feeding

Table 9. Effect of growing and laying dietary regimens on percent rate of lay.

Growing dietary regimen	1		3		4		2	
Means: 1/	69.6[a]		68.7[a]		67.4[a]		67.0[a]	
Laying dietary regimen		1				2		
Means: 1/		75.7[a]				60.7[b]		
Growing x laying interaction	(1-1)	(1-2)	(2-1)	(2-2)	(3-1)	(3-2)	(4-1)	(4-2)
Means:	75.8	63.3	76.8	57.3	74.8	62.7	75.3	59.6
Difference:	12.5		19.5		12.1		15.7	

1/ Means with different superscripts are significantly different ($P < 0.05$).

Table 10. Analysis of variance for indicated traits.

Source of variation	d.f.	Mean Squares: Age at sexual maturity	Mean Squares: Hen-day egg production	Mean Squares: Percent rate of lay
Growing	3	9.04***	239.65***	33.40
Laying	1	6.51***	4615.72***	5373.05***
Row	2	0.51	4.31	49.31
Cage	9	0.51	58.86**	53.17
Growing x laying	3	0.07	13.88	70.66
Error	77	0.27	17.11	53.77
Total	95			

**Significant ($P < 0.01$)

***Significant ($P < 0.001$)

the raw soybean meal laying diet depressed egg production regardless of the growing diet (Table 9).

Egg Weight--Average egg weight for each dietary regimen is shown in Table 11 and the analysis of variance in Table 12. These data show that the growing diets had a significant ($P < 0.05$) effect on average egg weight, although no trends were evident. Data in Table 11 show birds fed the soybean meal laying diet (1) had heavier eggs ($P < 0.05$) than those fed the raw soybean meal laying diet (2).

Blood spot data are not presented as the incidence was negligible in the eggs from all groups.

Body Weights--Data on percent change in body weight of various groups are shown in Table 13. Analysis of variance (Table 15) shows that the growing dietary regimens had a significant effect ($P < 0.01$) on changes in body weight during the laying period. Birds fed the raw soybean meal diet without supplemental methionine (4) gained more weight than either the group fed raw soybean meal with supplemental methionine (2 and 3) or soybean meal (1). An examination of the growing x laying interaction means shows that the large increase in body weight of group 4-1 was apparently the result of these birds compensating for some of the growth depression that occurred during the growing period.

The significant growing x laying interaction may have been due to the unexplainable growth response of the birds in group 1-2 compared to 1-1. A comparison of the growing x laying interaction means shows that the birds

Table 11. Effect of growing and laying dietary regimens on egg weight (gm.).

Growing diets and feeding regimens	4	2	1	3
Means:1/	56.1[a]	56.1[a]	56.0[a]	55.4[b]

Laying diets	1	2
Means:1/	56.5[a]	55.2[b]

1/ Means with different superscripts are significantly different ($P < 0.05$).

Table 12. Analysis of variance for egg weights.

Source of variation	d.f.	Mean squares
Growing	3	2.81*
Laying	1	41.34***
Row	2	0.34
Cage	9	0.95
Error	80	0.83
Total	95	

* Significant ($P < 0.05$)

*** Highly significant ($P < 0.001$)

Table 13. Effect of growing and laying dietary regimens on percent change in body weight.

Growing dietary regimen	1		2		3		4	
Mean: 1/	18.7^{c}		23.2^{bc}		25.1^{b}		35.0^{a}	
Laying dietary regimen		1				2		
Mean: 1/		26.5^{a}				24.5^{a}		
Growing x laying interaction	(1-1)	(1-2)	(2-1)	(2-2)	(3-1)	(3-2)	(4-1)	(4-2)
Mean:	16.6	20.8	25.9	20.5	24.7	25.4	38.9	31.1

1/ Means with different superscripts differ significantly ($P < 0.05$).

Table 14. Effect of growing and laying dietary regimens on feed conversion (lbs./doz. eggs).

Growing dietary regimen	1		2		3		4	
Mean: 1/	4.7^{c}		5.1^{b}		4.9^{bc}		5.4^{a}	
Laying dietary regimen		1				2		
Mean: 1/		4.4^{a}				5.6^{b}		
Growing x laying interaction	(1-1)	(1-2)	(2-1)	(2-2)	(3-1)	(3-2)	(4-1)	(4-2)
Mean:	4.25	5.28	4.46	5.72	4.32	5.39	4.68	6.03

1/ Means with different superscripts differ significantly ($P < 0.05$).

receiving raw soybean meal growing diets (2-1, 2-2, 3-1, 3-2, 4-1, and 4-2) had higher percentages of increase in body weight throughout the experiment than those fed soybean meal (1-1 and 1-2).

Feed Conversion--Feed conversion data are presented in Table 14. Analysis of variance of these data in Table 15 show the effects of both the growing and the laying diets on feed conversion were significant at ($P < 0.01$), but the growing x laying diets interaction had no significant effect on this trait. The mean values for the growing dietary regimens (Table 14) show there is no significant difference between pullets on regimens 2 and 3. A comparison between the two means of the laying dietary regimens shows birds fed the soybean meal laying diet (1) had better feed conversion than those fed the raw soybean meal laying diet (2). A comparison of growing x laying interaction means shows that regardless of the growing diet, feeding the raw soybean meal laying diet resulted in poorer feed conversion when compared to the soybean meal group. Birds that were switched from the raw soybean meal growing diet plus supplemental methionine to the soybean meal laying diet (2-1 and 3-1) were almost equal in feed conversion to the birds fed the soybean meal diets throughout (1-1). The best feed conversion (4.25) was obtained by birds maintained on soybean meal diets throughout the experiment (regimen 1-1) and the poorest (6.03) by the birds fed the raw soybean meal growing diet without supplemental methionine and the raw soybean meal laying diet (4-2).

Table 15. Analysis of variance for indicated traits.

Source	d.f.	Mean Squares: Percent change in body wt. (20-38 wk.)	Mean Squares: Feed conversion lb./doz. eggs
Growing	3	283.15**	0.4**
Laying	1	26.04	8.33**
Growing x laying	3	45.05*	0.04
Row	2	38.85	0.02
Error	14	13.22	0.03
Total	23		

*Significant ($P < 0.05$)

**Highly significant ($P < 0.01$)

DISCUSSION

Although the birds reared on a raw soybean meal growing diets plus supplemental methionine (dietary regimens 2 and 3) had lower average body weights at 20 weeks than those fed the 14 percent protein soybean meal growing diet throughout the growing period (regimen 1), this did not appear to have any adverse effect on subsequent laying performance of birds fed the soybean meal laying diet (regimens 2-1 and 3-1). Little difference among the laying regimens for mortality, hen-day production, rate of lay, and feed conversion further confirms the reports of Blaylock (1956), Nesheim (1967), Lillie and Denton (1966), Wright et al., (1968) and Ceballos et al. (1970) that satisfactory laying house performances can be obtained from pullets receiving nutritionally balanced laying diets after being raised on low protein growing diets. These results suggest that laying house performance of pullets depends more on types of laying than growing diets.

The birds on the raw soybean meal regimens (2-1 and 3-1) made up for their lower body weights at 20 weeks by growing more during the first part of the laying period when they were fed the soybean meal laying diet than did their counterparts that were switched to the raw soybean meal laying diets (2-2 and 3-2). This result is also consistent with the report of Nesheim (1967) who obtained more rapid and efficient gains from pullets that were switched from low protein growing diet to an adequate laying diet than those fed higher protein growing and adequate laying diets.

Lack of significant difference in all the parameters tested for the age (10 vs. 14 wk.) at which the pullets were switched from a regular growing diet to a raw soybean meal growing diet suggests that such a diet may be started as early as 10 weeks.

Significantly lower feed consumption between 10 to 22 weeks by the birds switched to the raw soybean meal growing diet at 10 weeks (2) compared with that of the birds on the soybean meal growing diet for the same period (1) suggests that reduced body weight at 20 weeks for those on diet 2 may be due only in part to depressed fat absorption (Nesheim, 1967) and impared protein digestion due to inhibitors in the raw soybean. The higher feed consumption by birds in regimen 1 was probably due to lower caloric content of the SBM diet, Table 2.

Although birds on the raw soybean meal laying diet, especially those on regimens 2-2, 3-2, and 4-2, made up for depressed growth at 20 weeks of age, this diet supported lower egg production compared with the soybean meal laying diet. This observation did not agree with those of Carver et al. (1946, Fisher et al. (1957), Griminger and Fisher (1960), Fisher and Griminger (1961), Saxena et al. (1966), and Salman and McGinnis (1968), but agrees with those of Hill and Renner (1963) and Rogler and Carrick (1964) who reported poor egg production with raw soybean meal laying diets. Birds that were on continuous soybean meal diets (1-1) had a lower rate of gain during the laying phase than their counterparts (1-2) that were switched to the raw soybean meal laying diet. This is probably because the latter group did not lay as many eggs but put on more weight.

The fact that raw soybean meal diets resulted in either depressed growth rate or poor egg production, depending on the age at which the feeding was started, agrees with the suggestions of Bornstein and Lipstein (1963) that age does not affect the sensitivity of chicks to improperly processed soybean meal diets.

The lack of a significant difference in feed consumption between birds in regimens 3 and 4, during the 14 to 22 weeks period, suggests the lower body weights at 20 weeks for birds in regimen 4 was due to a methionine deficiency in the non-supplemented diet rather than depressed feed consumption. This result agrees with those of Hayward and Hafner (1941). This factor also had a marked delaying effect on the age at sexual maturity of the birds in group (4-1) that were switched to the soybean meal laying diet. This result agrees with that of Hayward and Hafner (1941) who reported supplemental methionine improved the utilization of raw soybean meal diets for chicks. Although switching the birds from a methionine deficient diet to the soybean meal laying diet as in regimen 4-1 appeared to overcome some of the depressing effect when compared with regimen (3-1). However, this change did not completely compensate for the early loss in egg production due to delayed sexual maturity. The highest growth rate of 38.9 percent obtained by the birds in (4-1) can be explained from the point that the soybean meal laying diet enabled them to compensate for depressed growth during the growing phase.

A low incidence of blood spots in eggs from the various dietary regimens agrees with the report of Summers et al. (1966).

SUMMARY AND CONCLUSIONS

This study was designed to investigate the effect of feeding egg-type pullets during the latter part (10-22 wk.) of the growing phase and early part (22-38 wk.) of the laying phase, practical-type rations in which raw, unextracted soybean meal and sorghum grain were the main ingredients.

Four growing dietary regimens were used: 14 percent protein, soybean meal diet from 10-22 wk.; 12 percent protein, raw soybean meal plus supplemental methionine from 10-22 and 14-22 wk.; and 12 percent protein, raw soybean meal without supplemental methionine from 14-22 wk.

At 22 weeks birds in each of the four rearing dietary groups were sub-divided into two groups, half fed on 18 percent protein, soybean meal laying diet and half fed on 18 percent protein, raw soybean laying diet plus supplemental methionine.

Under the conditions of this study the following results were obtained:

1. The raw, soybean meal growing diet which was slightly deficient in all the critical amino acids except methionine depressed growth but had no adverse effect on subsequent performance of the pullets in the laying house when they were fed a soybean meal laying diet.
2. Age (10 vs. 14 wk.) at which the birds were switched to the raw soybean meal plus supplemental methionine had little effect on sexual maturity and laying house performance of the birds that

were switched to the soybean meal laying diet.

3. Pullets fed the raw soybean growing diet plus supplemental methionine between 10 and 22 weeks consumed less feed which contributed to depressed growth but they made up for growth depression when they were fed the soybean meal laying diet.
4. Supplemental methionine at the 0.5 percent level improved the performance of birds fed the raw soybean meal growing diet.
5. The raw soybean meal laying diet plus supplemental methionine supported a lower level of egg production and poorer feed efficiency when compared with the soybean meal laying diet.

These results suggest a low protein, raw, unextracted soybean meal practical-type growing diet may be an economical substitute for soybean meal diet for egg-type pullets between 10 and 22 weeks; particularly in those areas where raw soybean is available and protein supplements such as soybean meal are scarce.

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APPENDIX

Table A-1. Composition of standard starter and grower diets.

Ingredients	KSU 20% protein starter (0-6 wk.)	KSU 14.5% protein grower (7-10 wk.)
Soybean meal 44% solv. extr.	27.0	7.5
Yellow corn, ground	30.0	35.0
Sorghum grain, ground	30.0	34.0
Wheat middlings	-	10.0
Fish meal 60%	3.0	-
Meat and bone scraps	-	5.0
Alfalfa meal 17%	5.0	5.0
Fermentation solubles	2.0	-
Dicalcium phosphate	1.0	1.0
Limestone	1.5	1.0
Salt	0.5	0.5
Premixes (grams)		
Trace mineral premix (Z-5) 1/	23.0	-
Vitamin A (10,000 I.U/gm)	10.0	10.0
Vitamin D_3 (15,000 I.U/gm)	5.0	2.0
Vitamin B_{12} (20 mg/gm)	10.0	10.4
B-Complex (1233) 2/	46.0	5.8
Choline chloride (25%)	-	40.0
DL-Methionine	23.0	-
Amprol (R) 3/	23.0	22.7
Aurofac-10 (R)	16.0	20.8
Grain	-	342.3
Total	100.0	100.0

1/ Example--Trace mineral premix supplying by %: Mn 10; Fe 10; Ca max. 14; min. 12; Cu 1; Zn 5; I_2 0.3; Co 0.1.

2/ Example--B-Complex vitamin mix supplying in mg/lb: riboflavin 8,000; pantothenic acid 14,720; niacin 24,000; choline chloride 80,000.

3/ Amprol-25 (R)--At the rate of 1 lb/ton.

(R) = Registered trade mark.

Table A-2. Composition of experimental grower and layer diets.

	Grower diets			Layer diets	
Ingredients	SBM(14%)1/	RSM+M(12%)	RSM(12%)	SBM(18%)	RSM+M(18%)
Raw soybean meal, ground	-	12.0	12.0	-	35.0
Soybean meal 44% solv. extr.	14.0	-	-	28.0	-
Yellow corn, ground	36.0	-	-	-	-
Sorghum grain, ground	36.0	84.0	84.0	59.0	52.0
Oats	5.0	-	-	-	-
Alfalfa meal 17%	5.0	-	-	2.5	2.5
Dicalcium phosphate	1.5	1.0	1.0	2.0	2.0
Limestone	1.0	1.5	1.5	7.0	7.0
Salt	0.5	0.5	0.5	0.5	0.5
Trace mineral premix (Z-5)2/	23.0	23.0	23.0	23.0	23.0
Vitamin A (10,000 I.U/gm) gm	15.0	30.0	30.0	20.0	20.0
Vitamin D_3 (15,000 I.U/gm) gm	4.0	4.0	4.0	5.0	5.0
Vitamin B_{12} (20 mg/gm) gm	10.0	10.0	10.0	15.0	15.0
B-Complex (1233) (gm)3/	23.0	23.0	23.0	90.8	90.8
Choline chloride (25%) gm	-	40.0	40.0	40.0	40.0
DL-Methionine gm	68.1(0.15%)	249.7(0.55%)	-	14.2().25%)	14.2(0.25%)
Amprol-25(R) gm4/	23.0	23.0	23.0	-	-
Aurofac-10(R) gm	23.0	23.0	23.0	-	-
Grain (gm)	264.9	28.3	278.0	256.0	256.0
Total (lbs)	100.0	100.0	100.0	100.0	100.0

1/ Figures in parenthesis after various diet types show calculated levels of protein.

2/ Example--Trace mineral premix supplying by %: Mn 10; Fe 10; Ca, max. 14; min. 12; Cu 1; Zn 5; I_2 0.3; Co 0.1.

3/ Example--B-Complex vitamin mix supplying in mg/lb: riboflavin 8,000; pantothenic acid 14,720; niacin 24,000; choline chloride 80,000.

4/ Amprol-25(R)--At the rate of 1 lb/ton. (R) = Registered trade mark.

PRACTICAL -TYPE RAW, UNEXTRACTED SOYBEAN MEAL DIETS FOR EGG-TYPE PULLETS

by

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AN ABSTRACT OF A MASTER'S THESIS

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ABSTRACT

Starting at 10 weeks of age, egg type pullets were fed the following sorghum grain-base practical-type diets: 12 percent protein raw, unextracted soybeans with supplementary methionine (RSM + M); without supplementary methionine (RSM); and 14 percent protein soybean meal (SBM). At 22 weeks of age, half the pullets on each growing diet were switched to an 18 percent protein layer diet containing soybean meal (SBM) and the other half to an 18 percent protein diet containing raw, unextracted soybeans and supplementary methionine (SBM + M).

Greatest increase in body weight was obtained by pullets fed SBM diet and lowest from those fed RSM diet (106.4 vs. 88.4 percent). Supplemental methionine was effective in reducing the depressing effect of raw, unextracted soybean on growth. Both growing and laying diets had a significant effect on age at sexual maturity and hen-day rate of lay. Age at sexual maturity was 26.1, 25.1, and 24.7 weeks, respectively, for birds fed RSM, RSM + M, and SBM growing diets. Percent hen-day production was 56.8, 60.3 and 64.0, respectively, for birds fed RSM, RSM + M, and SBM growing diets. Percent hen-day production of birds reared on RSM + M diet and switched to SBM layer diet was nearly equal to that of birds fed SBM diet during both growing and laying periods (68.8 vs. 70.3 percent).