USE OF GRAIN SORGHUMS IN POULTRY DIETS

by

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ABSTRACT

A series of experiments were undertaken to compare corn with grain sorghum in the diet of broiler chicks and laying hens.

The first study compared grain sorghum to corn as a source of energy and protein in chick starter diets. No significant difference in body weights were observed when either cereal grain was fed.

The second study determined the effect of tannic acid on chick growth; since this compound has been implicated as a toxic component of grain sorghums. It was found that body weights were significantly depressed when the chicks were fed levels of tannic acid greater than 1%. However, only .25% tannic acid was needed to significantly depress feed conversion. The third experiment was carried out to determine the tannin content of several grain sorghum varieties. The tannin levels varied from 0.10% to 0.61%.

In a fourth experiment laying hens were fed grain sorghum or corn as the principle source of dietary energy.

Added linoleic acid was effective in increasing production and egg weight. Significant differences in egg production between grain sorghum and corn, within a protein level, were noticed when no supplemental safflower oil was fed favoring the diets based on grain sorghum. However, there were no significant differences in production when either cereal grain was fed at either protein level with supplemental linoleic acid present in the diet. Feed conversion, fertility, and hatchability were the same for the two grain sources, within a protein level.

CHAPTER I

INTRODUCTION

Poultry diets in many parts of the world depend upon the grain sorghums as an economical source of energy and protein. The grain sorghums are adaptable to many different climatic conditions since they grow well in humid, semi-arid areas, and with irrigation in dry areas.

Kafir corn or grain sorghum resembles corn in composition; however, the protein and energy contents of the grain sorghums vary considerably between strains. Because of the variation in protein and energy among the grain sorghums, interest has developed among poultry nutritionists as to the nutritional value and degree of utilization of grain sorghum used in poultry diets to replace corn. The problem has been amplified with the development of many new hybrids and varieties. It is possible that the presence of grain sorghums of low nutritive value would not produce any dramatically adverse effects on total production, but it might result in lower production efficiency, feed utilization, or egg size and consequently lower economic returns.

In many parts of the United States corn is the chief grain fed to poultry. Yellow corn has an advantage when compared with grain sorghums in that it contains a higher amount of beta-carotene or pro Vitamin A, and has xanthophyll pigments which produce the yellow color in egg yolk and body tissue. Corn has slightly more energy than grain sorghum, and contains more linoleic acid, which has been reported to affect egg size. However, corn is higher in cost in the western United States than sorghum grain.

The studies reported herein were undertaken to evaluate the use of grain sorghum in diets for chicks and hens. The grain sorghums used were mixtures of several varieties obtained from a commercial feed mill and would approximate the grain components present in commercially manufactured feeds.

REVIEW OF LITERATURE

Grain sorghum has been used for many years in feeds for poultry and livestock. It is used more so in those areas in which corn is limited, either by supply or by cost. Grain sorghum is an economical source of protein, energy, and other nutrients when compared with other grains.

Heywang and Morgan (1932), were among the first investigators to study the use of grain sorghum in broiler diets. They reported that milo or hegari would replace yellow corn in broiler diets at levels of from 50% to 100% of the grain portion. However, the "physiological efficiency of the diet," measured as the ratio of gain in live weight to feed consumption, was lower when grain sorghum replaced more than 20-40% of the yellow corn, although growth was not adversely affected.

Penquite (1931), Payne (1934), and Melass (1943), all confirmed the work of Heywang and Morgan (1932). The earlier researchers pointed out the need for alfalfa meal when grain sorghum was used to replace corn, due to the lower carotene content of the grain sorghum.

Contrary to the earlier reports, McClymont (1952), used grain sorghum in chicken diets and observed a growth depression of up to 50%. He postulated that the growth depression was due to a toxic factor present in grain sorghums. The possibility of toxic factors in grain sorghum was also indicated from the work of Thayer (1957), who noticed that the light colored seed varieties of sorghum were equal to yellow corn in growth promoting value and efficiency of food utilization with chicks, while the darker colored strains were inferior to corn. It was also specified that seed color of the improved grain sorghum varieties was not a reliable index of feeding value for growing chickens.

Harms et al. (1957) found that grain sorghum diets produced inferior growth to that obtained with yellow corn diets with broiler chicks. Harms et al. (1958) confirmed the earlier findings and specified that an increase in body weight was obtained as the grain sorghum was replaced with yellow corn up to 75%. An increase in the amount of yellow pigment deposited in the skin was obtained as the amount of yellow corn incorporated in the diet was increased. This was expected since corn supplied additional carotenoid pigments. These workers also reported a decrease in body weight as yellow corn was replaced with red milo and suggested that either the difference in energy value of the grain or some other factor was responsible for limiting the growth of broilers when grain sorghum was incorporated into the diet. The substitution of milo for corn in the diet did not significantly affect feed efficiency, although there was a trend to decreased feed utilization when milo was used. A decrease in the pigmentation of the birds as milo was substituted for corn was also noted.

Ozment et al. (1963) compared the nutritional value of four varieties of grain sorghum (Y-8, Y-10, Redland and De Kalb E56A) with yellow corn and concluded that corn and milo are equal in nutritive value in broiler diets when used on an equivalent nutrient intake basis.

Sanford (1963) obtained excellent growth and feed conversion by feeding a diet containing 35 parts of sorghum grain with 30 parts of corn in a practical-type, 21% protein broiler diet. However, differences in acceptability of various cereal grains and between different varieties of grain sorghum were found. Contrary to this report, Kemmerer and Heywang (1965) found that even a properly supplemented diet based on grain sorghum may not be equal in nutritive value to a corn diet, and that different varieties of sorghum grain differ in their influence on chick performance. When a diet containing corn was equated in protein content to the diet containing Martin milo, the corn diet produced superior weight gains.

Data concerning the amino acid and protein contents of various sorghum varieties are incomplete. There is general agreement that the grain sorghums are deficient in lysine and the sulfur containing amino acids. Adrian (1958) reported that African cereal grains, including sorghum, were deficient in lysine, and that grain sorghums have a protein digestability which is only 90 per cent that of corn for humans. Pond et al. (1958) confirmed this report and added that the protein was also inadequate in threonine for humans. Vavich et al. (1959) confirmed the findings of Adrian and Pond in that grain sorghum was deficient in lysine. The latter workers also compared a grain sorghum containing 10.5% protein with one of 15.3% protein for chick growth and concluded that the protein quality of the low protein grain sorghum was superior to that of the high protein sorghum grain sample. Microbiological amino acid assays showed that the low protein grain sorghum was higher in lysine and arginine than the high protein sample on a protein basis. Lysine supplementation improved the growth of chicks, but arginine supplements failed to do so.

Smith and Stephenson (1960) carried out biological and microbiological evaluations of eleven different grain sorghum samples. The chemical evaluations included moisture, protein, ash and fat determinations. The data, treated statistically, showed significant differences in fat and ash contents between the different grain sorghum samples. However, there were no differences in the protein or moisture contents. Microbiological assays for methionine and lysine on the various samples revealed that some strains had twice as much of the two amino acids as others, even though there were no differences found in the protein content of these same samples when analyzed chemically for nitrogen.

Fraps (1946) reported from studies on productive energy that grain sorghum contained 1,144 Calories of productive energy per pound while yellow corn contained 1,145 Calories. These values are lower according to Titus (1955) who reported that grain sorghum contained 1,099 Calories of productive energy per pound while corn had 1,105 Calories per pound.

A palatability and toxicity problem has been encountered with some varieties of sorghum, primarily those with dark seed coats, when fed to poultry. Most authors attribute this to be the tannin content of the pericarp. The new varieties can be identified by seed coat colors which range from pure white to a light brown or yellow color. The toxicity of tannin and tannic acid for monogastric animals has been reported by a number of workers. Robinson and Graessle (1943) reported that tannic acid was toxic when given intravenously or by subcutaneous injections to rats and mice. Lease and Mitchell (1940) fed crystalline tannic acid and its degradation product, gallic acid, to rats and found both were toxic. However, they found gallic acid to be more toxic than tannic acid. In an attempt to study the utilization of Lepedeza by poultry, Ringrose and Morgan (1940) fed pure tannic acid to chickens as 2% of the diet and obtained marked growth depression but no mortality. They concluded that the reduced growth was due to the reduction in feed consumption. Conversely, West (1961) reported that palatibility of a grain sorghum sample which was thought to be high in tannin was good.

Contrary to the findings of West, but in agreement with the earlier studies, Fuller et al. (1962) found that growth and feed efficiency were inversely related to the tannin content of grain sorghum. This report was confirmed by Chang and Fuller (1964). They fed several varieties of grain sorghum, varying in tannin content, to chicks as 50% of the diet. In another study they also fed graded levels of tannic acid per se in a corn-soybean meal basal diet. High tannin grain sorghum resulted in growth retardation which was similar in magnitude to that caused by an equivalent level of tannic acid. They also noted an increase in liver lipids in direct proportion to the level of tannic acid present in the diet. The growth depression was partially corrected when the diets were supplemented with additional choline and methionine.

The experiments reported herein were designed to determine the utilization of corn and sorghum as a source of protein and energy in broiler diets, to study the effects of tannic acid on chicks and to determine the tannin content of 28 different strains of grain sorghum.

EXPERIMENTAL PROCEDURE

Experiment 1: The purpose of this experiment was to compare corn and grain sorghum as sources of energy and protein for broilers (0-4 weeks). Growth and feed conversions were used as criteria in determining the optimum levels of dietary corn and grain sorghum.

One hundred and ninety-two, sexed day-old Rhode Island Red X Columbian chicks were randomly distributed into six groups of 32 birds each. Each group consisted of four pens of four males and four females. The chicks were weighed at the beginning of the experiment and placed in electrically heated battery brooders with raised screen floors. Feed and water were supplied *ad libitum*.

Two basal diets were used in this experiment. The difference between the two basal diets was that Basal Diet I had 7.50% fat, thus having more energy (one hundred eighteen Calories productive energy per pound of feed) than diet II, which contained 7.50% glucose instead of fat (Table 1). The grains or combinations were fed as 50% of the diet; the remaining 50% of the diet was supplied by the ingredients listed in Table 1. The experimental design is shown in Table 2. The grain sorghum used in this experimental study was a mixture of a number of varieties obtained from a commercial feed mill.

TABLE 1

COMPOSITION OF BASAL DIET

Ingredients	Basal I % (High Energy)	Basal II % (Low Energy)
Soybean meal (44%)	29.25	29.25
Fish meal (65%)	5.00	5.00
Dehydrated alfalfa meal	1.50	1.50
Dried whey	1.00	1.00
Distillers dried solubles	1.00	1.00
Hydrolyzed animal fat	7.50	--
Glucose	--	7.50
Dicalcium phosphate	1.00	1.00
Calcium carbonate	.75	.75
Salt	.30	.30
Methionine hydroxy analog	.10	.10
Vitamin premix[1]	2.50	2.50
Trace minerals[2]	.10	.10
Slack ingredients	50.00	50.00

[1]Supplied per pound of feed:

4500 I.U., vitamin A; 700 I.C.U., vitamin D; 2.00 mg riboflavin; 12.50 mg niacin; 5.00 mg calcium panthothenate (dextrorotatory); 400 mg. choline cloride; 0.006 mg. vitamin B_{12}; 2.5 I.U. vitamin E, 1.00 mg. vitamin K; 56.75 mg. santoquin (antioxidant), and 8.4 gm. soybean meal as a carrier.

[2]Supplied the following in mg. per pound:

iron, 9.1; zinc, 27.3; molybdenum, 0.47; manganese, 27.3; calcium, 76.5; copper, 1.8; iodine, 0.68; cobalt, 0.68.

TABLE 2

EXPERIMENTAL TREATMENTS

Diet	Description
1	50% Basal 1 + 50% corn
2	50% Basal 1 + 25% corn + 25% grain sorghum
3	50% Basal 1 + 50% grain sorghum
4	50% Basal 2 + 50% grain sorghum
5	50% Basal 2 + 25% corn + 25% grain sorghum
6	50% Basal 2 + 50% corn

The males and females were weighed separately by pen at four weeks. Feed conversions were based on body weight gained per gram of feed consumed from one day of age to four weeks of age. Weight data were treated statistically by an analysis variance and the means separated by Duncan's (1955) multiple range test.

<u>Experiment 2</u>: Chang and Fuller (1964) proposed that one of the differences between corn and sorghum grain was the tannin content of grain sorghum. They found that tannic acid at 0.10% of the diet did not appear toxic, but above 1.0% growth was depressed in direct relation to the level fed.

This experiment was undertaken to study the effects of tannic acid in broilers to 4 weeks of age. Growth, feed conversion, blood uric acid and blood hemoglobin were used as criteria of tannic acid toxicity.

One hundred and ninety-two, day-old Rhode Island Red X Columbian chicks were randomly distributed into six groups of 32 birds each. The chicks were weighed at the beginning of the experiment and placed in electrically heated battery brooders with raised screen floors. Feed and water were supplied <u>ad libitum</u>. The basal diet used is shown in Table 3.

TABLE 3

COMPOSITION OF BASAL DIET

Ingredients	%
Corn	52.50
Soybean meal (44%)	29.25
Fish meal (65%)	5.00
Dehydrated alfalfa meal	1.50
Dried whey	1.00
Distillers dried solubles	1.00
Hydrolyzed animal fat	5.00
Dicalcium phosphate	1.00
Calcium carbonate	.75
Salt	.30
Methionine hydroxy analog	.10
Vitamin premix[1]	2.50
Trace mineral mix[2]	.10
	100.00

[1]Supplied per pound of feed:

4500 I.I vitamin A; 700 I.C.U. vitamin D_3; 2.00 mg. riboflavin; 12.50 mg. niacin; 5.00 mg. calcium panthothenate (dextrorotatory); 400 mg. choline cloride; 0.006 mg. vitamin B_{12}; 2.5 I.U. vitamin E; 1.00 mg. vitamin K; 56.75 mg. ethoxyquin and 8.4 gm soybean meal as a carrier.

[2]Supplied the following in mg. per pound:

iron, 9.1; zinc, 27.3; molybdenum, 0.47; manganese 27.3; calcium, 76.5; copper, 1.8; iodine, 0.68; cobalt, 0.68.

One group of birds was kept as a control with no dietary tannic acid added. The other five groups received graded levels of tannic acid *per se* in order to determine the toxic level tannic acid.

The males and the females were weighed separately at four weeks and feed conversions were based on body weight gained per gram of feed consumed from one day to four weeks of age. All the weight data were treated statistically by analysis variance and the means separated by Duncan's (1955) multiple range test.

Blood samples from 8 birds (4 males and 4 females) from each group were taken by heart puncture at four weeks of age using one drop of heparin per sample as an anti-coagulant. The blood serum was deprotinized and blood uric acid determined by the method of Brown (1945). Also, at four weeks, blood samples were taken by wing vein puncture to determine blood hemoglobin by the method of Wintrobe (1956).

Experiment 3: It was mentioned earlier that Chang and Fuller (1964) reported that grain sorghum varies widely in its tannin content. They determined the tannin content of six different strains of grain sorghum and found them to vary from 0.10% to 2.00%. A study was carried out to determine the tannin content of 28 different strains of grain sorghum grown in different sections of Kansas. These samples were obtained through the courtesy of Dr. Charles W. Deyoe of Kansas State University.

The tannin content of grain sorghum was determined by the procedure of the Association of Official Agriculture Chemists (1960). The principle of this method is based on a color reaction with the Folin-Denis reagent. A one gram sample finely ground, treated with boiling water for twenty minutes, and then diluted to 250 mls with water, filtered and an aliquot withdrawn for color development.

RESULTS AND DISCUSSION

Experiment #1: The replacement of either one-half or all of the ground yellow corn in either of the basal diets did not significantly alter the growth rate of broiler chicks to four weeks of age. Birds fed the higher energy diets containing either corn, grain sorghum or an equal mixture of the two, exhibited significantly improved feed conversion compared with identical treatments of lower energy content; however, no significant differences were noted between the grain sources with regard to feed conversion (Table 4).

Similar results have been reported by Smith and Stephenson (1960), who found no statistically significant differences in growth or feed conversion when different strains of grain sorghum were used as replacements for corn in chick diets. On the other hand, Kemmerer and Heywang (1965) have reported corn to be superior to some strains of grain sorghum for chicks.

The study reported herein indicated that when corn is replaced pound for pound by grain sorghum in a practical chick starter diet there are no detrimental effects on either growth rate or feed conversion.

Experiment #2: A decrease in body weight of chicks was observed at four weeks as the level of tannic acid in

TABLE 4

GROWTH AND FEED CONVERSION OF BROILERS FED DIFFERENT LEVELS OF CORN, SORGHUM GRAIN AND ENERGY

Diet	Treatment	Body Weight in gms	Feed Conversion
1	Basal 1 + 50% corn	385.0[a][1]	1.72[a]
2	Basal 1 + 25% corn and 25% grain sorghum	396.0[a]	1.71[a]
3	Basal 1 + 50% grain sorghum	384.6[a]	1.77[ab]
4	Basal 2 + 50% grain sorghum	382.6[a]	1.87[c]
5	Basal 2 + 25% corn + 25% grain sorghum	378.4[a]	1.90[c]
6	Basal 2 + 50% corn	390.5[a]	1.83[bc]

[1]Means having the same superscript were not significantly different at the 0.05 level of probability.

the diet was increased (Table 5). These differences, above 1% tannic acid, were statistically different from the control group (Table 5). The best feed conversion was obtained with the diet containing no tannic acid. The differences between the feed conversions of the control diet and the rest of the diets were statistically significant, indicating that tannic acid affected feed utilization even at a 0.25% level. However, as mentioned earlier, the average body weights were depressed only when the diet had more than 1% tannic acid.

Chang and Fuller (1964) have reported that tannic acid at 0.10% of the diet was not toxic but at higher levels (0.50% to 2.00%) growth was depressed in direct relation to the level of tannic acid in the feed. In this study a statistically significant difference in body weights was observed when tannic acid was used at levels higher than 1%.

Chang and Fuller (1964) also found that tannic acid inhibited protein digestability. Since uric acid is a primary excretory product of nitrogen metabolism in chicks, it was thought that there might be a relationship between dietary tannic acid and blood uric acid levels.

No significant differences in the blood uric acid levels were noted with the feeding of tannic acid at the

TABLE 5

EFFECT OF FEEDING DIFFERENT LEVELS OF TANNIC ACID ON BODY WEIGHT AND FEED CONVERSION OF CHICKS AT FOUR WEEKS

Diet	Treatment (Dietary)	Body Weight in gms.	Feed Conversion
1	Basal + 0.00% tannic acid	389.4[c][1]	1.73[a]
2	Basal + 0.25% tannic acid	386.9[bc]	1.83[b]
3	Basal + 0.50% tannic acid	383.1[bc]	1.80[b]
4	Basal + 1.00% tannic acid	378.8[bc]	1.80[b]
5	Basal + 1.50% tannic acid	365.8[ab]	1.82[b]
6	Basal + 2.00% tannic acid	345.5[a]	1.85[b]

[1]Means having the same superscripts were not significantly different at the 0.05 level of probability.

levels tested (Table 6). Hemoglobin has been reported by Lease and Mitchell (1940) to be decreased with high concentrations of tannic acid in the diet of the rat. In this study there were no significant differences in blood hemoglobin when different levels of tannic acid were fed in the diet (Table 6).

The results of this study indicate that tannic acid at levels higher than 1% of the diet depressed body weight gain and that small amounts of the acid in the diet will depress feed conversions. These data also indicate that the levels of blood uric acid and hemoglobin were not affected by the feeding of tannic acid. Since tannic acid was toxic for growth at levels greater than 1% of the diet, attention should be given to the tannin content of the grain sorghum when formulating diets for poultry.

Experiment #3: The tannin content of different varieties of grain sorghum was found to vary with variety and location in which they were grown (Table 7). The differences in tannin content of the same varieties grown in different counties of Kansas can perhaps be attributed to differences in soil, soil humidity and cultivation practices (Tables 7 and 8). On the other hand the difference in tannin content of different strains grown in the same county might be attributed mainly to genetic differences, and to some

TABLE 6

EFFECT OF FEEDING LEVELS OF TANNIC ACID ON BLOOD URIC ACID AND BLOOD HEMOGLOBIN

Diet	Dietary Treatment	Uric acid (mg/100 ml)	Hemoglobin (gm/100 ml)
1	Basal + 0.00% tannic acid	3.70[a][1]	8.52[a]
2	Basal + 0.25% tannic acid	3.23[a]	7.72[a]
3	Basal + 0.50% tannic acid	2.95[a]	8.33[a]
4	Basal + 1.00% tannic acid	3.71[a]	8.07[a]
5	Basal + 1.50% tannic acid	3.28[a]	8.41[a]
6	Basal + 2.00% tannic acid	2.82[a]	7.52[a]

[1]Means having the same superscripts were not significantly different at the 0.05 level of probability.

TABLE 7

TANNIN CONTENT OF TWENTY-EIGHT DIFFERENT VARIETIES OF GRAIN SORGHUM GROWN IN DIFFERENT SECTIONS OF KANSAS

Strain	% Tannic Acid Eastern Kansas[1]	Central Kansas[2]	Western Kansas[3]	Western Kansas[4]
Asgrow's Raider B	.43	.24	.26	.12
Asgrow's Rico	.50	.28	.22	.18
Dekalb's C44B	.32	.25	.26	.22
Dekalb's F-64	.29	.27	.27	.19
Dekalb's E-57	.21	.24	.20	.16
K S 651	.26	.22	.21	.10
O K 612	.61	.19	.32	.17
O K 613	.21	.28	.32	.18
O K 632	.22	.19	.25	.14
Pioneer 846	.26	.24	.22	.15
Pioneer 820	.29	.29	.30	.24
Pioneer 844	.34	.19	.32	.19
R S 619	.45	.26	.24	.22
R S 625	.37	.24	.20	.22
R S 621	.34	.22	.24	.17
R S 626	.37	.23	.23	.18
R S 610	.36	.18	.20	.16
R S 650	.34	.31	.20	.21
R S 640	.44	.31	.29	.12
R S 624	.35	.23	.24	.21
R S 622	.27	.19	.20	.22
R S 623	.19	.24	.19	.17
R S 616	.37	.26	.23	.18
T. E 66	.18	.21	.20	.17
T. E Grainmaster	.26	.20	.26	.18
62CS0044	.52	.22	.32	.20
62CS004	.47	.29	.28	.22
58MH107	.30	.45	.20	.12

[1]Grain sorghum grown in Brown county.

[2]Grain sorghum grown in Ellis county.

[3]Grain sorghum grown in Finney county.

[4]Grain sorghum grown under irrigation in Finney county.

TABLE 8

AVERAGE TANNIC ACID CONTENT OF TWENTY-EIGHT DIFFERENT VARIETIES OF GRAIN SORGHUM GROWN IN DIFFERENT SECTIONS OF KANSAS

Entry	% Tannic Acid
Grain sorghum grown in eastern Kansas[1]	0.34
Grain sorghum grown in central Kansas[2]	0.25
Grain sorghum grown in western Kansas[3]	0.24
Grain sorghum grown in western Kansas[4]	0.18

[1]Brown county

[2]Ellis county

[3]Finney county (non-irrigated)

[4]Grown under irrigation in Finney county

extent, to difference in soil and soil humidity.

It was noticed that the color of the kernels with the highest amounts of tannin was darker when compared with other varieties which had less tannin. The same characteristics in color in relation to the tannin were reported by Heuser (1955). He found the white kernels of sorghum grain had less tannin.

None of these varieties tested would be expected to depress body weight gain when fed to chicks, since in a previous study (Experiment 2) more than 1% tannic acid was needed to depress body weight. However, feed conversions might be adversely affected with some of these strains. Since the previous experiment (Experiment 2) indicated that 0.25% tannic acid in the diet depressed feed conversions. The results of this study indicate that the varieties of grain sorghums tested varied in their tannin content from 0.10% to 0.61% (Table 7).

CHAPTER II

REVIEW OF LITERATURE

Holst and Newlon (1927), Payne (1926) and Sherwood (1926) have suggested that grain sorghum may be substituted in part for yellow corn in the diet for laying hens. Payne (1934) found that good quality kafir or milo could be substituted for either white or yellow corn for laying hens when diets were adequately supplied with other nutrients. Hammond (1942) found that either yellow milo or hegari was of equal value to white corn in a well balanced diet for laying hens.

Berry (1954) compared different diets in which the grain was either all corn, half corn half milo, and all milo. In these studies the dietary protein content was not equalized among diets. The production performance in the all corn diet was slightly higher than the all milo diet, but the differences were not significant. The mixed grain group had the lowest production level. Adolph and Grau (1956) compared the performance of commercial layers on five California poultry farms for two-six week periods. The birds were fed a 17.43% protein diet which was predominately corn and an 18.03% protein diet, predominately grain sorghum. No difference in production between the two diets was observed.

Contrary to the work of Adolph and Grau (1956), Malik and Quisenberry (1963) reported that grain sorghum, used as the only grain component in laying diets, resulted in poorer egg production, smaller egg size, and poorer feed conversions compared with similar diets containing corn. They also reported that as corn was substituted with grain sorghum yolk pigment score declined. However, they found that a 50:50 combination of corn and grain sorghum produced as many eggs as the diet containing corn as the only grain component.

Bray (1960) fed pullets a combination 55:45 soybean meal and corn protein and obtained a response to supplemented methionine. In a more recent study, Bray (1964), using a similar combination of 55:45 soybean and corn protein obtained higher egg production rates than when he used a 55:45 ratio of soybean to grain sorghum protein. However, this difference was reversed in the presence of supplemented D L-methionine. Maximum response to supplemental methionine was obtained when soybean supplied 85% of the protein in either grain sorghum--soya or corn--soya diets. The same year Bray (1964) reported that pullets fed a 40:60 soybean and corn protein diet responded to lysine and isoleucine supplementation but not to supplemental methionine. This indicated that different combinations of cereal grains require different supplemental amino acids for optimum performance.

Jensen et al. (1958), Berg (1959), Shutze et al. (1959), Combs and Helback (1960), and Shutze et al. (1962) reported that an unidentified factor necessary for maximum egg size, and that yellow corn was one source of this factor. Contrary to these reports, Berg and Bearse (1957) and Combs (1961) reported that an increase in egg weight was obtained by an increase in the energy content of the laying diet. Harms and Waldroup (1961), Creger and Couch (1961) presented evidence for a factor other than energy which was responsible for producing heavier eggs.

The experiment reported herein was undertaken to compare corn and grain sorghum as sources of energy and protein for laying hens, and to determine if added linoleic acid was effective in increasing egg production or egg weight.

EXPERIMENT PROCEDURE

In this study 640 Dekalb range reared pullets, hatched May 1964, were randomly distributed into 8 treatment groups. Each group consisted of two replicate pens of forty females and two males. Water and feed were given *ad libitum*.

This study consisted of eight treatments (Table 9). Four of the treatment diets contained 12% protein calculated to meet the minimum essential amino acid requirements of the laying hen. The other four diets contained 15% protein. Corn or sorghum grain was used as the grain source in the experimental diets. Safflower oil was added to sorghum diets 6 and 8 in order to equalize the linoleic acid content to that of the corn diets 1 and 3. Diets 5 and 7, in which corn was used as the grain source, also received the same amount of safflower oil to evaluate the effect of higher linoleic acid levels on laying hen performance (Table 9).

The experiment was initiated on December 2, 1964 and was continued for eight twenty-eight day periods. Records were kept on egg production, egg weight, fertility, hatchability, feed conversion, linoleic acid content of the eggs and mortality. Egg production was calculated on a hen day-basis each twenty-eight day period. Eggs were weighed and graded during three consecutive days per period, and hatchability and fertility were checked three times throughout the

TABLE 9

EXPERIMENTAL DIETS FOR HENS

Ingredients	12% Protein Diet		15% Protein Diet		12% Protein Diet		15% Protein Diet	
	1 %	2 %	3 %	4 %	5 %	6 %	7 %	8 %
Ground yellow corn	74.64	--	69.38	--	74.64	--	69.38	--
Ground grain sorghum	--	74.64	--	69.38	--	74.64	--	69.38
Animal fat	1.00	1.00	1.00	1.00	0.10	0.10	0.37	0.37
Fish meal sardine (65%)	5.21	5.21	4.37	4.37	5.21	5.21	4.37	4.37
Cottonseed meal (41%)	--	--	2.50	2.50	--	--	2.50	2.50
Meat and bone scraps (50%)	--	--	5.85	5.85	--	--	5.85	5.95
Dehydrated alfalfa meal (17%)	3.84	3.84	3.00	3.00	3.84	3.84	3.00	3.00
Wheat bran	4.42	4.42	4.61	4.61	4.42	4.42	4.61	4.61
Methionine Hydroxy analog	0.07	0.07	--	--	0.07	0.07	--	--
Vitamin premix[1]	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Calcium carbonate	8.01	8.01	6.94	6.94	8.01	8.01	6.94	6.94
Dicalcium phosphate	0.48	0.48	--	--	0.48	0.48	--	--
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Trace mineral mix[2]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Safflower oil	--	--	--	--	0.90	0.90	0.63	0.63

[1]Supplied the following per pound of diet: 2000 I.U. vitamin A; 700 I.C.U. vitamin D_3; 2.0 mg. riboflavin; 5.0 mg. niacin; 2.5 mg. calcium pantothenate; 227 mg. choline cloride, and 6.0 gm. soybean meal as a carrier.

[2]Supplied the following in PPM: 20 iron; 60 zinc; 1 molybdenum; 60 manganese; 168 calcium; 4 copper; 1.5 iodine, and 1.5 cobalt.

experiment. Eggs were collected twice during the experiment for the determination of linoleic acid content by gas liquid chromatography. All results were analyzed by analysis of variance and the means separated by Duncan's (1955) multiple range test.

RESULTS AND DISCUSSION

Egg production: The effect of the two protein levels, grain sources and safflower oil on egg production performance are given in Table 10. When the two 12% protein diets without safflower oil were compared, egg production was significantly higher for the grain sorghum diet than for the equivalent corn diet. The same was true when the 15% protein diets without safflower oil were fed. This perhaps can be attributed to differences in protein quality between grain sorghum and corn, however; there were no significant differences in egg production when either grain sorghum or corn was fed at the same protein level and safflower oil was added to increase the linoleic acid content of the diet. This suggests that safflower oil supplementation improved the corn diets more than the sorghum diets.

The National Research Council (1960) states that the optimum protein requirement is 15% for laying hens. In this study the 15% protein diets were significantly higher in egg production than the 12% protein diets indicating that for maximum production it is not only necessary to meet the essential amino acid requirements but also a total nitrogen requirement. The 12% protein diets met the essential amino acid requirements but of course contained less total nitrogen. Quisenberry and Bradley (1962) have found that laying hens fed 17% protein lay at a significantly

TABLE 10

EFFECT OF DIETARY PROTEIN, GRAIN SOURCE AND LINOLEIC ACID ON PERCENT PRODUCTION, FEED CONVERSIONS AND EGG WEIGHT

Dietary Treatment						
Diet	% Protein	Linoleic Acid %	Grain Source	% Production	Feed Conversion	Average Egg Weight (gms)
1	12	1.60	Corn	54.01[a] [1]	4.77[b]	56.4[a]
2	12	1.05	Sorghum	57.85[b]	4.56[b]	56.1[a]
3	15	1.43	Corn	61.98[c]	4.29[a]	57.6[b]
4	15	1.00	Sorghum	65.54[d]	4.12[a]	56.7[ab]
5	12	2.27	Corn	56.62[ab]	4.54[b]	57.2[b]
6	12	1.66	Sorghum	56.49[ab]	4.70[b]	56.8[ab]
7	15	1.86	Corn	66.62[d]	4.16[a]	57.7[b]
8	15	1.43	Sorghum	63.94[cd]	4.19[a]	56.9[ab]

[1]Means having the same superscript were not significantly different at the 0.05 level of probability.

higher rate than when fed 13% protein, even though both diets met the essential amino acid requirements.

There were no significant differences in feed conversion between grain sources within a protein level. However, the 15% protein diets were significantly better in feed conversion than the 12% protein diets (Table 10). These data suggest that the laying hen, fed suboptimal nitrogen levels, tended to overconsume feed.

No significant differences were obtained in egg size due to the grain component of the diet (Table 10). The feeding of 12% protein diets containing either corn or grain sorghum produced average egg weights of 56.4 and 56.1 grams, respectively. A significant improvement in egg weight was obtained between the corn based diets containing 15% protein and 12% protein (Diets 1 and 3). A significant increase in egg weight was also obtained with the supplementation of safflower oil in the 12% protein diets containing corn. The effect of dietary protein level on egg weight in the corn based diets was not evident when safflower oil was fed.

No improvement in average egg size was obtained in the grain sorghum diets which could be attributed to dietary protein level. Supplemental safflower oil also appeared to be without effect on egg size in the grain sorghum diets.

The dietary linoleic acid contents determined by gas liquid chromatography indicated, as would be expected, that the diet based on corn contained higher amounts of linoleic acid than equivalent protein diets formulated with grain sorghum (Table 11). The differences in the fatty acid composition of the two grain sources resulted in rather large differences in linoleic acid contents of the egg yolk. Supplementation with safflower oil increased the egg yolk linoleic acid (Table 11).

Fertility and hatchability were checked three times throughout the experiment, but there was no significant differences due to dietary treatment.

The results of this study suggest that grain sorghum can be used in laying hens' diet to replace corn if substituted on a pound for pound basis. It can also be concluded from this study that under these conditions the total nitrogen requirement of the laying hen is greater than 12% protein equivalent, since production, feed conversion and egg weight of the hens fed the 12% protein diets, were inferior to those obtained with the hens fed 15% total protein diets.

TABLE 11

EFFECT OF DIETARY PROTEIN, GRAIN SOURCE AND SAFFLOWER OIL ON THE LINOLEIC ACID CONTENT OF THE EGG FAT

Dietary Treatment			Dietary Linoleic Acid		Linoleic Acid
Diet	% Protein	Grain Source	Calculated %	Determined %	Of Egg Fat %
1	12	Corn	1.66	1.78	14.64
2	12	Sorghum	1.05	1.27	9.57
3	15	Corn	1.43	1.68	13.98
4	15	Sorghum	1.00	1.24	7.80
5	12	Corn	2.27	2.59	19.80
6	12	Sorghum	1.66	1.38	13.95
7	15	Corn	1.87	1.85	13.94
8	15	Sorghum	1.43	1.64	12.23

SUMMARY

Four experiments were carried out to determine the nutritional value of grain sorghum when compared to corn for broilers and laying hens.

The first experiment was designed to determine the utilization of corn and grain sorghum as sources of protein and energy in broiler diets. There were no significant differences in body weights when the two cereal grains were compared.

A second experiment was undertaken to study the effect of tannic acid on the chicks; since this compound has been implicated as a toxic substance of grain sorghums. Body weights were significantly depressed when the chicks were fed levels of tannic acid greater than 1%. Also differences in feed conversion between the control group and the diets containing tannic acid were statistically significant indicating that tannic acid exceeding 0.25% of the diet is slightly toxic. There were no significant differences in blood uric acid and blood hemoglobin.

In a third experiment the tannin content of several varieties of grain sorghum were determined and found to vary from 0.10 to 0.61%.

The fourth experiment compared corn to grain sorghum

as sources of energy and protein for laying hen diets, and evaluated the effect of added linoleic acid on egg weights. The results of this study showed no significant difference between the grain sources within protein levels in feed conversion, fertility and hatchability. Significant differences in production between the grain sources, within protein level, were noticed when no safflower oil was added, favoring the grain sorghum diet. However, there were no significant differences in production between grain sources, within protein level, when safflower oil was fed. The linoleic acid content of the egg fat and the egg weights were higher for the diets containing corn. This was expected since the corn diets were higher in linoleic acid than the sorghum diets.

It can be concluded that sorghum grain is equal to corn and that the protein requirement of the laying hen under these conditions was greater than 12%, since an improvement in egg production, egg weight and feed conversion was obtained with the 15% protein diets compared to a 12% protein level.

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