

JUNE, 1934

BULLETIN 268

AGRICULTURAL EXPERIMENT STATION
KANSAS STATE COLLEGE OF AGRICULTURE
AND APPLIED SCIENCE
Manhattan, Kansas

THE COMPARATIVE NUTRITIVE VALUE OF
SORGHUM GRAIN, CORN, AND WHEAT
AS POULTRY FEEDS

PRINTED BY THE
KANSAS STATE COLLEGE PRESS
MANHATTAN, KANSAS
1934

TABLE OF CONTENTS

Introduction	5
Sorghum grown extensively in Kansas.....	6
Popularity of kafir and milo.....	6
Comparative feeding value of kafir, milo, and corn.....	8
Preliminary Experimental Work.....	9
Rations used.....	9
Results, 1920-1925.....	10
Experimental Results, 1930-1932.....	15
Method of procedure, 1930-1931.....	16
Rations used.....	16
Method of procedure, 1931-1932.....	18
Feed consumed.....	20
Weights of pullets.....	21
Egg production.....	22
Hatchability	25
Mortality	28
Summary	28
Conclusion	31
Grain Sorghum Rations Recommended.....	31

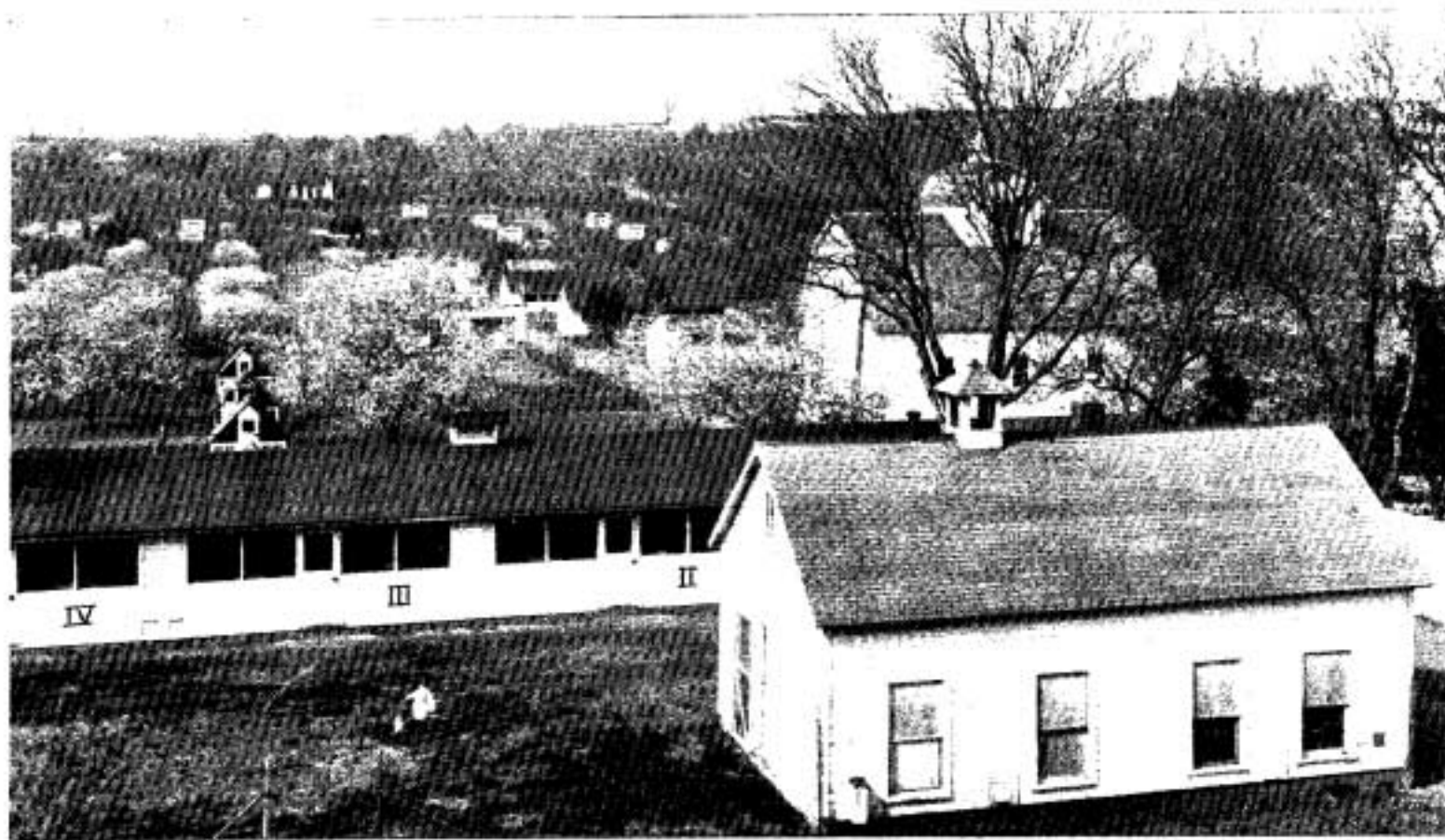


Fig. 1.—A portion of the laying house used for the pullets in the 1930-'32 experiments. This is the house shown in figure 2 after it was remodeled. The pens used are numbered II, III, and IV, corresponding to the lot number of the birds occupying them. The kafir lot, Lot I, is obscured by the building in the foreground. The poultry farm is shown in the background.

THE COMPARATIVE NUTRITIVE VALUE OF SORGHUM GRAIN, CORN, AND WHEAT AS POULTRY FEEDS¹

Loyal F. Payne

INTRODUCTION

While the seed of certain grain sorghums have been used extensively for many years in poultry rations, reports of dissatisfaction are occasionally heard in the region where these grains are grown. Live-stock feeders in the grain sorghum producing states have frequently shown a preference for corn, even when it had to be shipped long distances at somewhat increased costs. Poultry raisers in these same sections have frequently discredited the value of sorghum grain in the rations, while the manufacturers of commercial poultry feeds in most parts of the country and especially in the East have shown a preference for these grains. In fact, a large percentage of sorghum grain shipped out of Kansas to eastern and western markets is used for poultry feed. This difference in attitude may be attributed in part, at least, to the methods employed in harvesting and storing grain sorghums and to the way in which they are fed.

The sorghum heads with the grain are frequently cut from the stalk and stacked in the open. Being exposed to the weather, the stack collects moisture from the rain and snow, which may eventually damage much of the grain. The moldy, musty heads of grain are later fed to the chickens along with the undamaged grain. This practice while not always fatal to the adult stock is usually disastrous to baby chicks. Field ear corn when exposed to the weather is less subject to such damage and it is fairly well cleaned when shelled and cracked. The panicle of the sorghum head, being divided into many fine branches, has a greater tendency to collect moisture and decay than the corn cob. The common farm practice of letting the chickens pick the grain from the heads gives the birds every opportunity to ingest large amounts of this decaying material.

Such grain not infrequently constitutes a large percentage of the poultry ration. When an adequate supply of vitamin A is not available to the poultry flock, "nutritional roup" (A-avitaminosis) frequently develops. Such experiences soon cause the flock owner to lose confidence in sorghum grain as a poultry feed.

The sorghum grain shipped to distant markets is handled

Acknowledgment.—Mr. F. E. Fox began the preliminary work on this experiment December 1, 1920. The author, who took charge of the project in February, 1921, gratefully acknowledges the assistance of Norma Harper who made the statistical studies and Raymond T. Harper who was actively in charge of the birds the last two years of the experiment.

1. Contribution No. 72 from the Department of Poultry Husbandry.

very differently. It is threshed soon after harvesting, placed in dry granaries, elevators, or box cars and sold on a graded basis with but little if any opportunity to become damaged. The dealers who buy it utilize the grain as only one ingredient in a ration which is well balanced with other grains and mill by-products.

SORGHUM GROWN EXTENSIVELY IN KANSAS

While there are many varieties of sorghum, only those of kafir, milo, and feterita are grown primarily for their grain.² Figures from reports of the State Board of Agriculture show that the average annual acreage and value of the above three grain sorghums in Kansas for the period 1915 to 1928 was 1,449,450 acres valued at \$26,532,155. The acreage and value of all sorghum grown in the state were surpassed only by two other cereals, wheat and corn.

POPULARITY OF KAFIR AND MILO

While feterita is listed with kafir and milo as a grain sorghum, it does not compare with them either in acreage grown or in the value of the crop harvested. When comparing kafir and milo in Kansas, it is found that kafir plantings represent about 82 per cent of the acreage and 84.5 per cent of the value while milo is grown on 18 per cent of the acreage and represents 15.5 per cent of the value. (Report of the State Board of Agriculture for the period 1915 to 1928.) The value of kafir is increased when figured on a percentage basis by virtue of a yield of 0.8 bushel per acre more than milo. When the prices of the two grains are compared on a pound basis, milo usually sells for more than kafir. The average low price paid for No. 2 grain on the Kansas City market for the 11-year period from 1921 to 1931 was \$1.02 a hundred for white kafir and \$1.09 a hundred for yellow milo according to figures supplied by the Department of Agricultural Economics, Kansas Agricultural Experiment Station. This represents a difference of 7 cents a hundred in favor of milo. There was only one year (1923) during the 11 when kafir sold for more than milo.

According to a report of the Los Angeles, Calif., Grain Exchange, compiled by the Federal State Marketing Service at Sacramento, Los Angeles received for the six-year period from 1923-'24 to 1928-'29, 2,985 cars of milo and 2,358 cars of kafir. While the report does not indicate how these grains were used the main portion in all probability went into poultry feeds.

The greater market value of milo is apparently due to the color of the grain and the more limited supply. It cannot be based on a higher nutritive value as will be pointed out later in this publication. The yellow color of milo adds attractiveness to a grain mixture. A combination of white corn, wheat, and kafir is somewhat colorless and unattractive to the buyer,

2. This statement, together with the figures on sorghum which follow, was supplied by H. H. Laude, Professor of Farm Crops, Kansas State College.

COMPARATIVE NUTRITIVE VALUE OF POULTRY FEEDS 7

whereas the substitution of either yellow milo or yellow corn for any of the above grains adds attractiveness and "richness" to the mixture and thus enhances its sales value. Most of the popular scratch grain mixtures contain a variety of brightly colored grains.

The popularity of kafir and milo for use in commercial poultry feeds is indicated in the registrations of poultry rations with the Control Division of the State Board of Agriculture, Topeka, Kan. The report dated September, 1931, lists 269 scratch grain mixtures for growing chicks and 325 for laying hens. A tabulation of the ingredients used as pertaining to kafir and milo is given in Table I.

TABLE I.—FREQUENCY WITH WHICH KAFIR AND MILO WERE REPORTED IN CHICK AND HEN SCRATCH GRAINS REGISTERED IN KANSAS.

	Chick rations		Hen rations	
	Number registered	Percentage	Number registered	Percentage
Kafir as only grain sorghum listed	125	46.4	152	46.8
Both kafir and milo listed.....	99	36.8	122	37.5
Kafir or milo listed.....	23	8.6	31	9.5
Milo as only grain sorghum listed	10	3.7	6	1.8
Neither kafir nor milo listed.....	12	4.4	14	4.3
Total.....	269	99.9	325	99.9

It will be observed from Table I that either kafir or milo (or both) is used in more than 95 per cent of the scratch grain mixtures registered in Kansas for growing chicks and laying hens. On the other hand, one seldom finds either listed in the growing or laying mash mixtures. Kafir was listed in a variety of ways such as whole kafir, cracked kafir, cut kafir, kafir chop, kafir grits, steel-cut kafir, and screened cracked kafir. Milo was usually listed as milo, cracked milo, or screened cracked milo.

Kafir and milo are not generally recommended in poultry rations by agricultural experiment stations. A recent study made by the author, of rations for growing chicks and laying hens recommended by the poultry departments in 30 different state agricultural experiment stations revealed the fact that not a single state recommended either grain as first choice in the laying mash. Texas was the only state that used either or both in the scratch grain, and none of the states used either grain in their all-mash starting feeds for baby chicks.

C. R. Ball in Farmers' Bulletin 448 of the United States Department of Agriculture, published in 1911, states that grain sorghum seed are well adapted both in size and composition for

feeding all classes of poultry. "There were," he continues, "in 1908 more than 100 firms engaged in the manufacture of over 200 brands of poultry feed. Thirty-three of these showed an annual output of about 30,000 tons of these products. One-third of this total consisted of the seed of Blackhull kafir. It is estimated that kafir and other grain sorghums formed fully 25 per cent of the prepared poultry feed sold in this country." These figures appear very small compared with those of today. The United States Department of Commerce reported 750 establishments prepared 7,353,244 tons of feed for animals and fowls in 1929. The number of firms preparing poultry feed and the output classed as poultry feed were not given, but one large Middle West feed company estimated that approximately 50 per cent of this tonnage was prepared for poultry.

COMPARATIVE FEEDING VALUE OF KAFIR, MILO, AND CORN

Numerous chemical analyses have shown that kafir and milo are slightly higher in protein and lower in fiber than corn, while corn is higher in fat than the sorghums. However, there does not appear to be a sufficient variation in either the chemical composition or in the digestibility of the three grains to cause any material difference in their nutritive value. In reviewing the literature covering sorghum feeding experiments with farm animals, it was found that most of the early experimental work was done with cattle, sheep, and hogs and very little with poultry. Poultry differ widely from other farm animals in eating habits and ability to utilize grain. For example, pigs frequently do not thoroughly masticate their feed. As a result, some of the smaller uncracked grains, such as the sorghums and wheat, pass through the animal undigested. Cattle likewise pass undigested grain and their ability to utilize crude fiber also differs from poultry in that the latter digest but little if any of this material. The more thorough masticating habits of sheep and the efficiency with which their feed is digested correspond perhaps more closely to the chicken than to either of the other groups named. There is no record of whole grain feeds passing through the digestive tract of adult Chickens. Certain weed seeds, however, have been known to pass through growing chicks apparently undamaged.

In reviewing the results of more than 40 experiments with farm animals and poultry in which actual comparisons were made with corn, kafir, and milo it was found that corn was ranked first 11 times or in 64 per cent of the 17 comparisons; kafir was given first place 8 times or in 50 per cent of the 16 tests; and milo stood first 3 times or in 33 per cent of the 10 instances where a comparison was possible. Differences in the feeding value of these grains appear to be very little. While corn may have a slight advantage, the statement by early writers that grain sorghum seed possessed only 90 per cent of the feeding value of corn does not appear to be substantiated by

COMPARATIVE NUTRITIVE VALUE OF POULTRY FEEDS 9

the available experimental data. In fact, the results frequently showed kafir and milo to be equal and occasionally superior to corn. While kafir usually gave better results than milo the latter was superior in some of the tests. The impression that sorghums were inferior to corn was apparently gained in early studies when the vitamin-A-deficient sorghums were compared with yellow corn which is rich in this vitamin. The kind of corn used in the early work was not recorded. The yellow varieties, however, have long been preferred for feeding live stock and were probably employed in most comparisons. When alfalfa hay was used to supplement the grain rations, the importance of bright green, unbleached hay in supplying vitamin A was probably not realized.

V. G. Heller of the Oklahoma Agricultural Experiment Station in a personal communication stated that it has been found in recent analyses at that station that the variation in chemical composition from year to year of any particular grain sorghum is almost as much as for different sorghums in the same year. This is due, he states, to moisture, climatic conditions, etc. Mr. Heller further said: "We have also determined that widely varying types of soils affect the analyses of the grains to a considerable extent." In the light of this statement, slightly different feeding results may be expected at different stations and at the same station for different years.

PRELIMINARY EXPERIMENTAL WORK

An experiment to compare the relative feeding value of sorghums alone, as for example Blackhull kafir, Dwarf Yellow milo, and Kansas Orange sorgo³ seed, with a mixture composed of corn, wheat, and kafir was begun December 1, 1920. Each of the four test flocks consisted of 11 White Leghorn females and one male. The birds were confined in 7- by 16-foot pens in an open-front semimonitor house. (Fig. 2.) Chicks were hatched from each of the four lots in the spring of 1921 and 12 pullets from each lot were reared to maturity on rations similar to those supplied the parent stock. The original birds were also continued on the same rations for a second laying year. The 34 hens surviving the first year were all mated with the same cockerel the second year in order that all chicks to be used in continuing the work might have a common sire. Thus all females used subsequent to the beginning of the year 1922-'23 were half sisters. This procedure was followed for the purpose of eliminating as much as possible the breeding factor and individual variability.

RATIONS USED

During the first year of the experiment the regular mash recommended by the station for laying hens was used. This feed will be referred to hereafter as the regular college ration. The mash consisted of 32.2 per cent each of ground corn and

ground oats, 16 per cent each of wheat bran and meat scraps, and 3.5 per cent dried buttermilk. The scratch consisted of the grains to be tested. Lot 1 received milo; lot 2, sorgo; lot 3, kafir; and lot 4, control, cracked yellow corn 66.6 per cent, wheat 16.6 per cent, and kafir 16.6 per cent.

The grain ration was supplemented with green sprouted oats fed at the rate of 1 square inch a bird daily. Crusted oyster shell, grit, and water were available at all times.

RESULTS 1920-1925

Since the rations fed differed somewhat the first year from those used thereafter, the results are reported separately. The

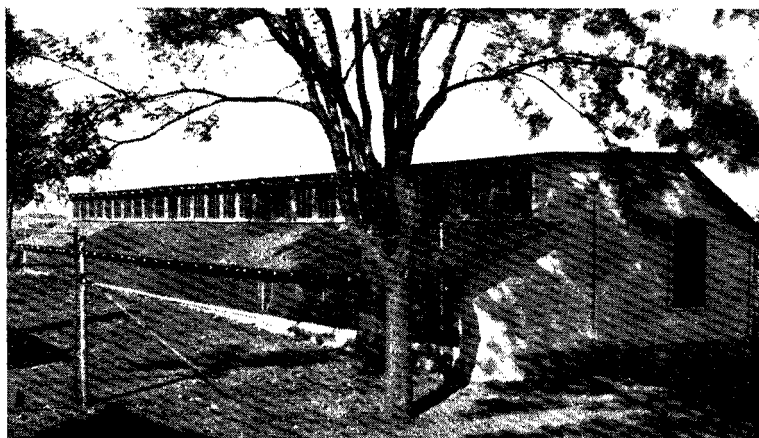


Fig. 2.—The semimonitor house used in the preliminary work. This house was divided into a series of small pens, 7 by 16 feet, with a 4-foot aisle at the back. The front was covered with screen wire to exclude insects. The birds in the five-year preliminary experiment occupied the four pens at the far end.

period of the experiment was from December 1, 1920, to November 30, 1921. The average number of eggs produced per hen was, for the milo group, 153.1; sorgo group, 129.4; kafir group, 152.8; and the mixed-grain group, 133.2. It will be seen from these figures that milo and kafir gave about equal results followed by the control or mixed grain lot and the sorgo group.

Beginning with the year 1921-'22, the grains to be tested were increased to about 87.5 per cent of the ration and this system was followed until the completion of the preliminary work in 1925. This change in the composition of the rations was accomplished by substituting a mash composed of 76 per cent of the grain to be tested and 25 per cent high-grade meat scraps for the mash used in 1920-'21, and feeding the mash and

3. This variety has sometimes been referred to as Kansas Orange cane.

COMPARATIVE NUTRITIVE VALUE OF POULTRY FEEDS 11

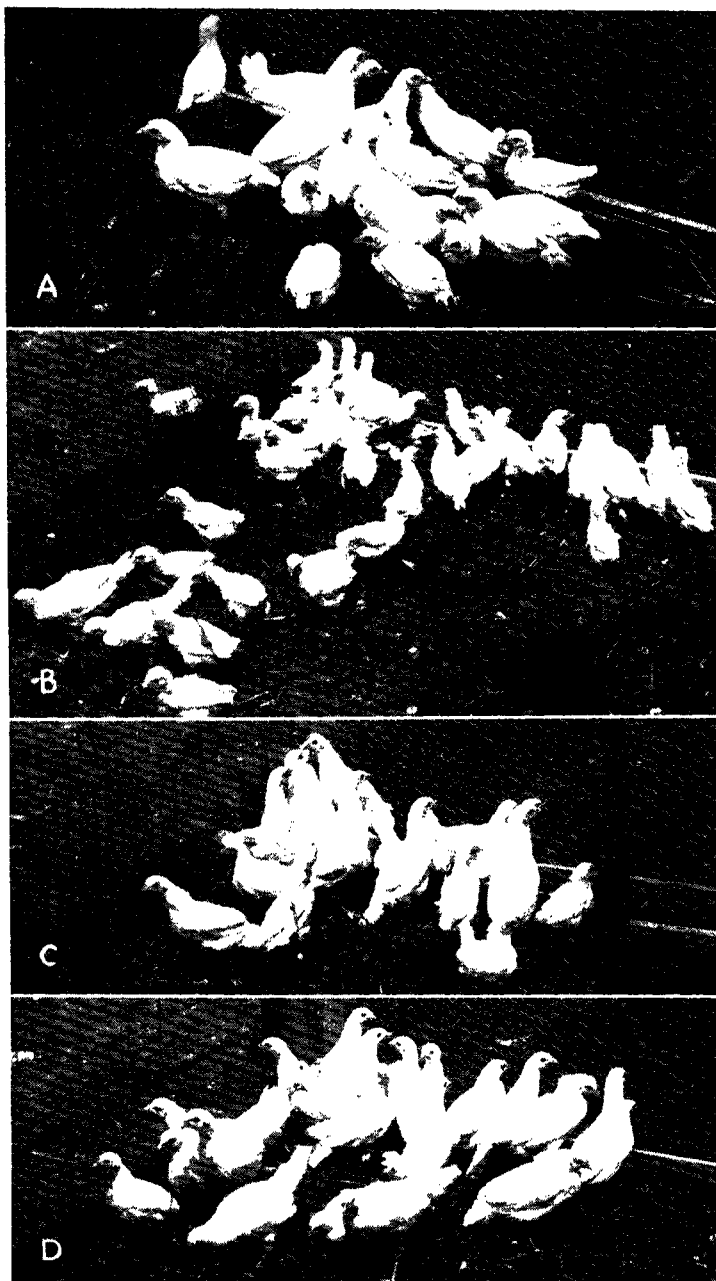


Fig. 3.—One hatch of eight-week-old Leghorn pullets from half-sisters and a common sire. Group A received the milo ration; B, the sorgo ration; C, the kafir ration; and D, the control ration. All groups were fed liquid buttermilk daily.

scratch feeds in equal quantities. Three years' results with pullets and two years' with hens on these rations are given in Tables II and III. It should be remembered that all birds in these tests received the rations under comparison from the time the chicks were hatched to the end of the experiment, which was two to three years for those that lived. (Figs. 3 and 4.) In the live-stock experiments reviewed, the animals were grown to maturity on normal rations and finished on one of the grain sorghums for a feeding period of a few months. In Table II

TABLE II.—RESULTS FOR SORGHUM FEEDING EXPERIMENT WITH LEGHORN PULLETS GROUPED BY YEARS.

Year	Average Weight		Annual egg production	
	Start	Finish	Number	Percentage
Milo	Lbs.	Lbs.		
1921-'22.....	2.6	3.1	170	46.57
1922-'23.....	3.0	3.6	130	35.61
1923-'24.....	2.2	3.5	121	33.15
Average.....	2.6	3.4	140	38.35
Sorgo				
1921-'22.....	2.4	3.4	140	38.35
1922-'23.....	2.6	3.1	98	26.84
1923-'24.....	1.1	3.0	84	23.01
Average.....	2.0	3.1	107	29.31
Kafir				
1921-'22.....	2.0	2.6	163	44.65
1922-'23.....	1.7	3.6	153	41.91
1923-'24.....	3.0	3.8	162	44.38
Average.....	2.2	3.3	159	43.56
Control				
1921-'22.....	2.7	3.4	117	32.05
1922-'23.....	2.9	3.7	156	42.75
1923-'24.....	3.3	3.5	172	47.12
Average.....	2.6	3.6	148	40.54

are given the gain in weight, feed consumption, and average egg production for the pullets for the three tests.

In this series of experiments if the control group be considered as 100 per cent efficient in egg production, then kafir rates 107.4 per cent, milo 94.5 per cent, and sorgo 72.2 per cent. That is, the pullets which received kafir had a better average production for the three years than any of the other lots. Feed weights were kept each year, but the shifting of males, mortality of birds, and the overlapping of the pullet- and hen-production years made it difficult to keep these records accurate; therefore, they were omitted in Tables II and III. The sorgo seed was not nearly so palatable as the other grains tested judg-

COMPARATIVE NUTRITIVE VALUE OF POULTRY FEEDS 13

ing from the amount of scratch grain consumed. The sorgo lot showed a distinct preference for the mash feed, while the control lot consumed more grain than mash. The kafir and milo groups ate about equal amounts of grain and mash.

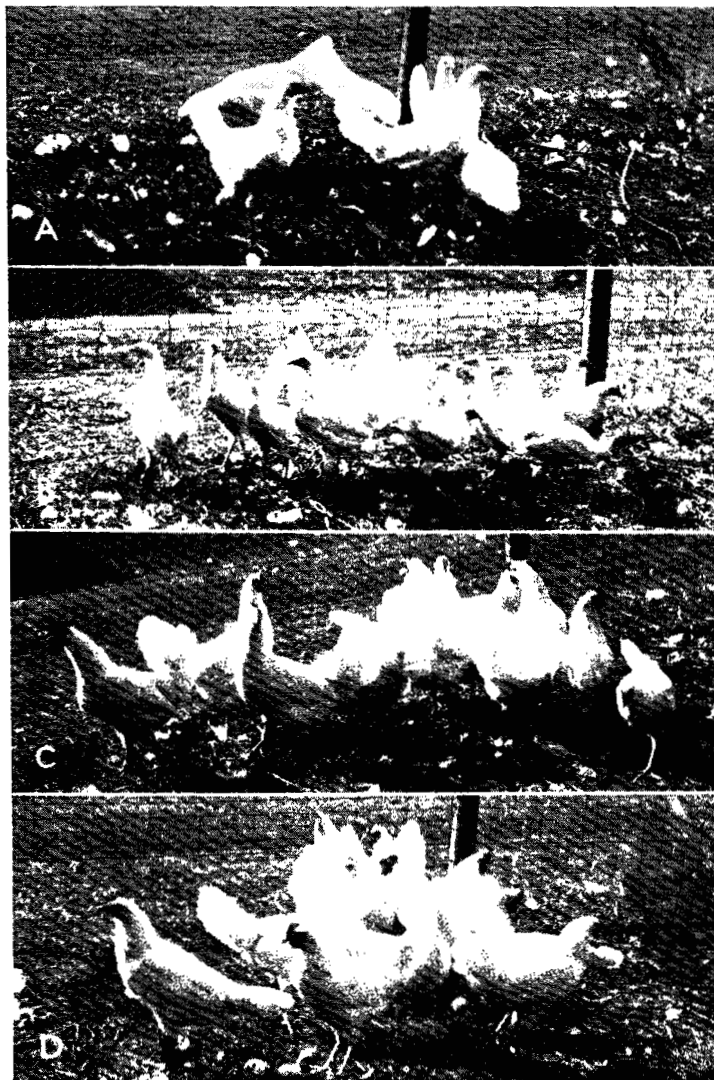


Fig. 4.—The same pullets shown in figure 3, photographed October 1, 1923, when 23 weeks old. The rations fed were: A, milo; B, sorgo; C, kafir; and D, control ration. A few of the pullets in the kafir and control groups were laying. The average weight of the sorgo group was slightly more than 1 pound each.

There was a gain in average weight in all lots during the three experiments. The birds in the control lot averaged a little heavier than the others, while the sorgo group weighed the least.

Table III gives similar information for birds on the same rations the second or hen year of their production.

TABLE III.—RESULTS OF SORGHUM FEEDING EXPERIMENT WITH LEGHORN HENS GROUPED BY YEARS.

Year	Average weight		Annual egg production	
	Start	Finish	Number	Percentage
Milo	Lbs.	Lbs.		
1921-'22	3.0	3.5	100	27.39
1923-'24	3.6	4.0	136	37.26
Average	3.3	3.7	118	32.32
Sorgo				
1921-'22	3.3	3.2	99	27.12
1923-'24	3.1	3.6	113	30.95
Average	3.2	3.4	106	29.04
Kafir				
1921-'22	3.2	3.8	102	27.94
1923-'24	3.6	3.9	136	37.26
Average	3.4	3.8	119	32.60
Control				
1921-'22	3.1	3.3	116	31.78
1923-'24	3.7	3.9	133	36.43
Average	3.4	3.6	124	33.97

Here again, if the control group is rated 100 per cent in production, kafir would rate 95.9 per cent; milo, 95.1 per cent; and sorgo, 85.3 per cent. It will be observed that all groups gained slightly in weight. The hens showed the same dislike for sorgo seeds that was evident with the pullets.

A few birds were available for third-year production records. Beginning with the third year, the rations were reversed. The birds which had been reared on milo were fed the kafir ration: those reared on sorgo were given mixed grain; the kafir group was fed milo; and the mixed grain lot was supplied sorgo.

The number of hens which completed 12 months' production for each of the three years, the rations fed each year, and egg production of each lot for each of the three years are given in Table IV.

In this particular group of experiments, the sorgo followed by control did not produce so well as the control followed by

COMPARATIVE NUTRITIVE VALUE OF POULTRY FEEDS 15

TABLE IV.—RATIONS FED, NUMBER OF HENS COMPLETING AN EGG-PRODUCTION RECORD IN EACH LOT EACH YEAR, AND THE EGG PRODUCTION FOR EACH LOT EACH OF THE THREE YEARS.

Lot	Rations			Number of hens completing each year's production record			Egg Production		
	1st yr.	2d yr.	3d yr.	1st yr.	2d yr.	3d yr.	1st yr.	2d yr.	3d yr.
Milo.....	Milo	Milo	Kafir	7	7	5	130	136	91
Sorgo....	Sorgo	Sorgo	Control	11	10	5	98	113	79
Kafir.....	Kafir	Kafir	Milo	10	10	4	153	136	104
Control..	Control	Control	Sorgo	11	10	3	156	133	92

Note.—The milo lot received kafir the third year; the sorgo lot received the control ration the third year; the kafir lot received milo the third year; and the control lot received sorgo the third year.

sorgo. Neither combination proved as satisfactory as the kafir and milo groupings. A comparison based on the control group as 100 per cent gave the following ratings:

Feed	First-year percentage	Second-year percentage	Feed	Third-year percentage
Milo	83.3	102.2	Kafir	115.1
Sorgo	62.8	84.9	Control	100.0
Kafir	98.0	102.2	Milo	131.6
Control	100.0	100.0	Sorgo	116.4

This comparison shows the advantage of a good starting and growing ration. The control group which led the first year ranked third the second year and fourth the third year. The kafir group which rated second the first two years led all others the last year when fed milo. The milo-kafir combination averaged better than the control-sorgo lots.

In the foregoing experiments the control group showed a slight advantage over both kafir and milo, and sorgo was quite inferior. The results from the kafir-fed birds were a little better than the milo group. Since small numbers of birds were used in the different tests it was decided to repeat the work using much larger numbers.

EXPERIMENTAL RESULTS, 1930-1932

It was not until the spring of 1930 that suitable equipment was available to continue the experimental work on grain sorghums with large numbers of birds. A long brooder house equipped with gas brooder stoves was used for starting the chicks. An open-front, straw-loft house (fig. 1) 20 by 80 feet

in size and divided into four pens, each of which contained 400 square feet of floor space, was used as laying quarters for the birds.

METHOD OF PROCEDURE, 1930-1931

Twelve hundred Single Comb White Leghorn chicks were hatched from the college flock on May 14, 1930. These were divided into four lots of 300 each and reared to maturity in a long brooder house which was equipped with sanitary runways in order that the chicks might have outdoor exercise without coming in contact with the ground. When about half grown, the pullets were transferred to their laying quarters where they were kept confined throughout a nine-month laying period.

The cockerels were separated from the pullets on June 11 in order to give the latter more room. On June 26, coccidiosis was discovered in Lot I. Within four days it had spread to Lots II and IV. Lot III was never so seriously infected as the other lots. Thirty-five per cent of dried buttermilk was added to the ration and the necessary sanitary precautions were taken to combat this disease. The infection had disappeared by July 12. While only healthy and normal appearing birds were kept for this experiment, this disease and a subsequent infestation of tapeworms probably interfered with the results and caused heavy mortality among the adult birds.

RATIOS USED

The grains to be tested were kafir, milo, white corn, and yellow corn and wheat. On the basis of previous experiments it was felt that sorgo was not a satisfactory poultry feed when it constituted the major bulk of the feed, hence its use experimentally was discontinued. The supply of kafir and milo for the first experiment was purchased in one order from a firm in

TABLE V.—AMOUNT OF INGREDIENTS USED IN THE DIFFERENT RATIONS.

Lot and Ration	I Kafir	II Milo	III White corn	IV Yellow corn and wheat
Ingredients	Lbs.	Lbs.	Lbs.	Lbs.
Kafir, ground.....	50	..	..	..
Milo, ground.....	..	50	..	..
White corn, ground.....	..	..	50	..
Yellow corn, ground.....	..	..	..	25
Wheat, ground.....	..	..	..	25
Wheat bran.....	19	19	19	19
Alfalfa leaf meal.....	10	10	10	10
Meat and bone scraps.....	10	10	10	10
Dried buttermilk.....	5	5	5	5
Steamed bone meal.....	2	2	2	2
Calcium carbonate.....	2	2	2	2
Cod-liver oil.....	1	1	1	1
Salt.....	1	1	1	1
Total.....	100	100	100	100

COMPARATIVE NUTRITIVE VALUE OF POULTRY FEEDS 17

Kansas City. The white corn, yellow corn, wheat, and other ingredients were obtained from local feed dealers. To a common basal ration was added an equal amount of the different grains thus making the ration carry 50 per cent of the grain to be studied. The complete rations are given in Table V.

After the rations were thoroughly mixed, samples from each were analyzed in the analytical laboratory. The results of these analyses are given in Table VI.

TABLE VI.—CHEMICAL COMPOSITION OF RATIONS.

	Moisture	Protein	Fat	Fiber	Ash	Nitrogen free extract
Lot and Ration	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
I. Kafir	8.92	16.63	5.09	3.91	11.01	54.44
II. Milo	8.85	16.94	5.00	3.83	11.22	54.16
III. White corn	8.99	16.00	5.50	4.10	10.63	54.73
IV. Yellow corn and wheat	8.91	16.88	4.92	4.16	11.41	53.72

The author desires to express his indebtedness to Prof. W. L. Latshaw, in charge of the analytical laboratory, K. S. C., for his care in supervising all chemical analyses included in this investigation.

These figures show but little variability in the chemical constituents of the rations fed. The all-mash feed was available in open hoppers from the time the chicks were hatched until the end of the first laying year 15 months later. Grit, oyster shell, water, and straw litter were the only supplements available. No scratch grain, green succulent feed, or wet mash was fed. Artificial lights were not used. This applied particularly to the sorghum-reared birds as contrasted with the group described in the following paragraph.

While chicks were being reared in the above manner, several hundred other White Leghorn chicks hatched from the same strain but several weeks earlier in the spring were reared in battery brooders the first four weeks, then transferred to gas burning brooders for four weeks after which the pullets were removed to an alfalfa range where they were kept until mature. This group received the regular college ration which is given in Table VII.

Scratch grain composed of equal parts of cracked yellow corn and wheat was hopper fed in addition to the above growing mash after the chicks were nine weeks of age.

On November 1, 50 of the more desirable pullets from each of the four lots reared in confinement and 50 pullets reared on the range were leg banded, weighed, and placed in each of the four pens in the laying house. The object was to compare birds reared in confinement on the different rations being tested, with

TABLE VII.—AMOUNT OF INGREDIENTS USED IN THE DIFFERENT RATIONS FOR GROUP 2, UNTIL MATURE.

Ingredients	Starting ration, 1-8 weeks	Growing ration, 9-24 weeks
	Lbs.	Lbs.
Yellow corn, ground.....	45	51
Wheat bran.....	15	15
Oats, ground.....	15	15
Oat groats, ground.....	15	15
Meat and bone scraps.....	10	10
Dried buttermilk.....	5	5
Alfalfa leaf meal.....	5	5
Bone meal.....	3	3
Cod-liver oil.....	1	1
Salt.....	1	1
Total.....	100	100

birds reared on the college ration with free range and placed on the test rations at maturity. The handling of the latter group conformed more closely to the methods used in grain-sorghum feeding experiments with other types of farm animals, while the former method served as a check on the earlier work at this station with poultry. The two groups of birds are referred to hereafter as group 1, reared in confinement on experimental ration, and group 2, reared on range and fed college ration prior to the test period.

METHOD OF PROCEDURE, 1931-1932

The outbreak of coccidiosis and the high mortality among the mature pullets in 1930-1931 made it seem advisable to repeat the experiment. Therefore, chicks of Single Comb White Leghorns from the college flocks taken off April 25 and May 9, 1931, were reared in storage brooders until four weeks of age when they were transferred to the long brooder house and reared under gas heated brooders until about eight weeks of age. The two hatches were put together June 6 when the first group was six weeks of age. The males were disposed of as broilers. The pullets were transferred to more commodious quarters in the laying pens on August 11. The house was thoroughly cleaned and disinfected after the adult birds from the previous experiment were removed August 1. With minor exceptions the same rations and methods of feeding used in the previous year's work were followed the second year. To minimize the development of slipped tendons, possibly resulting from a feed very high in minerals, the steamed bone meal and calcium carbonate were omitted from all four rations, and meat cracklings, low in ash and testing about 75 per cent crude protein, were substituted for meat and bone scraps for the first eight weeks. After eight weeks, meat and bone scraps, which tested about 50 per cent crude protein, replaced the cracklings in the different rations. The chicks did exceptionally well from the beginning and there were no disease or parasitic outbreaks

COMPARATIVE NUTRITIVE VALUE OF POULTRY FEEDS 19

to interfere with the results. The lots were designated as Lots V, VI, VII, and VIII which corresponded to Lots I, II, III and IV, respectively, for the year 1930-'31.

The all-mash rations used during the year 1931-'32 are given in Table VIII.

TABLE VIII.—AMOUNT OF INGREDIENTS USED IN THE DIFFERENT RATIONS.

Lot and Ration	V Kafir	VI Milo	VII White corn	VIII Yellow corn and wheat
Ingredients	Lbs.	Lbs.	Lbs.	Lbs.
Kafir, ground.....	50	..	..	..
Milo, ground.....	..	50	..	..
White corn, ground.....	..	..	50	..
Yellow corn, ground.....	..	..	..	25
Wheat, ground.....	..	..	..	25
Wheat bran.....	25	25	25	25
Alfalfa leaf meal.....	10	10	10	10
Meat cracklings.....	10	10	10	10
Dried buttermilk.....	5	5	5	5
Cod-liver oil.....	1	1	1	1
Salt.....	1	1	1	1
Total.....	100	100	100	100

The 4 pounds of bone meal and calcium carbonate formerly used were replaced by 4 pounds additional wheat bran. A chemical analysis was not made of these rations but aside from the decrease in ash the composition was probably quite similar to that of the first year.

A corresponding number of Leghorn pullets were again reared on the regular college ration and in a manner similar to the method outlined for the previous year.

All pullets were carefully examined on October 1, 1931, and 50 from each group were leg banded, weighed individually, and returned to their respective pens and designated as group 1, which meant they had been reared in confinement on the experimental rations. A corresponding number of Leghorn pullets from the range were similarly selected, leg banded, weighed, and placed in each of the four pens. These were designated group 2 which signified that they were reared on the range and fed the college ration until mature. This procedure provided 100 pullets for each of the four lots. Those from the range, having been hatched earlier than those reared in confinement, were in fairly heavy production by the first of October. Very few of the pullets in group 1 were in production at this time. The pullets were placed in the laying house one month earlier than the previous year.

The work progressed very satisfactorily until about the middle of March when infectious bronchitis appeared in Lot V. Because of the serious nature of this disease, trapnesting ceased in this lot from March 15 to 21, inclusive, in order to prevent

the trapnester from spreading the disease on his hands and clothing to the other lots. While mortality from this cause was not large, the individual trapnest record had been interrupted thus making it impossible to treat the results statistically for the entire production period. The eggs laid during this period were credited to the pen as a whole the same as eggs laid on the floor or outside the trapnests.

The criteria used for measuring the nutritive value of the grains were: (1) Feed consumption, (2) gain or loss in adult weights, (3) egg production, (4) hatchability of eggs, and (5) mortality of adult birds. The results for the two years are presented in Tables IX to XV, inclusive.

FEED CONSUMED

The all-mash feed was available in open hoppers at all times throughout the duration of the experiment. While there was some waste, it was reduced to a minimum by the style of hoppers used. The amount of feed consumed is given in Tables IX and X.

TABLE IX.—POUNDS OF FEED CONSUMED PER CHICK FOR 170 DAYS IN GROUP 1.

Reared in confinement on experimental ration (a).

Lots - - - - -	Kafir	Milo	White corn	Yellow corn and wheat
1930-'31.....	18.87	17.56	18.53	18.47
1931-'32.....	18.70	18.74	18.74	18.44
Average for two years.....	18.78	18.15	18.63	18.45

(a) The pullets in group 2 had free range with the college flock. Therefore, feed consumption figures were not kept on group 2 previous to November 1.

It will be observed from the figures in Tables IX and X that the feed consumption by all groups was practically the same. All-mash feeding for experiments of this type is a very accurate method of measuring the actual amount of feed consumed and it is a guarantee that each bird consumes the feed in the proportions used in mixing the ration. In other words, there is no

TABLE X.—POUNDS OF FEED CONSUMED PER HEN, GROUPS 1 AND 2, NOVEMBER 1 TO JULY 31.

Lots - - - - -	Kafir	Milo	White corn	Yellow corn and wheat
1930-'31.....	59.82	56.84	56.93	57.72
1931-'32.....	60.32	58.16	58.28	59.01
Average for two years.....	60.07	57.50	57.60	58.86

COMPARATIVE NUTRITIVE VALUE OF POULTRY FEEDS 21

opportunity for selection of grains as is afforded in scratch grain and mash or free-choice feeding. The feed consumption records were calculated on a hen-day basis in order to include the feed consumed by birds which did not live throughout the experiment.

WEIGHTS OF PULLETS

The pullets were individually weighed in grams on a Quick Stop Chatillion spring scale at the beginning and conclusion of the laying period. The results are given in Tables XI and XII.

TABLE XI.—WEIGHTS IN GRAMS OF BIRDS IN GROUPS 1 AND 2 FOR 1930-'31.

Lots	Kafir	Milo	White corn	Yellow corn and wheat
Group 1				
November 1, 1930.....	1,351	1,356	1,400	1,321
August 1, 1931.....	1,304	1,339	1,347	1,286
Gain or loss.....	-47	-17	-53	-35
Percentage loss.....	-3.47	-1.25	-3.78	-2.64
Group 2 (a)				
November 1, 1930.....	1,554	1,474	1,569	1,449
August 1, 1931.....	1,421	1,347	1,432	1,369
Gain or loss.....	-133	-127	-137	-80
Percentage loss.....	-8.55	-8.61	-8.78	-5.52
Average of Groups 1 and 2				
November 1, 1930.....	1,453	1,415	1,480	1,385
August 1, 1931.....	1,358	1,343	1,389	1,326
Gain or loss.....	-95	-72	-91	-59
Percentage loss.....	-6.53	-5.08	-6.14	-4.25

(a) The pullets in group 2 were a few weeks older than those in group 1.

The figures as recorded in Table XI show that the birds in all lots for 1930-'31 lost weight during the nine-month laying period. The average loss for group 1 was 2.78 grams, and for group 2, 7.86 grams. The average loss for both groups was only slightly less for Lot IV, which received corn and wheat, than for the other lots. The results for 1931-'32, presented in Table XII, are the reverse of those of the previous year in that all birds made slight gains during the nine-month laying period. The birds reared in confinement made an average gain of 13 grams while those reared on the range after eight weeks of age gained an average of only 3.9 grams. When the figures for the two years are combined, the changes in body weight become insignificant in all groups. While the all-mash system of feeding has certain advantages as given above, it is with difficulty that body weight is increased or even maintained under heavy

egg production, especially when artificial illumination is not used. The birds never seem to gorge their crops with finely ground feeds before going to roost as they do when supplied whole or cracked grain. During the long winter nights, the

TABLE XII.—WEIGHTS IN GRAMS OF BIRDS IN GROUPS 1 AND 2 FOR 1931-'32.

Lots - - - - -	Kafir	Milo	White corn	Yellow corn and wheat
Group 1				
October 1, 1931 (a).....	1,186	1,177	1,244	1,213
August 1, 1932.....	1,390	1,390	1,366	1,361
Gain or loss.....	-204	+153	-122	+148
Percentage gain.....	+17.2	+12.9	-9.8	+12.2
Group 2				
October 1, 1931 (a).....	1,417	1,413	1,382	1,389
August 1, 1932.....	1,486	1,421	1,444	1,471
Gain or loss.....	-69	-8	-62	+82
Percentage gain.....	+4.8	+0.56	-4.4	+5.9
Average of Groups 1 and 2				
October 1, 1931.....	1,302	1,295	1,313	1,301
August 1, 1932.....	1,435	1,375	1,405	1,421
Gain or loss.....	-133	-80	-92	+120
Percentage gain.....	+10.2	+6.1	+7.1	+9.2
Average of Groups 1 and 2 (Both years)				
October 1 and November 1.....	1,394	1,358	1,412	1,364
August 1.....	1,401	1,360	1,396	1,372
Gain or loss.....	+7	-2	-16	+8
Percentage.....	+0.5	-0.14	-1.1	+0.58

(a) The pullets were hatched earlier for both groups than the previous year and they were weighed into the laying house October 1 instead of November 1.

birds in all probability do not consume an adequate amount of feed for heavy egg production and the maintenance of body weight.

EGG PRODUCTION

All birds were trapnestered throughout the experiment thus making individual egg records available except for one week in 1932 for Lot V when the nests were left open to eliminate handling the birds during a threatened disease outbreak. The egg records were calculated on a hen-day basis. Eggs laid on the floor or droppings boards were recorded as floor eggs and credited to the pen total for group averages. In considering individual averages, all eggs laid outside the trapnests were omitted. The results for the two groups during both years are given in Table XIII.

COMPARATIVE NUTRITIVE VALUE OF POULTRY FEEDS 23

TABLE XIII.—AVERAGE EGG PRODUCTION PER BIRD FOR NINE MONTHS.
November 1 to August 1.

Year	Kafir	Milo	White corn	Yellow corn and wheat	Average, all lots
Group 1					
1930-'31 (a)	134.7	139.6	136.2	131.0	135.3
1931-'32 (a)	153.5	146.3	133.5	132.9	141.5
Average	144.1	142.9	134.8	131.9	138.4
Group 2					
1930-'31 (a)	141.2	117.7	116.8	120.5	124.0
1931-'32 (a)	154.8	158.2	157.6	154.1	156.1
Average	148.0	137.9	137.2	137.3	140.1
Average for Groups 1 and 2 (Both years)					
1930-'31 (b)	142.1	131.4	128.9	128.7	132.7
1931-'32	157.4	154.7	150.5	146.9	152.3
Average	149.7	143.0	139.7	137.8	142.5
Percentage production	54.8	52.3	51.1	50.4	52.1

(a) These production figures include only the eggs laid in trapnests.

(b) These figures include all eggs which were laid both in the nests and on the floor.

While the differences in egg production in Table XIII are not great, it will be noted that in the average for both years the kafir lot led all others. The milo lots were second, followed by white corn and the mixed grain or check ration. Since kafir gave almost as good results as the other grains with which it was compared in the five-year preliminary experiments and slightly better results both years when tested with large numbers of birds, it would appear that it was equal to these grains as a feed for poultry.

In the production figures for groups 1 and 2 for 1930-'31 the pullets in group 1 averaged 11.3 eggs each more than those in group 2. The pullets in group 2 were hatched earlier in the spring than group 1 and a fairly large number had been laying a few weeks when the experiment was begun November 1. Many of the pullets in group 2 later went through a winter molt which retarded egg production. There was no unseasonable molting by either group during the 1931-'32 season and a comparison of the production figures shows an average of 14.6 eggs per bird in favor of group 2, which was reared on an alfalfa range. Combining the two years' results for both groups, group 1 averaged 138.4 eggs per bird and group 2 averaged 140.1 egg each. While the pullets were placed in the laying house October 1, or one month earlier in 1931-'32 than the previous year, the egg records for the month of October were not included in the above figures. The additional month merely served as a preliminary period for adjustment and adaptation to the new quarters for the birds brought in from the range. The pullets in group 1 had already occupied these quarters since the middle of August.

In order to calculate the error of the mean, the individual trapnest egg records for all birds which laid through the nine-month period were used. All floor eggs and the eggs from all birds that died before August 1 were deleted from the averages submitted. The eggs produced the week of March 15 to 21, 1932, when trapnest records were not available from Lot V, were also deducted from all lots. Therefore, the means for 1931-'32 were for 38 weeks of egg production while for 1930-'31 they were for 39 weeks. The results are given in Table XIV.

TABLE XIV.—MEAN EGG PRODUCTION FOR ALL BIRDS THAT LAID FROM NOVEMBER 1 TO AUGUST 1 EACH YEAR.

Lots - - -	Kafir	Milo	White corn	Yellow corn and wheat
1930-'31	142.89±2.71	128.97±3.13	128.55±3.02	138.89±3.21
1931-'32	148.93±2.64	150.72±2.61	142.39±2.86	147.61±3.27
Both years combined.....	145.89±1.90	141.77±2.09	136.05±2.11	143.72±2.32

The greatest difference in the combined results was between Lots I and III. The difference here was 9.84 eggs while the probable error of the difference for the two means was 2.84. None of the differences, therefore, can be regarded as being significant.

The above difference would probably be changed but little if an actual record of all eggs laid could have been recorded. The eggs laid on the floor could not be credited to individual hens. Usually the number of floor eggs averaged about the same for the various lots. However, there were more than the usual number of such eggs in Lot I the first year and in Lot III the second year. The number of floor eggs for the two years is given in Table XV.

TABLE XV.—NUMBER OF EGGS PRODUCED OUTSIDE THE TRAPNESTS, DESIGNATED AS FLOOR EGGS.

Lots - - - - -	Kafir	Milo	White corn	Yellow corn and wheat
1930-'31	377	220	252	233
1931-'32	296	228	407	222
Total.....	673	448	659	455

After evaluating all of the above data on egg production, one might conclude that while the kafir lot holds a slight advantage, the difference is not great. Any of the grains tested might be used successfully as the basis of a ration for laying

COMPARITIVE NUTRITIVE VALUE OF POULTRY FEEDS 25

pullets. So consideration has been given to the cost of the different grains tested. In the grain sorghum area, where kafir and milo are usually much cheaper than corn and wheat, it would seem logical to depend upon these grains entirely with proper supplements for preparing poultry rations.

HATCHABILITY

Early in April each spring five Single Comb White Leghorn males were placed in each lot for the purpose of comparing the

TABLE XVI.—HATCHING RECORD FOR 1931.

Lots - - - - -	I Kafir	II Milo	III White corn	IV Yellow corn and wheat
Group 1				
Number of eggs set.....	197	194	187	179
Number of eggs fertile.....	145	137	107	102
Percentage fertile.....	73.6	70.6	57.2	57.0
Number of eggs hatched.....	105	93	87	70
Percentage fertile eggs hatched.....	72.4	67.8	81.3	68.6
Group 2				
Number of eggs set.....	189	182	208	182
Number of eggs fertile.....	158	171	184	159
Percentage fertile.....	83.5	94.0	88.5	87.4
Number of eggs hatched.....	115	116	124	124
Percentage fertile eggs hatched.....	72.7	67.8	87.3	77.9
Groups 1 and 2				
Number of eggs set.....	386	376	395	361
Number of eggs fertile.....	303	308	291	261
Percentage fertile.....	78.5	81.9	73.7	72.3
Number of eggs hatched.....	220	209	211	194
Percentage fertile eggs hatched.....	72.6	67.9	72.5	72.3

TABLE XVII.—HATCHING RECORD FOR 1932.

Lots - - - - -	V Kafir	VI Milo	VII White corn	VIII Yellow corn and wheat
Group 1				
Number of eggs set.....	242	236	234	167
Number of eggs fertile.....	142	165	166	90
Percentage fertile.....	58.7	69.9	70.9	67.7
Number of eggs hatched.....	83	126	124	66
Percentage fertile eggs hatched.....	58.5	76.4	74.7	73.3
Group 2				
Number of eggs set.....	247	247	262	195
Number of eggs fertile.....	173	198	201	132
Percentage fertile.....	70.0	80.2	76.7	53.9
Number of eggs hatched.....	100	132	147	87
Percentage fertile eggs hatched.....	57.8	66.7	73.1	65.9
Groups 1 and 2				
Number of eggs set.....	489	483	496	362
Number of eggs fertile.....	315	363	367	222
Percentage fertile.....	64.4	75.2	74.0	61.3
Number of eggs hatched.....	183	258	271	153
Percentage fertile eggs hatched.....	58.1	71.1	73.8	68.9

hatchability of the eggs. One week's production of eggs were taken from each lot and set April 17, 1931, and April 12, 1932. The complete records for each group and lot are given for both years in Tables XVI and XVII.

In the data for 1931, Lot I led by a fraction of 1 per cent in hatchability, followed in order by Lots III, IV, and II. The difference was only 4.5 per cent between Lot I with the highest hatchability and Lot II which ranked lowest. However, in 1932, the difference between the highest and lowest groups was 15.7 per cent and there was almost a reversal of results, the lots ranking in the following order: VII, VI, VIII, and V.

The hatchability of all lots in group 1 for both years was 71.5 per cent, and for group 2, 68.7 per cent. This would indicate that rearing birds in confinement for one season did not interfere with the hatchability of their eggs. The hatchability records for both years combined are given in Table XVIII.

TABLE XVIII.—HATCHABILITY RECORD FOR BOTH YEARS COMBINED.

Lots - - - - -	Kafir	Milo	White corn	Yellow corn and wheat
Group 1				
Number of eggs set	439	430	421	346
Number fertile	287	302	273	192
Percentage fertile	65.3	70.1	64.8	55.4
Number hatched	188	219	211	136
Percentage fertile eggs hatched	65.5	72.5	77.3	70.8
Group 2				
Number of eggs set	436	429	470	377
Number fertile	331	369	385	291
Percentage fertile	75.9	86.0	81.9	77.1
Number hatched	215	248	271	211
Percentage fertile eggs hatched	65.0	67.2	70.4	72.5
Groups 1 and 2				
Number of eggs set	875	859	891	723
Number fertile	618	671	658	483
Percentage fertile	70.6	78.1	73.8	66.8
Number hatched	403	467	482	347
Percentage fertile eggs hatched	65.2	69.6	73.3	71.8

In order to obtain a better comparison of the above results, the means for the percentage hatchability and the probable error of the difference were calculated as follows:

(a) Means for percentage hatchability

$$Em = 0.6745 \times \sqrt{\frac{P \times Q}{N}}$$

when P=percentage successes (percentage hatch)

Q=percentage failures (percentage not hatched)

N=Number of fertile eggs set

(b) Probable error of the difference

$$E \text{ (dif)} = \sqrt{E^2(1) + E^2(2)}$$

COMPARATIVE NUTRITIVE VALUE OF POULTRY FEEDS 27

The results are presented in Table XIX.

TABLE XIX.—MEAN PERCENTAGE HATCHABILITY OF FERTILE EGGS.

Lots - - - - -	Kafir	Milo	White corn	Yellow corn and wheat
Group 1				
1930-'31.....	72.4	67.8	81.3	68.6
1931-'32.....	58.5	76.4	74.7	73.3
Mean.....	65.5±1.89	72.5±1.73	77.3±1.71	70.8±2.21
Group 2				
1930-'31.....	72.7	67.8	67.3	77.9
1931-'32.....	57.8	66.7	73.1	65.9
Mean.....	65.0±1.77	67.2±1.65	70.4±1.57	72.5±1.77
Average, Groups 1 and 2				
1930-'31.....	72.6	67.9	72.5	74.3
1931-'32.....	58.1	71.1	73.8	68.9
Mean.....	65.2±1.30	69.6±1.19	73.3±1.16	71.8±1.38

The comparisons given in Table XX indicate that the only significant difference in hatchability occurred between Lots I

TABLE XX.—DIFFERENCES AND PROBABLE ERRORS OF THE DIFFERENCES IN HATCHABILITY OF EGGS FROM THE FOUR LOTS.

Lots - - - - -	II Milo	III White corn	IV Yellow corn and wheat
Group 1. Reared in confinement (1930-'31 and 1931-'32 combined).			
I. Kafir.....	7.0±2.56	(a) 11.8±2.55	5.3±2.91
II. Milo.....		4.8±2.43	1.7±2.81
III. White corn.....			6.5±2.79
Group 2. Reared on range and fed college ration (1930-'31 and 1931-'32 combined).			
I. Kafir.....	2.2±2.42	5.4±2.37	7.5±2.50
II. Milo.....		3.2±2.28	5.3±2.42
III. White corn.....			2.1±2.37
Groups 1 and 2. Combined.			
I. Kafir.....	4.4±1.76	(a) 8.1±1.74	6.6±1.89
II. Milo.....		3.7±1.66	2.2±1.82
III. White corn.....			1.5±1.80

(a) The hatchability for the kafir group in 1931-'32 was 58.5 per cent. Two of the three trays on this occasion hatched poorly which might have been due to inferior males or faulty incubation. With a normal hatch as obtained the first year the difference probably would not have been significant.

and III in group 1 and also when the two groups were combined. These differences are more than four times their probable errors. As explained in the footnote, the differences might have been due to inferior male birds or to improper incubation for the kafir lot the second year.

MORTALITY

As previously stated, the mortality of adult birds for the first year was extremely high. It was thought this might be due to chronic coccidiosis. However, an examination of several birds by the poultry bacteriologist revealed negative results. Many of the birds examined were badly infested with tapeworms. The losses could not be attributed to any one specific disease as the birds died from miscellaneous causes. The mortality was much lower the second year as indicated in Table XXI.

TABLE XXI.—MORTALITY OF ADULT BIRDS.

Lots - - - - -	Kafir	Milo	White corn	Yellow corn and wheat
Group 1				
1930-'31	9	21	19	19
1931-'32	8	8	9	16
Total	17	29	28	35
Group 2				
1930-'31	15	21	12	23
1931-'32	14	8	6	12
Total	29	29	18	35
Groups 1 and 2				
1930-'31	24	42	31	42
1931-'32	22	16	15	28
Average for both years	23	29	23	35

For some unexplainable reason the control lots experienced the greatest mortality. These lots were housed in the west end of the building where they were possibly exposed more to the northwest winds than the other lots. This, however, did not appear to make a great difference in the comfort of the pens. The milo group showed greater mortality than the kafir group, which is in harmony with the results obtained in the preliminary experiments.

SUMMARY

The grain sorghums are extensively grown in Kansas. Kafir and milo lead all other varieties in popularity. They are commonly used for feeding poultry when available and they are in great demand for use in preparing commercial feeds on both the east and west coasts. Results from the feeding of these sor-

COMPARATIVE NUTRITIVE VALUE OF POULTRY FEEDS 29

ghums have been satisfactory except when the grain has been damaged by exposure to the weather or by improper storage. Since the possibilities of grain sorghums becoming damaged are somewhat greater than for field corn, the former are looked upon with disfavor by many poultrymen. Corn is still shipped into the grain-sorghum area of southwestern Kansas for feeding poultry. This seems unnecessary in the light of the experiments reported in this publication. The old belief that kafir and milo have 10 per cent less feeding value than corn is not substantiated by these poultry-feeding experiments.

The sorghum-feeding experiments with poultry herein reported may be summarized, according to the criteria used in measuring the results, as follows:

Feed Consumed.—The difference between the maximum and minimum amount of feed consumed in the last two experiments by any two lots was only 2.98 pounds per bird for a period of nine months. The amount eaten agreed fairly well with the number of eggs produced. The kafir lot which laid the greatest number of eggs led in the amount of feed consumed. This indicated that all grains used in these experiments were equally palatable when fed in all-mash rations.

Maintenance of Body Weight.—While an appreciable gain in body weight during the laying year was possible with grain and mash feeding in the preliminary experiments, quite the reverse was found to be true when feeding all-mash rations. Possibly artificial illumination would have assisted in maintaining body weight. The loss in weight during the first year that all-mash feed was used ranged from 4.26 per cent for the control group to 6.53 per cent for the kafir lot. The second year a small gain was recorded in all lots ranging from a gain of 10.2 per cent for the kafir lot to 7.1 per cent for the pullets fed milo. The differences were so small in all comparisons that they may be regarded as insignificant. When the results of both years are combined slight gains in original body weight are evident in all except the white-corn lot which lost 1.1 per cent.

Egg Production.—When considering the 1930-32 results the kafir lot led in egg production in the majority of comparisons, although statistically the differences were not significant. The kafir lots were followed by the milo and control lots. The latter two lots exchanged positions in different comparisons. The white-corn lot gave slightly less production than any of the others. The greatest difference in the combined results from all 1930-'32 comparisons was 9.84 while the probable error of the difference for the two means was 2.84.

Hatchability.—A fairly large number of eggs were set from each lot of pullets and if the grains fed affected the hatchability, it should have appeared in the result. A variation the first year from 67.9 per cent for the milo lot to 72.6 per cent hatchability for the kafir lot is not a wide range. The results from the other

two lots were between these figures. A poor hatch of 58.1 per cent for the kafir lot the second year reduced the average for this group materially. The white-corn lot led with 73.8 per cent. In the combined results, the white-corn lot, which showed the highest hatchability, averaged 8.1 ± 1.74 per cent more than the kafir lot, which had the lowest average. While this difference is significant, it probably would not have been with a normal hatch in the kafir lot.

Mortality.—The mortality of adult birds was least in the kafir lot the first year and greatest in the control group. The second year the lowest death rate was in the white-corn lot and again the highest was in the control pen. Combining the results for both years, the kafir and white-corn lots had a mortality of 23 per cent; milo, 29 per cent; and the yellow corn and wheat lot, 35 per cent. These results again place kafir ahead of milo and mixed grain.

While the control group did not show up so well as the others, the results were probably about normal for this strain of birds. The environment, care, and management were the same for all lots. The appearance of the pullets placed in Lot IV at the beginning of each year was equal to that of any of the others. Lots I and IV occupied the end pens in the house and were, therefore, more exposed to the weather than Lots II and III. Other experiments in the same house before and since this one have not resulted in less satisfactory results in Lot IV.

The average egg production for Lot IV was 52.1 per cent, which was at the rate of 190 eggs per bird a year. This, with an average hatchability of 71.8 per cent was as satisfactory as ordinarily obtained from this strain of birds. The high mortality in this lot was the only criterion by which the group appeared abnormal.

The feeding experiments with poultry reported in this publication indicate that the nutritive value of kafir and milo is about equal and that both of these grain sorghums may give as good or better results than white corn or yellow corn and wheat when fed at the rate of 50 per cent of the total ration. An important fact to keep in mind is that all grains used in these experiments were of excellent quality at the time they were fed.

It should also be remembered that both sorghum and white corn are deficient in vitamin A and unless this important vitamin supplements rations composed largely of these grains, feeding results will not be satisfactory. This vitamin can be supplied adequately in the form of green succulent feed or as alfalfa leaf meal. The results from vitamin-A-deficient grains properly supplemented compare very favorably with rations in which yellow corn, which contains this vitamin, is used as the principal grain.

COMPARATIVE NUTRITIVE VALUE OF POULTRY FEEDS 31

CONCLUSION

Good-quality kafir or milo can replace either white or yellow corn pound for pound in a ration for growing chicks or laying hens when adequately supplemented with other nutrients.

GRAIN SORGHUM RATIONS RECOMMENDED

In view of the results here reported by feeding grain sorghums, it would not seem necessary or advisable to ship corn into the grain-sorghum area to feed poultry. The grain sorghums so extensively grown in that section can be utilized when properly supplemented with other nutrients in the preparation of complete and well-balanced rations. The following cornless poultry rations can be used where good-quality kafir and milo are available:

I. Rations for Laying and Breeding Stock

Dry Mash		Scratch Grain	
Kafir or milo, ground.....	100 lbs.	Wheat	200 lbs.
Oats or barley, ground.....	100 lbs.	Kafir or milo.....	200 lbs.
Wheat, ground	100 lbs.		
Meat and bone scraps (a) ..	75 lbs.	Total	400 lbs.
Alfalfa leaf meal.....	50 lbs.		
Salt	4 lbs.		
Total			
			429 lbs.

(a) If skim milk or fresh buttermilk is available, feed 3 gallons daily per 100 hens and omit 50 pounds of meat and bone scraps. When liquid milk is not accessible, the above rations can be improved slightly by replacing one-third of the meat and bone scraps with either an equal amount of dried milk or by feeding 2 to 3 pounds (depending upon the size of birds) of condensed buttermilk per 100 hens daily. The condensed milk can be fed on top of the dry mash in the feed hoppers without diluting with water. During the winter months fresh meat as supplied by rabbits from which the hair has been singed or the skins removed makes a good substitute for meat and bone scraps. Such meat should be available daily. It should not be used when spoiled.

One per cent of a potent cod-liver or sardine oil in the mash is advisable from November to April when the birds are confined in the house and denied direct sunshine. Birds on free range do not require fish oils. The variety and amount of grains used in the scratch mixture should depend upon the price and availability.

Fourth or fifth cutting bright green alfalfa hay should be kept in racks before hens at all times during the winter when green succulent feed or alfalfa leaf meal is not available. Such hay when finely ground makes a good substitute for commercial alfalfa leaf meal. The dry mash should be kept in open hoppers and accessible at all times.

The scratch grain can be scattered in deep litter or fed in troughs each evening at the rate of 12 to 14 pounds per 100 hens. It is better, however, to feed according to the birds' appetites rather than by measure. The previous scratch feed should be cleaned up before additional grain is fed. Clean

water, grit, and crushed oyster shell or high-grade crushed limestone should be available at all times.

II. Rations for Growing Chicks

(To be fed as all-mash the first four weeks. See scratch grain below.)

Kafir or milo, ground.....	40 lbs.
Bran or ground wheat.....	20 lbs.
Oats or barley, ground.....	14 lbs.
Alfalfa leaf meal.....	10 lbs.
Meat and bone scraps.....	10 lbs.
Dried buttermilk (a).....	5 lbs.
Salt	1 lb.

Total.....100 lbs.

(a) If skim milk or buttermilk is available, supply all the chicks will drink, omit dried milk and add 5 pounds of ground grain to the above ration. Keep the milk before chicks the first month or longer if it is plentiful. In order to compel the chicks to drink the milk readily and take a sufficient amount, it is suggested that no water be given the first week. When water is not given, the buttermilk should not be thick nor the skim milk clabbered.

When chicks do not have access to direct sunshine after one week of age, 1 per cent of a vitamin-D-potent cod-liver or sardine oil should be added to the above mixture beginning with the first feed.

The starting ration should be fed in open hoppers as soon as the chicks are placed in the brooder or when 24 to 36 hours of age, and it should be available at all times. One 4-foot hopper accessible on both sides should be provided for each 100 chicks.

Scratch Grain composed of 50 pounds of whole kafir or milo and 50 pounds of whole wheat should be hopper fed beginning with the fifth week and thereafter. The alfalfa leaf meal may be omitted after the chicks are 8 to 10 weeks of age when outdoor range with access to green feed is provided. An equivalent amount of ground kafir or milo should be added to the mash.

III. Rations for Fattening Poultry

A. Crate Feeding

Kafir or milo, ground....	60 lbs.
Wheat, ground.....	40 lbs.
Buttermilk	200 lbs.

B. Pen or Lot Feeding

Kafir or milo.....	100 lbs.
Liquid milk—all birds	will drink.

Ration A.—Mix 2 pounds of buttermilk with 1 pound of mash and feed twice a day in a V-shaped trough. When liquid milk is not available, add 40 pounds of condensed milk to 100 pounds of grain and enough water to give the consistency of thick cream. Start the birds gradually not supplying all they will eat until the third day. Fatten 10 to 14 days.

Ration B.—The grain can either be soaked in milk or it can be fed dry and milk can be supplied as a beverage for a period of four to six weeks.