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The Influence of Various Protein Concentrates on Egg Production

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An important problem of the poultry raiser with reference to feeding is to supplement the cereal grains and their by-products with some suitable protein concentrate in order to establish a proper balance between the carbohydrates, fats, proteins, and minerals.

Repeated experiments at the Missouri Agricultural Experiment Station and elsewhere have demonstrated that this is an economical and practical principle. In Missouri Agricultural Experiment Station Bulletin 225 it was concluded that the use of protein supplements such as commercial meat scrap, tankage, sour skim milk or dried buttermilk resulted in a production of approximately twice as many eggs as compared with similar rations which contained no such supplement and that the feeding of meat scrap, tankage or milk products reduced the amount of feed required to produce a pound of eggs nearly one-half.

The work with cottonseed meal as a protein concentrate was not especially encouraging but the question was raised as to whether or not the failure of cottonseed meal might be due to mineral rather than a protein deficiency.

In the experiments reported in this bulletin this particular phase was investigated. Further comparisons with the usual protein concentrates used in rations for egg production (meat scrap and tankage) were continued. In addition, other protein concentrates; namely fish meal, soybean meal, ground soybeans, and dried buttermilk were used.

GENERAL CONDITIONS

Housing.—The hens have been housed in a special house consisting of eight pens. Each pens is 12′ x 14′, is equipped with trap nests and is provided with a yard 24′ x 100′.

Stock.—With the exception of the year 1927-28 when White Leghorn pullets were used, White Leghorn hens were used in the feeding tests. The basis of selection of these birds and their distribution was the previous trap nest record of the bird. It was thought that this gave a more uniform selection than the use of pullets would make possible.

The Rations.—Throughout the experiments a combination of grain and laying mash has been fed. The grain which constituted approxi-

mately two-thirds of the ration consisted of 2 parts, by weight, of yellow corn and 1 part oats. Any changes made in the scratch feed was made in all pens at the same time, the only variable part of the ration being the type of mash fed. The mashes varied in the type of protein concentrate, the use of mineral supplements when vegetable protein concentrates were used, and the type of mineral supplement. The basal mash consisted of equal parts, by weight, of bran, shorts, and yellow corn meal. With the exception of two rations the mashes contained one per cent salt, and in addition different protein concentrates as indicated in the following table.

TABLE 1.—COMPOSITION OF MASHES USED IN FEEDING EXPERIMENTS
(Percent in Pounds)

Ration No.	400	401	402	403	404	405	406	407	408	409	410
Bran	* 23	22	20	23	22	20	22	26	26	26	21
Shorts	23	22	20	23	22	20	22	26	26	26	21
Cornmeal	23	22	20	23	22	20	22	26	26	26	21
C. S. Meal	30	30	30								
S. B. Meal				30	30	30					
Gr S. Beans							30				
Meat Scrap								20			
Tankage									20		
Fish meal										20	
Dried B. Milk											35
Bone meal		4			4		4				
RockPhosphate			8			8					
Salt	1	1		1	1	1	1	1	1	1	1

*Enough of the basal mash (bran, shorts and cornmeal) was used to bring the total up to 100.

Methods of Feeding Grain.—From November 1 to April 1 a small amount of grain was fed in the morning at the rate of 3 to 5 pounds per 100 hens. For the remainder of the year no morning scratch grain was fed. At night the hens were given all the grain they would consume. This was fed just before the birds went to roost. During winter the amount fed at the night feeding was approximately 10 pounds per 100 hens, while in summer it was probably not more than 7 or 8 pounds. The changing quantities of grain fed depended upon the season of the year and the appetites of the hens.

Methods of Feeding.—The mash was fed dry and was kept in open reel hoppers before the hens all the time. Once daily at noon a crumbly wet mash was fed.

All pens had access to hoppers containing limestone rock and oyster shell.

PROTEIN CONCENTRATES USED

The experiments involve the use of cottonseed meal, soybean meal, ground soybeans, fish meal, meat scrap, tankage, and dried buttermilk

as protein supplements in rations for laying hens. The following table shows the analysis of these feeds as taken largely from "Feeds and Feeding" by Henry and Morrison.

TABLE 2.—COMPOSITION OF PROTEIN CONCENTRATES USED IN FEEDING EXPERIMENT

	Water	Ash	Protein	Fibre	N. Free Extract	Fat
Cottonseed meal	7.8	6.6	39.8	10.1	26.4	8.3
Soybean meal*	11.8	5.4	41.4	5.3	28.7	7.4
Ground Soy Beans	9.9	5.3	36.5	4.3	26.5	17.5
Tankage	7.4	10.5	63.1	3.6	2.5	12.9
Meat Scrap	7.1	21.0	53.9	2.2	5.0	10.7
Fish Meal	7.1	14.8	60.9	.5	2.6	14.1
Dried Buttermilk†	9.6	11.3	32.2	.3	43.2	2.2

*The guaranteed analysis showed a minimum of 38 per cent protein and 4.5 per cent fat.

†Analysis claimed by manufacturer.

I. Experiments with Protein Concentrates of Animal Origin

	Ration Number	*Protein Concentrate*
a.	410	Dried Buttermilk
b.	407	Commercial Meat Scrap
c.	408	Tankage
d.	409	Fish Meal

DRIED BUTTERMILK

Milk products have always proved adequate protein supplements in rations for egg production. Where the hens have access to liquid skim milk or buttermilk the hens apparently consume milk in sufficient quantities to properly balance the ration. Experiments at this station have shown that the egg production was slightly higher when milk was given as a drink as compared to the use of meat scrap or tankage. The hens each consumed 88 pounds of liquid milk in a year's time. Using this as a basis for determining the amount of dried buttermilk to be used, Formula 410 containing 35 per cent dried buttermilk and 1 per cent salt was fed. Table 3 shows the results of five tests with this ration.

TABLE 3.—RESULTS PER HEN PER YEAR WITH DRIED BUTTERMILK

Year	Grain	Mash	Eggs	Pounds feed to produce 1 dozen eggs
1923-24	56	24	128	7.5
1924-25	48	21	137	6.04
1925-26	51	24	150	6.0
1926-27	54	29	140	7.11
1927-28	46	34	181	5.3
Average	51	26	148	6.39

The results covering a period of five years indicate that dried buttermilk is a satisfactory source of protein so far as egg production is concerned. The average amount of feed to produce a dozen eggs ranged from 5.3 for 1928 to 7.5 for 1924 with a five-year average of 6.39. The egg production was uniform with the exception of 1928. This may be explained by the fact that for this test pullets were used and they are usually more productive than are hens. In these tests the hens consumed 9.1 pounds of dried buttermilk per year which is practically equivalent in dry matter to the 88 pounds of liquid skimmilk used in earlier tests.

It has not been possible to investigate the most economical amount of dried buttermilk to use. Whether or not equally satisfactory results might have been obtained with smaller proportions of milk was not determined in this experiment. Due to the price of dried buttermilk its inclusion in the ration materially increases the cost. The value of the use of milk cannot be based alone on the number of eggs obtained. It was observed that the eggs produced in 1928 were larger as compared to those produced in other pens and that they retained their quality while being held in storage. These factors are of economic importance.

COMMERCIAL MEAT SCRAP

Commercial meat scrap, a by-product of the packing houses, has been universally used as a protein supplement in rations for egg production. Previous experiments at this station have demonstrated its usefulness. It was also found that poultry mashes which contained 20 per cent meat scrap were adequate and most economical. For a basis of comparison, feeding tests with this product were continued. In these tests the mash formula 407 was used. This contained 20 per cent meat scrap and 1 per cent salt. Table 4 shows the results covering a five-year period.

TABLR 4.—RESULTS PER HEN PER YEAR WHEN USING MEAT SCRAP

Year	Grain	Mash	Eggs	Pounds feed to produce a dozen eggs.
1923-24	56	20	107	8.52
1924-25	58	21	134	7.07
1925-26	55	31	143	7.21
1926-27	64	28	139	7.94
1927-28	43	27	142	5.92
Average	**55**	**25.4**	**133**	**7.33**

It will be observed that with the exception of 1924 the egg production was very uniform and satisfactory. It will be noticed that the grain consumption was lower for 1928. Whether or not this was due to the fact that pullets were used is a question. It will be observed that the lowest feed requirement for the production of a dozen eggs was for

this year. As compared to the use of dried buttermilk the five-year average shows an average of 15 less eggs per hen. For three of the five years the production of the hens fed meat scrap was not materially different from those fed dried buttermilk. The differences were quite marked for the other two years. Even with a production of 15 less eggs per hen the lower cost of the ration would justify the use of commercial meat scrap. Based on the average of 5 years results it required 7.33 pounds of feed to produce a dozen eggs as compared to 6.39 for the dried buttermilk pens. The eggs produced were slightly smaller but these eggs possessed excellent storage qualities.

TANKAGE

Commercial tankage is often used in rations for egg production. It is quite similar to meat scrap but is likely to be less uniform in quality. As a general rule it is higher in protein and lower in mineral. No attempt was made to correct any mineral deficiency which might be present. There is very little difference in a high grade of tankage and commercial meat scrap. Earlier tests at this station show that hens fed tankage laid practically the same number of eggs as did those fed meat scrap. Mash formula 408 was used. This contained 20 per cent tankage and 1 per cent salt. Table 5 shows the results.

TABLE 5.—RESULTS PER HEN PER YEAR USING TANKAGE.

Year	Grain	Mash	Eggs per hen	Pounds feed required to produce a dozen eggs.
1923-24	54	20	109	8.15
1924-25	56	20	122	7.47
1925-26	64	25	125	8.54
1926-27	55	27	125	7.87
1927-28	46	21	125	7.39
Average	**55**	**23**	**120**	**7.88**

With the exception of the first year the number of eggs produced per hen was uniformly less than with the use of commercial meat scrap. For the five-year period the hens averaged 13 eggs less than did those fed meat scrap. In spite of the fact that tankage is a cheaper product, the results would not justify its use as compared to commercial meat scrap. It required a half pound more feed to produce a dozen eggs. This does not imply that tankage in rations for egg production should not be used, but emphasizes the necessity of selecting a product of high quality. Certainly one should use tankage in preference to no protein concentrate. It was estimated that based on the farm prices of eggs for 1928 the income over feed cost per hen was only 11 cents per hen less, or 7 per cent less for the tankage fed hens than for those fed meat scrap.

FISH MEAL

Fish meal is another source of animal protein for laying hens. It is used more extensively in the coast states and is claimed to be equal to meat scrap or tankage. The product was used for three years. The mash contained 20 per cent, or in other words, the only difference in the mash as compared to meat scrap or tankage was the substitute of fish scrap in equal quantities for these products. Thus the mash formula (409) was used. Table 6 shows the results.

TABLE 6.—RESULTS PER HEN PER YEAR WITH FISH MEAL.

Year	Grain	Mash	Eggs	Pounds feed to produce a dozen eggs
1924	53	20	111	7.9
1925	50	19	107	7.69
1926	52	20	109	7.93
Average	**51.6**	**20**	**108**	**7.84**

From these tests it will be seen that the egg production was not as satisfactory as with milk, meat scrap or tankage. The mash consumption was also slightly less, thus indicating that the mash was not quite so palatable. It would appear from these data that other sources of protein will more adequately fill the poultryman's needs.

II. Experiments With Protein Concentrates of Vegetable Origin

	Ration Number	*Protein Concentrate*	Mineral Supplement
a.	400	Cottonseed Meal	
b.	401	Cottonseed Meal	Bone Meal and Salt
c.	402	Cottonseed Meal	Rock Phosphate and Salt
d.	403	Soybean Meal	
e.	404	Soybean Meal	Bone Meal and Salt
f.	405	Soybean Meal	Rock Phosphate and Salt
g.	406	Ground Soybeans	Bone Meal and Salt

COTTONSEED MEAL

Earlier experiments with the use of cottonseed meal failed to produce satisfactory egg production. In this series of experiments mash 400 containing 30 per cent cottonseed meal was used for three successive years with the following results:

TABLE 7.—RESULTS PER HEN PER YEAR WITH COTTONSEED MEAL

Year	Grain	Mash	Average egg production
1923-24	50	21	67
1924-25	46	19	68
1925-26	41	17.6	45
Average	**46**	**19**	**60**

These results would verify earlier conclusions that cottonseed meal as a sole substitute for commercial meat products such as meat scrap and tankage or milk products was not satisfactory. Some attempts were made by earlier investigators to explain these results on the basis of the type of protein contained in cottonseed meal but the fact that such a protein concentrate was low in mineral content was overlooked. To add further light on this phase of the problem Ration 401 was used. The only difference in this mash formula as compared to Ration 401 is that 4 per cent bone meal and 1 per cent salt was added and the amount of basal ingredients correspondingly reduced. This ration was fed for five successive years with the following results:

TABLE 8.—RESULTS PER HEN PER YEAR WITH COTTONSEED MEAL

Year	Grain	Mash	Eggs
1923-24	55	15	117
1924-25	45	18	125
1925-26	52	18	136
1926-27	48	25	135
1927-28	44	27	145
Average	**49**	**21**	**133**

It is obvious from the above results that when cottonseed meal is supplemented with bone meal and salt that the egg production is more than doubled over that obtained when similar rations which do not contain the bone meal and salt were fed. In fact, the egg production compared favorably with that obtained where protein concentrates of animal origin were used. Certainly it is a mistake to not supplement protein concentrates of vegetable origin with suitable minerals. Since the hens have access to calcium carbonate in the form of oyster shell and limestone rock with both rations the beneficial effects resulting from the additional bone meal and salt are probably due to the calcium phosphate in the bone meal. However, not all the differences can be attributed to this cause. In earlier experiments reported in Bulletin 225 it was shown that the addition of bone meal results in an increase of 32 eggs per hen over similar rations not containing the bone meal whereas the later results where both bone meal and salt were added the increase in egg production is much more marked, being 73 eggs. The use of one per cent salt in poultry mashes has become quite general.

Since the absence of calcium phosphate is apparently one of the chief mineral deficiencies in rations where vegetable protein concentrates are employed, tests in which rock phosphate was used as a substitute for bone meal were made. Due to the smaller quantity of calcium phosphate in rock phosphate as compared to bone meal, double the amount was used in the mash. The composition of the mash is shown in mash formula 402. It contains 30 per cent cottonseed meal, 8 per cent bone meal and the usual amount of salt.

Two years' tests were made with the following results:

TABLE 9.—RESULTS PER HEN PER YEAR WITH COTTONSEED MEAL SUPPLEMENTED WITH ROCK PHOSPHATE AND SALT

Year	Grain per hen	Mash	Eggs per hen
1926-27	51	25	125
1927-28	47	29	151
Average	**49**	**27**	**138**

It is obvious that rock phosphate is equally satisfactory as a source of calcium phosphate for laying hens as the results are practically the same as where bone meal was used. From these experiments one may conclude that a mash containing 30 per cent cottonseed meal when supplemented with 4 per cent bone meal and 1 per cent salt or 8 per cent rock phosphate and 1 per cent salt is adequate for laying hens. With these rations no greater mortality was experienced than in the other pens. The eggs when laid were attractive and wholesome, but they do not appear to possess the quality of holding up under storage conditions. A discussion of this feature will appear later.

SOYBEAN MEAL

During recent years soybean meal has come into use as a source of protein for laying hens. Soybean meal is the ground residue after the fat has been extracted. Since its protein analysis is practically the same as for cottonseed meal the same amount was incorporated in the mash. The general plan of the experiment was the same as for cottonseed meal. Mashes containing 30 per cent soybean meal with no mineral supplement, soybean meal with 4 per cent bone meal and one per cent salt, and soybean meal with rock phosphate and salt were used. Table 10 shows the results with the use of soybean meal with no mineral supplement. This is Ration 403.

TABLE 10.—RESULTS PER HEN, USING SOYBEAN MEAL.

Year	Grain	Mash	Eggs	Pounds feed to produce a dozen eggs
1923-24	55	17	70	12.34
1924-25	46	19	71	11.6
1925-26	42	12	47	15.0
Average	**47**	**16**	**64**	**12.8**

It is thus seen that the ration was inadequate as were similar rations with cottonseed meal. That the failure to produce satisfactory results was due to mineral deficiencies is shown by comparing these results with those secured when the soybean meal was supplemented with bone meal and salt as in ration number 404. Table 11 shows the results for five different trials.

Results per hen using soybean meal supplemented with bone meal and salt are shown as follow:

TABLE 11.—RESULTS PER HEN PER YEAR WITH SOYBEAN MEAL SUPPLEMENTED WITH BONE MEAL AND SALT

Year	Grain	Mash	Eggs	Lbs. feed to produce a doz. eggs
1923-24	50	21	121	7.04
1924-25	55	15	129	5.58
1925-26	43	16	139	5.1
1926-27	55	24	132	7.18
1927-28	42	22	129	5.95
Average	**49**	**20**	**129**	**6.17**

It is thus seen that by properly supplementing the soybean meal with minerals the results compare favorably with any other type of protein concentrate. The hens laid twice as many eggs as did those fed similar rations but where no mineral supplement was used. One year's

test with a mash containing 30 per cent soybean meal, 8 per cent rock phosphate and 1 per cent salt, the balance of the mash being equal parts of bran, shorts and corn meal showed a consumption per hen of 47 pounds of grain and 25 pounds of mash. The hens laid 133 eggs thus requiring 6.5 pounds of feed to produce a dozen eggs. It would seem that 8 pounds of rock phosphate is the equivalent of 4 pounds of bone meal and that both are suitable sources of minerals. It is interesting to note that eggs laid by hens fed soybean meal held up well in storage and in this respect soybean meal appears to be much superior to cottonseed meal.

Two tests were made using ground soybeans. These trials were made in an effort to discover a ration consisting almost entirely of home grown grains. The only difference in this ration and Ration 404 was the substitution of ground soybeans for soybean meal. Bone meal and salt were used as supplements. Table 12 shows the results.

TABLE 12.—RESULTS PER HEN PER YEAR WITH GROUND SOYBEANS SUPPLEMENTED WITH BONE MEAL AND SALT

Year	Grain	Mash	Eggs	Lbs. feed to produce doz. eggs
1926-27	52	24	113	8.07
1927-28	43.5	18	100	7.38
Average	**48**	**21**	**102**	**7.72**

It will be noted that these results are not as satisfactory as with the use of soybean meal. Evidently the additional fat in the beans made it impossible to secure a proper balance in the ration, and one should not consider ground soybeans as a satisfactory source of protein concentrate for laying hens. Attempts to feed whole soybeans as a part of the scratch feed were unsuccessful. The hens failed to eat the beans unless starved, and poor egg production naturally resulted.

Discussion

GENERAL RESULTS

Table 13 summarizes the various feeding trials and presents at a glance the comparison of the various rations. It is interesting to note that low egg production was accompanied by lower food consumption. It will be also observed that the grain consumption was slightly higher with the rations using protein concentrates from animal source. In general the mash consumption was higher when the egg production was higher. With reference to egg production the pen fed dried buttermilk was highest followed by the pen fed cottonseed meal and rock phosphate. Too much emphasis should not be placed on the performance of this pen as one of the two tests was with pullets and this fact materially affects the results. There was practically no difference in the pens fed cottonseed meal or soybean meal supplemented with minerals and those fed meat scrap. The tankage fed group laid 13 less eggs than did those fed meat scrap, while a production of 102 and 107 eggs per hen for those fed ground soybeans and fish meal indicates lack of efficiency in these rations. Based on the feed required to produce a dozen eggs there was practically no difference between the pens fed cottonseed meal or soybean meal and mineral and those fed dried buttermilk. The other rations required more feed to produce a dozen eggs, especially the hens fed cottonseed meal or soybean meal with no mineral supplement in which case it required just twice as much feed to produce a dozen eggs as when the mineral supplement was used.

DISTRIBUTION OF EGG PRODUCTION

Table 14 summarizes the egg production of the various groups. The monthly distribution shows a consistent rise in egg production from November to the spring months, the high peak being reached in April, May and June, after which there is a gradual decline. The hens fed vegetable protein concentrates with no mineral supplement consistently laid fewer eggs each month in the year. While those fed dried buttermilk laid more, although there are several months in which the production of this pen failed to excel some of the others. With the less success-

ful rations the hens failed to reach as high a peak and the decline was more rapid. In general, the total egg production for the year represents the relative merits of the various rations with reference to egg productions. Using the prices obtained by Missouri demonstration flock owners from November 1, 1927 to October 31, 1928, the computed value of the eggs produced by the pen fed dried buttermilk was $3.44 per hen as compared to $3.21 and $3.37 for those fed cottonseed meal plus mineral; $3.01 and $3.20 for those fed soybean meal and mineral while the meat scrap, tankage, fish meal and ground soybean fed hens produced eggs worth $3.04, $2.77, $2.44, and $2.33 respectively. The eggs from the hens fed soybean meal or cottonseed meal with no mineral supplement were worth $1.44 and $1.41 respectively. These figures are based on mere numbers and fail to consider egg size or quality.

TABLE 13.—SUMMARY OF FEED CONSUMPTION PER HEN PER YEAR AND EGG PRODUCTION

Ration Number	400 Cotton-seed Meal	401 Cotton-seed Meal and Salt	402 Cotton-seed Meal, Rock Phos-phate, and Salt	403 Soy Bean Meal	404 Soy Bean Meal, and Salt	405 Soy Bean Meal, Rock Phos-phate and Salt	406 Ground Soy Beans	[redacted] 409 Fish Meal	[redacted] 407 Tankage	[redacted] 408 Meat Scraps	410 Dried Butter Milk
Number of Tests	3	5	2	3	5	1	2	3	5	5	5
Grain Consumed	45.6	49.0	49.0	47.0	49.0	47.0	48.0	52.0	55.0	55.0	51.0
Mash Consumed	19.3	20.6	27.0	16.0	20.0	25.0	21.0	20.0	23.0	25.0	26.0
Total Food Consumed	65.0	69.6	76.0	63.0	69.0	72.0	69.0	72.0	78.0	80.0	77.0
Eggs Per Hen	62	136	144	64	129	133	102	107	120	133	148
Pounds Feed Per Dozen Eggs	13.3	6.3	6.6	12.8	6.2	6.5	7.7	7.8	7.9	7.3	6.4

TABLE 14.—DISTRIBUTION OF EGG PRODUCTION

Ration Number	400 Cotton-seed Meal	401 Cotton-seed Meal and Salt	402 Cotton-seed Meal, Rock Phos-phate, and Salt	403 Soy Bean Meal	404 Soy Bean Meal, and Salt	405 Soy Bean Meal, Rock Phos-phate, and Salt	406 Ground Soy Beans	407 Tankage	408 Meat Scraps	409 Fish Meal	410 Dried Butter Milk
November	2.24	5.56	6.15	1.4	5.4	9.46	3.66	4.44	3.46	2.58	5.19
December	1.5	6.16	6.77	2.92	6.69	8.34	3.53	4.58	5.0	2.83	8.3
January	2.84	7.2	7.67	2.6	6.37	9.94	7.08	6.42	7.33	4.7	7.76
February	4.83	11.75	13.35	4.84	9.54	9.71	9.3	9.46	10.95	8.56	10.68
March	8.45	15.32	16.63	8.45	15.67	15.43	12.37	13.92	16.25	14.13	16.8
April	11.61	16.96	16.63	9.66	16.29	16.3	12.33	15.5	17.3	15.95	17.54
May	9.66	17.76	18.53	9.11	17.28	16.64	14.4	15.72	17.9	16.14	19.4
June	7.56	18.58	18.42	8.33	14.51	17.3	14.25	15.38	15.63	13.33	17.03
July	6.31	14.00	13.49	7.8	13.78	10.6	10.9	12.96	14.96	10.55	14.94
August	3.6	12.53	10.74	4.28	10.4	7.92	6.5	11.15	12.24	9.93	14.27
September	1.67	8.1	9.4	1.81	7.97	8.12	3.12	6.48	7.13	5.72	10.22
October	1.87	5.06	6.61	2.8	5.22	5.2	4.22	4.31	4.51	2.92	5.86
Total	62.14	136	144	64	129	133	101.6	120	133	107	148
Value*	$1.41	$3.21	$3.37	$1.46	$3.01	$3.20	$2.33	$2.77	$3.04	$2.44	3.44

*Based on farm prices for 1927-28.

INFLUENCE OF VARIOUS LAYING RATIONS ON THE KEEPING QUALITY OF EGGS

During the year 1927-28 eight lots of pullets were fed mash made up according to the following formulas:

Ration Number	Mash
401	30 per cent cottonseed meal plus 4 per cent bone meal
402	30 per cent cottonseed meal plus 8 per cent rock phosphate
404	30 per cent soybean meal plus 4 per cent bone meal
405	30 per cent soybean meal plus 8 per cent rock phosphate
406	30 per cent ground soybeans plus 4 per cent bone meal
407	20 per cent tankage
408	20 per cent meat scraps
410	30 per cent dried buttermilk

In April and July representative samples consisting of 45 eggs were placed in cold storage at a commercial packing cold storage plant at Moberly, Missouri. On November 7 the July eggs were examined by a practical egg candler and divided into three classes:

No. 1 consisted of clear eggs of good quality so far as yolk color is concerned, and so far as candling would permit. The shell being white it was felt that considerable accuracy was attained in determining the white. A few watery whites were observed but these were generally distributed among the different lots.

No. 2 consisted of eggs with slightly heavy yolks showing a slight reddish cast before the candle. In no case were the yolks stuck to the shell nor was any tendency toward blackened yolks discernible.

No. 3 consisted of eggs in which there appeared a greenish cast of the yolk comparable to the olive colored yolks known to the trade. In all cases the white appeared perfectly clear, the discoloration being confined to the yolk.

TABLE 15.—COMPARATIVE KEEPING QUALITY OF EGGS PRODUCED ON VARIOUS RATIONS

Ration Number	No.	No. 1	Per Cent	No. 2	Per Cent	No. 3	Per Cent
401	45	23	51	12	27	10	22
402	45	32	71	9	20	4	8
404	45	44	97.8	1	2.2	--	--
405	43	42	93.3	2	4.4	1	2.2
406	45	23	51	13	29	9	20
407	45	30	66.7	12	26.7	3	6.6
408	45	40	89	5	11	--	--
410	45	42	93.2	3	6.6	--	--

Comparing the cottonseed meal and soybean meal and combining the two lots the following results are obtained:

TABLE 16.—COMPARATIVE QUALITY OF EGGS PRODUCED ON RATIONS CONTAINING COTTONSEED MEAL AND SOYBEAN MEAL

Protein Supplement	No.	No. 1	Per Cent	No. 2	Per Cent	No. 3	Per Cent
Cottonseed Meal	90	55	61	21	23.3	14	15.5
Soy Bean Meal	90	86	95.5	3	3.3	1	1.1

In light of the superiority of soybean meal over cottonseed meal it is interesting to note that in pen 26, fed ground soybeans, the keeping qualities of the eggs was no better than were the eggs produced by hens fed cottonseed meal.

The two lots were held in storage until December 20, and were again examined when the following observations were made:

TABLE 17.—CONDITION OF APRIL EGGS

Ration Number	No.	No. 1	Per Cent	No. 2	Per Cent	No. 3	Per Cent
401	45	--	--	6	13.3	39	86.7
402	45	--	--	10	22.2	35	77.8
404	45	43	95.6	2	4.4	--	--
405	45	44	97.8	1	2.2	--	--
406	45	37	82.2	8	17.8	--	--
407	43	37	86.1	5	11.6	--	--
408	43	39	90.7	4	8.9	--	--
410	43	40	93.0	3	7.0	--	--

TABLE 18.—CONDITION OF JULY EGGS

401	41	--	--	4	9.8	37	90.2
402	41	--	--	21	51.2	20	48.8
404	43	21	48.8	22	51.2	--	--
405	45	18	40.0	19	42.2	8	17.8
406	43	--	--	17	39.5	26	60.5
407	44	9	20.5	16	36.4	19	43.1
408	37	31	81.1	6	16.2	--	--
410	36	30	83.3	6	16.7	--	--

It will be observed that none of the April stored eggs, from hens fed cottonseed meal, graded as No. 1, while 82 per cent graded as No. 3. With hens fed soybean meal 97 per cent graded as No. 1 as compared to 86 per cent for the lot fed tankage, 91 per cent for the meat scrap lot, 82 per cent for those fed ground soybeans, and 93 per cent for those fed dried buttermilk. The eggs from hens fed soybean meal or milk were

of exceptional quality even after having been stored for approximately 8 months.

The eggs stored in July, when examined in December, also showed no No. 1 eggs from the hens fed cottonseed meal while 70 per cent graded as No. 3. It will be noted the eggs from the other pens showed a much lower number in the No. 1 grades and a much larger number in the other grades as compared to the eggs stored in April. No explanation can be offered for the appearance of No. 3 eggs for the hens fed soybean meal, ground soybeans, or tankage as these observations are not in accordance with the results observed for the April eggs. The appearance in storage of dark yolked (olive green) eggs from hens fed cottonseed meal suggests the inadvisability of using this particular product in rations for laying hens, especially during that season of the year when eggs are going into storage. The maximum amount of this feed stuff which may be used without affecting the keeping qualities of the eggs remains to be determined.

INFLUENCE OF PROTEIN CONCENTRATES ON EGG SIZE

It was observed that hens fed rations which were not suitable for egg production laid eggs smaller in size. During the spring of 1928 three samples of eggs were weighed and the results are shown in Table 19.

TABLE 19.—INFLUENCE OF RATIONS ON EGG SIZE
(Average weight of eggs in grams)

Ration		Apr. 1	May 2	May 3
402	Cottonseed meal plus rock phos.	51.14	51.93	51.78
401	Cottonseed meal plus bone meal	50.25	51.33	51.88
405	Soybean meal plus rock phosphate	52.49	52.37	51.44
404	Soybean meal plus bone meal	51.41	51.72	51.62
408	Tankage	51.2	50.97	51.22
407	Meat scraps	51.48	51.96	51.58
406	Ground Soybeans	49.72	49.87	50.42
410	Dried buttermilk	54.45	54.79	53.86

The eggs laid by the hens fed milk were largest in size while those laid by the hens fed ground soybeans were smallest. With the other groups, no particular difference in egg size was noticeable.

EFFECT OF THE RATIONS ON HATCHABILITY

Table 20 shows a summary of all eggs from the various pens used for incubation purposes. The highest hatchability of all eggs set was for the pen fed ground soybeans. This was followed by the pens fed dried buttermilk or soybean meal. Based on total number of eggs set, the pen fed tankage was slightly superior to those fed meat scrap. Those pens

fed vegetable protein concentrates with no mineral supplement showed the highest infertility. The percentage hatch of fertile eggs, with the exception of those fed soybean meal and no mineral and ground soybean was in favor of the milk fed hens. On this basis the hens fed meat scrap, tankage and soybean meal plus mineral gave the better results. It is interesting to note that in general lower infertility, and higher hatchability of fertile eggs resulted with the use of soybean meal than with cottonseed meal.

The author prefers to omit further discussion of these points other than to point out that perhaps other factors may have been responsible for the results. No attempt was made to use the same males in different pens as this would have interfered with pedigree record work. The eggs were incubated in all types of incubators and with many different operators (students operating many machines). While all the eggs were probably subjected to the same treatment and the results may be comparable there is no evidence to point to any marked superiority of one ration over the other other than perhaps the reference to the inferior results from the pens fed cottonseed meal.

CONCLUSIONS

1. Dried milk, meat scrap, tankage, and fish meal rank in the order named with reference to influencing egg production.
2. In addition to the grains and grain by-products the amounts of animal protein concentrates consumed per year per hen in the respective rations were as follows: dried buttermilk 9.1 pounds; meat scrap 5 pounds; tankage 4.6 pounds; fish meal 4 pounds.
3. Cost is an important factor in selecting a protein concentrate. The extra eggs laid by the hens fed dried buttermilk would not pay for the extra cost of the ration as compared to the lot fed meat scrap.
4. Cottonseed meal, when supplemented with bone meal or rock phosphate and salt, produced satisfactory egg yields although the eggs did not possess as good keeping qualities as did the eggs from hens fed other rations.
5. Soybean meal when properly supplemented with minerals proved an excellent protein supplement.
6. Ground soybeans even though supplemented with minerals did not prove to be an adequate protein supplement.

TABLE 20.—EFFECT OF PROTEIN CONCENTRATES ON HATCHABILITY

Ration Number	400	401	402	403	404	405	406	407	408	409	410
Type of Ration	Cotton-seed Meal	Cotton-seed Meal and Salt	Cotton-seed Meal, Rock Phos-phate, and Salt	Soy Bean Meal	Soy Bean Meal, and Salt	Soy Bean Meal, Rock Phos-phate and Salt	Ground Soy Beans	Tankage	Meat Scraps	Fish Meal	Dried Butter Milk
Number Set	290	900	253	266	868	97	140	405	709	869	1085
Number Infertiles	91	215	67	105	133	21	10	118	146	225	157
Per Cent Infertiles	31.4	24.0	26.5	39.5	15.3	21.6	7.0	29.0	20.6	26.0	14.5
Number Hatched	103	238	48	119	390	27	78	129	304	363	552
Per Cent Hatched	35.5	26.4	19.0	44.7	45.0	27.8	55.7	32.0	43.0	42.0	51.0
Per Cent Hatch Fertile Eggs	51.7	34.7	26.0	74.0	53.0	35.5	60.0	45.0	54.0	56.0	59.0