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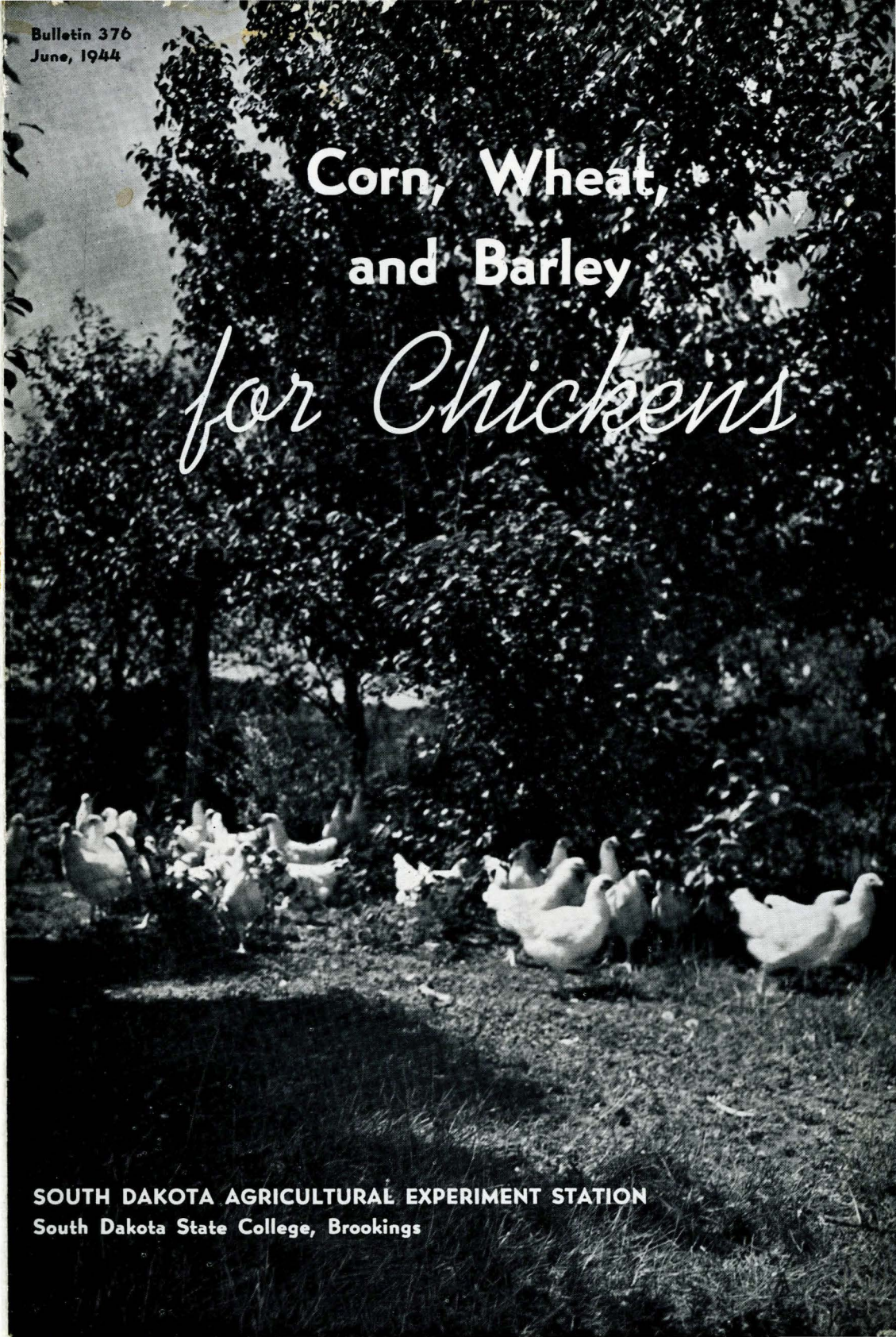

SOUTH DAKOTA AGRICULTURAL EXPERIMENT STATION
South Dakota State College, Brookings

Contents

Corn, Wheat, and Barley for Chickens

By W. O. Wilson, Poultry Husbandman[1]

Farm grains for many years were almost the only feed used for poultry. As more was learned about feeding poultry, it was discovered that grains lacked certain nutrients needed by chickens. The first attempt to correct this deficiency was by the use of a greater variety of grains. Then mashes were developed. These mashes now contain the minerals, proteins (amino acids), and vitamins known to be lacking in grains.

Ground grains or grain byproducts (such as bran and middlings) make mashes more tempting to chickens, and so a large percentage of them is added to the mineral, protein, and vitamin feeds. The amount added varies. Sometimes, as in fattening, it may be 80 percent or more of the mash ration. It may be as high as 80 to 90 percent of the total intake of feed. The feeding value and price of grains is obviously very important to the poultryman.

The importance of relative feeding values and prices of grains is also apparent because cost of feed represents 60 percent or more of the cost of producing eggs. Frequently one grain is much higher in price than others. When the feeding values of the grains are nearly the same, it is more economical to feed the cheaper grain.

Corn, wheat, and barley are all grown in South Dakota. In some sections of the State or on individual farms, one grain is likely to be more plentiful than others. Corn is most abundant in the eastern and southeastern counties and wheat in the northcentral counties. Because of the war many changes have had to be made in poultry rations.

The purpose of the experiments reported in this bulletin was to determine the comparative feeding values of corn, wheat, and barley for chickens. These experiments were conducted at the South Dakota Station between 1936 and 1943. Starting, growing, and laying rations containing large percentages of these grains were fed. Special emphasis was placed on the quality of meat and eggs produced.

The physical and chemical composition of the poultry carcass was measured to determine the effect of the grain fed on the resulting quality of broilers (young chickens having meat soft enough to be cooked tender by broiling) and roasters (young chickens weighing more than 3½ pounds). The quality of the egg produced was also measured. As the detailed results of the starting and growing tests have been published elsewhere, only the principal results are summarized in this bulletin.

[1] The author gratefully acknowledges the assistance on this project of W. E. Poley, A. L. Moxon, and R. L. Dolecek.

Method of Procedure

The new material presented here includes additional data for growing trials, measures of meat quality for fowls, and laying trials.

Growing trials. For growing trials in 1941, three lots of Rhode Island Red cockerels were fed a mash consisting of 60 percent of either yellow corn, barley, or wheat. The corresponding whole grain was fed in feeders as scratch grain. However, the yellow corn was cracked. Sixty birds were kept in each of the lots and were housed in a colony house. The chicks had been kept under similar conditions and were sorted at random. The birds were 8½ weeks old when the test started. They were fed these rations until they were 28 weeks old. Individual body weights were taken every 4 weeks. There was very little green feed in the lots during the greater part of the test, which ended about the middle of December.

Physical measurements. For studying physical measurements of fattening and fleshing fowls during 1940 and 1941, 10 Barred Rocks and 10 Rhode Island Red hens were used. These birds were taken at random from a group of hens that had been fed standard laying rations. The use of two breeds and 2 years' work makes possible a more accurate measure of the variation due to sources other than differences in rations. The measurement relationships were considered after the differences due to breeds and years had been eliminated. The measurements made on fowls were for the most part the same as those made on roasters and reported elsewhere.[2] In the dressed bird the height of the keel on the sternum (breast bone) was measured. A sharp rod was pushed through the skin between the flesh and the keel until it struck the sternum. The point of measurement was five eighths of an inch from the front of the keel.

The amount of fat present on a bird influences its flavor and palatability. A simple way to estimate the amount of fat on a bird would have possible commercial application. An attempt was made to measure fat by electrical methods. There are good reasons why fat can be measured electrically. It has a low conductivity for electrical currents. It has been shown that an increase in fat is accompanied by a decrease in moisture. Consequently a decrease in conductivity would be expected with fatter birds.

The measuring device consisted of a voltmeter, galvanometer, switch, and flexible cords attached to a plastic insulator which was used for mounting the

[2] Effect of corn, wheat and barley in the diet on the physical and chemical composition of fryers and roasters. W. E. Poley, A. L. Moxon, W. O. Wilson, and R. L. Dolecek (1941) Jour. of Agr. Res. 61: 161-178.

Effect of corn, wheat and barley in the diet on the flavor of fried and roasted chickens. W. E. Poley, Amanda Rosenquist, and A. L. Moxon (1941) Jour. of Agr. Res. 61:179-190.

Physical measurements of carcass quality in roasters. R. L. Dolecek, W. O. Wilson, and W. E. Poley (1941) Poul. Sci. 20:161-170.

the electrodes. The electrodes or needles were slightly smaller than phonograph needles. Steel, platinum, and tungsten were tested. The amounts of insulation to place on the electrode were also investigated. Other factors studied were differences in spacing between electrodes of 1, 2, 3, 4, and 5 centimeters, differences in amount of applied voltage on the galvanometer reading, the time factor and its relationship to the final reading. All electrical measurements were on dressed birds that had been kept at a refrigerator temperature of 36° F.

Chemical analyses of fat and moisture were made on the flesh of the left half of the bird which also included one half of the abdominal fat and the skin with its adhering subcutaneous fat. Duplicate analyses were made on all samples.

Laying trials. In 10 laying trials 34 lots of pullets were used since the beginning of this work in 1936. There were 30 to 60 birds per lot. The following breeds and varieties were tested: White and Barred Plymouth Rocks, New Hampshires, Rhode Island Reds, and White Leghorns. All of the experiments began in the fall when the pullets were 6 to 7 months old and covered a period of 32 to 48 weeks. The birds were kept confined in the laying houses for the entire period. Body weights of the individuals were taken every 8 weeks, and the feed was weighed every 4 weeks.

The grain in the mash was coarsely ground. The size of the mesh of the hammer-mill screen was one-eighth inch. The hens were hopper-fed whole grains and mash in all pens .Water, oyster shells, and grit were provided at all times in all lots. Artificial lights were used from 4 a.m. (Standard time) until daylight from October 15 to April 1. This gave the hens about 13 to 14 hours of light.

Protein level of mashes. Different kinds of laying mashes which are fed to poultry as well as different trade names and terminology of mashes sometimes confuse poultry raisers. There are four kinds of mashes commonly fed:

All mash (about 16 percent protein)
Regular mash (about 20 percent protein)
Grain balancer (about 26 percent protein)
Mash concentrate (about 32 percent protein)

Experiments were conducted to determine if the mash having 32 percent protein was most economical where home grains are available. The protein level is usually increased when the quantity of ground grains and grain byproducts in the mash is increased. The mashes having the highest protein level usually have the highest prices.

In general the purposes of these laying tests were to compare: (1) Mash rations which analyzed 20, 26, and 32 percent protein (Table 1, Rations 1, 2, and 3). The grain fed was a mixture of corn, wheat, and barley. (2) The feeding of corn, wheat, or barley with a 32-percent protein mash (Table 1, Ration 3). (3) Rations consisting of little or no

animal feedstuffs (Table 3, Rations 4, 5, 6, and 7). The last group of rations were the result of the wartime shortage of animal byproducts such as fish or meat scraps, dried milk, and other ingredients commonly used in feeding poultry.

Egg quality measurements. These were made in only the last trial (1942-43). A small sample of eggs, 29 in each lot, was taken at random. These averages should give some indication as to the quality of eggs produced by the different pens. Since the measure of egg quality are standard to some extent, explanations are omitted; but full information can be obtained from the Poultry Department.

Discussion of Results

The growing rations consisting of 60 percent of a single ground grain—corn, wheat, or barley—gave good results when fed to roasters. Since the scratch grain was the same kind as that fed in the mash, the amount of a single grain in the total ration was high. The actual percentages were 83 percent of barley and of corn and 90 percent of wheat. More whole wheat than corn or barley was consumed as scratch. The high palatability of wheat as a poultry scratch feed is generally recognized.

Gains on Corn, Wheat, and Barley

When gains alone are considered, corn, wheat, and barley have equal feeding value according to these tests. Each year the grains

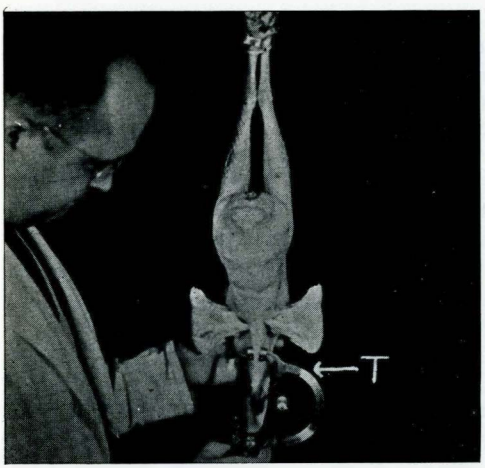

Fig. 1. Measuring neck feather tract thickness with indicating calipers. This thickness varies with the fat on the bird.

tested ranked in a different order for producing gains. In 1936 wheat was best, corn was second, and barley was third. In 1937, corn gave the best gains, wheat was second, and barley was third. In 1941, barley ranked first, wheat was second, and corn, third.

The measurement of fowl carcass quality was primarily concerned with measuring the fat on the bird. A strong relationship was found to exist between the thickness of the breast (pectoral) feather tract and the percent of fat in the total edible meat on the left half of the carcass, and between the thickness of the breast feather tract and the weight of the abdominal fat. A thick breast feather tract indicates that the bird is fat. The neck (cervical) feather tract thickness also varies with the amount of fat on the hen. Fig. 1 shows how this measurement was made. The relative thickness of these two feather tracts can be judged by feeling the chilled carcass of a fowl. This finding is of practical importance and agrees with previous work on the quality of roaster meat.

As very little work had been done with the electrical measurement of fat, it was necessary to further develop the technique. The pure tungsten needle gave the best results. It was necessary to insulate the needles with insulating varnish. A definite area of the electrode was exposed by grinding away the insulation. The electrodes were placed in the dressed birds to a depth of 0.5 centimeters. This depth was just underneath the skin and below the layer that possesses a high conductivity. Between the electrodes the distance that gave best results in this study was 1.0 centimeter. The amount of applied voltage that gave most consistent results was .85 volt.

The needles were inserted and galvanometer readings were taken at different intervals of time. After about 30 seconds the galvanometer readings remained constant. When the voltage was first applied, the galvanometer swung over and gradually receded.

There was no single position that gave readings that were correlated with the percent fat in the birds. However, the difference between the reading made on the breast and on the neck was significantly correlated ($P < 5\%$) with the amount of fat on the bird's carcass. There is probably no practical value of this finding at the present time, but more work should be done on the subject.

Egg Production Varied Within Pens

Differences between the number of eggs produced when the hens were fed either corn, wheat, barley or a mixture of the three grains were not statistically significant. This was true whether the mash was 20 percent or 32 percent protein. Likewise there was no significant difference among the pens fed 20, 26, and 32 percent protein laying mash with a combination of corn, wheat, and barley.

There was a tendency for egg production to be progressively higher with the increase in protein content of the mash with the exception

that one lot fed 32 percent protein in 1 year's work had the lowest. This lack of significance is the result of the high variability that exists in egg production between hens fed on the same ration. The high variability that occurs in egg production is the result of the management, disease, genetic, and environmental factors. The variation in egg production may amount to 33 percent according to Crampton.[3] One year's work might show significance, but when all years' work is combined there remains no important difference between the egg production of the various lots.

There were a few hatches from the lots on test. The weighted average egg production of the survivors was calculated. The average egg production per hen expressed in percent is given for comparable tests. Percent production was used instead of actual number of eggs per bird as the tests were not for the same length of time.

The results of the four tests on protein levels were as follows: 20 percent protein mash gave 39.52 percent egg production, 26 percent protein mash gave 44.14 percent egg production, and 32 percent protein mash gave 48.22 percent egg production.

The combined results of the two tests comparing corn, wheat, and barley fed as grains with a 32-percent mash were: corn 49.39 percent egg production; wheat, 43.16 percent egg production; and barley, 43.44 percent egg production.

The results of two additional comparisons of corn and barley were available. The total of four replications of corn versus barley as a grain fed with a 32 percent protein mash gave the following results: corn, 42.52 percent egg production; barley, 38.25 percent egg production.

There were differences between the feeds, but they were not significant. The trend was toward higher hatchability from the higher protein ration. When yellow corn was hopper-fed with a 32 percent protein mash, hatchability tended to be poorer than when either barley or a mixture of corn, wheat, or barley was fed.

Mortality in the various laying pens was high. The average was about 30 percent. The principal cause of death was the avian leukosis complex. This disease has many symptoms. It is commonly called fowl paralysis when the nerves are effected, grey eye when the eyes are affected, or big-liver disease when the viscera is affected. The visceral type was the most common. Tumors and disturbances of the reproductive tract were very common. High mortality in a flock is generally associated with the lower than average egg production. This fact emphasizes the importance of the effect of environment on egg production.

[3] The comparative feeding values for poultry of barley, oats, wheat, rye, and corn. Earle W. Crampton, Canada (1936) Nat'l. Res. Council Report No. 9.

Hens Balanced Protein Intake

The birds preferred wheat, corn, and barley in the order named when the grains were kept in hoppers before them at all times. The same was found true for roasters. The level of protein fed in the mash did not change the relative proportion of the three grains consumed.

The three rations tested varied in many respects other than protein content (Table 1). It is not correct to attribute all the differences in the results of these experiments to differences in protein content. The amount of grain consumed was less when the 20 percent protein mash was fed and about the same for the 26 and 32 percent protein mashes. The calculated percentage of protein intakes for four trials is shown

TABLE 1. COMPOSITION OF DIFFERENT MASH INGREDIENTS FED WITH RATIONS HAVING DIFFERENT PERCENTAGES OF PROTEIN

Mash ingredients	Ration 1 (20% protein)	Ration 2 (26% protein)	Ration 3 (32% protein)
	perct. or lb.	*perct. or lb.*	*perct. or lb.*
Yellow corn	21.2		
Oats	22.0		28.2
Wheat bran		18.2	
Wheat middlings	22.0	19.0	
Meat and bone scraps	10.0	15.0	25.0
Soybean oil meal	6.0	10.0	20.0
Alfalfa leaf meal	7.0	15.0	10.0
Dried buttermilk	5.0	15.0	10.0
Bone meal	1.0		
Salt mixture	1.0	1.0	1.0
Ground limestone	4.0	6.0	5.0
Fish oil concentrate	0.8	0.8	0.8
Totals	100	100	100
Scratch grain (hopper-fed)*			
Corn			++++++
Wheat			++
Barley			++++
Corn, wheat, and barley	++++++	++++	++++

* The plus sign designates the scratch grain fed. The number of plus signs indicates replicate lots.

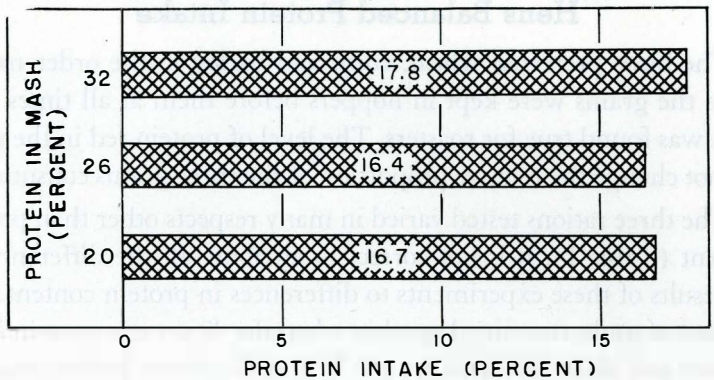

Fig. 2. Effect of protein content of laying mashes on protein intake when grains were hopper-fed.

in Fig. 2. This intake was calculated by multiplying the percentage of protein in the feeds (mash and each grain) by the number of pounds of each feed consumed and dividing the total amount of protein by the total number of pounds of feed fed. With these rations the high protein level in the mash was wasteful of proteins.

It is easy to find the approximate proportions of mash and grains the birds should eat (Fig. 3).

When fed a 20-percent protein mash and hopper-fed grains, hens on these tests did not eat equal parts of mash and grain. Instead, they ate about three parts of grains to one part of mash. This preference may have been due to either the colder weather or the higher protein content of South Dakota grains. It is important in preparing formulas for egg mashes. When the consumption is three parts of grain to one part of mash, a ration would be deficient that has a mash containing only enough minerals and vitamins to be fed in equal parts with grain.

It has been said that a hen will balance her own ration if allowed access to proper ingredients. This may be true with proteins but cannot be true at the same time for minerals and vitamins when those nutrients are at a low level in the mash. When the vitamin requirement is met, the amount of protein consumed may be too high. State feed laws often limit the amount of minerals that may be added to a feed. Due recognition should be given the type of feed considered. The law might read that a maximum of 5 percent of minerals could be added. But the concentrates may be deficient in minerals. Hens might be expected to eat one part of 32 percent protein concentrate to four

parts of grains. If the mash or concentrate contained 5 percent calcium carbonate (this is equivalent to 1.96 percent calcium) and the grain 0.05 percent calcium and no oyster shells were fed, the hen's intake

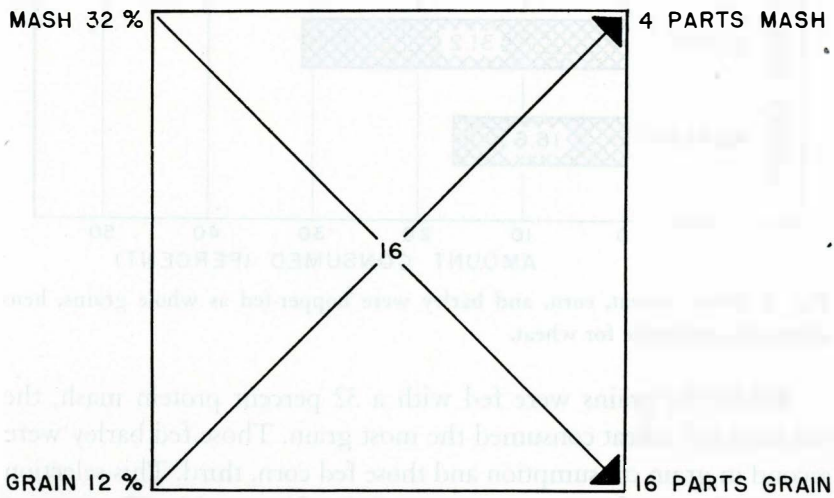

Fig. 3. The right proportions of mash and grains to feed can be determined as follows and illustrated above. Put the protein content of the mash and of the grain on two corners of one side of a square (32 and 12). In the center place the desired protein content (usually 16 percent). Using the center figure (16) as one number and one of the corner figures (12) as another, subtract the smaller from the larger. Place your answer (4) on the corner in line with (12) and (16) and diagonally across from them. Repeat this procedure, using the center figure and (32). Place your answer in the fourth corner (16). As shown above, you will want to feed 4 parts mash and 16 parts grain.

would be only 1.58 percent. The calcium requirement is 2.00 percent. This is only one added mineral; in addition, salt and phosphorus should be added.

Hens Preferred Wheat

The average amounts of the three grains consumed give some idea of the palatability of these grains for laying hens. Factors influencing the palatability may be particle size, particle shape, and color. For the twelve lots hopper-fed corn, wheat, and barley with mashes of different protein levels, the percentage of each grain consumed is shown in Fig. 4. This graph shows the hens' preference and not the feeding value of the grain.

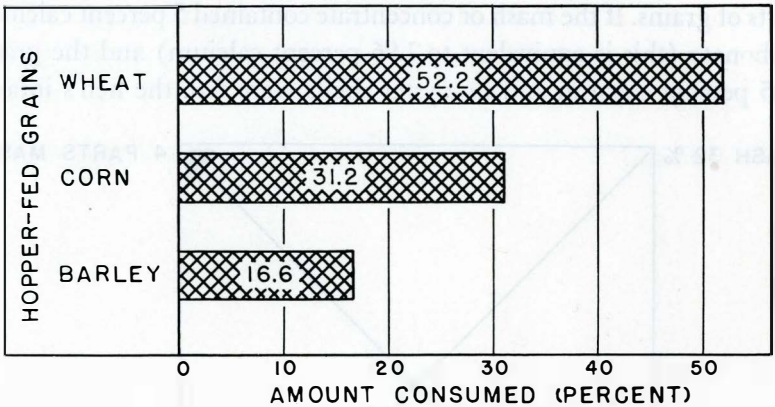

Fig. 4. When wheat, corn, and barley were hopper-fed as whole grains, hens showed a preference for wheat.

When the grains were fed with a 32 percent protein mash, the chickens fed wheat consumed the most grain. Those fed barley were second in grain consumption and those fed corn, third. This selection may be due to the protein content of the three grains. The lots fed wheat were balancing their protein intake by eating more grain and less mash.

Grains raised in South Dakota usually have a higher protein content than the generally accepted average content. (See Station Circular 47.) The Station Chemistry Department analyses for a large number of samples of South Dakota grains are as follows: wheat, 17.2 percent crude protein; barley, 13.2 percent; and corn, 10.8 percent. For laying hens a 16 percent protein intake is usually considered adequate provided the proper amino-acids are present. It is a well known fact that the cereal grains are lacking in some of the essential amino-acids. For example, the proteins from corn are of low quality because they are deficient in a certain amino-acid (lysine).

In the two trials where a comparison was possible it would appear that a combination of grains is to be preferred to feeding corn alone. The problem is to supplement these grains with the best available protein, mineral, and vitamin feed.

Vegetable Proteins Gave Good Results

Wartime shortages of feedstuffs prompted experimental work on rations containing little or no animal protein. The results of feeding trials from various sections of the country indicate that earlier state-

ments that plant proteins were inferior to animal proteins should be qualified. It is recognized that animal products usually contain a better assortment of essential amino-acids than is found in plant products.

Good growth and egg production were obtained from rations containing a large percentage of vegetable proteins provided the rations were properly balanced with respect to minerals and vitamins. The rations were so arranged that the source of protein was the chief variable. Whole yellow corn was fed as scratch grain in each group. Because of the importance of research on this pressing problem the results are given in more detail than were the results of the other experiments (Table 2). Only one year's results are available and further work might give different results.

The rations were planned for laying, not for breeding. However, three settings were made from the pens in late February and early March, when hatches are usually below normal. Only the control lot and the lot containing vegetable protein but no animal protein gave

TABLE 2. SUMMARY OF RESULTS OF POULTRY EXPERIMENTS FROM NOVEMBER 11, 1942, TO AUGUST 11, 1943

Items	Ration 8 (15% animal feed stuffs)	Ration 9 (No animal feed stuffs)	Ration 10 (7 % animal feed-stuffs)	Ration 11 (5% animal feed-stuffs)
Egg production (average per bird)	83.00	96.90	78.20	86.30
Average egg weights (grams)	57.80	56.50	56.70	55.50
Feed consumed per bird (lb.)	72.10	68.80	56.30	56.00
Gain or loss in weight per bird (grams)	−142.00	+60.00	−18.00	−14.00
Hatchability (%)	63.49	70.97	48.52	37.30
Egg quality (average of 29 eggs):				
Albumen height (millimeters)	66.90	62.17	59.65	61.04
Albumen index	80.52	73.76	70.00	72.57
Apparent score	1.97	2.21	2.33	2.25
Specific gravity	1.081	1.086	1.084	1.081
Yolk color	13.86	14.48	13.91	14.32
Shell grade	2.45	2.38	2.09	2.54
Shell weight (grams)	5.25	5.53	5.36	5.09
Calculated chemical composition:				
Protein (%)	19.80	18.40	18.80	18.80
Calcium (%)	3.15	2.05	2.15	2.11
Phosphorus (%)	1.06	1.03	1.05	1.03
Vitamin A (I. U. per lb.)	1,545	2,389	2,161	2,399
Riboflavin (gammas per lb.)	1,749	1,452	1,478	1,624

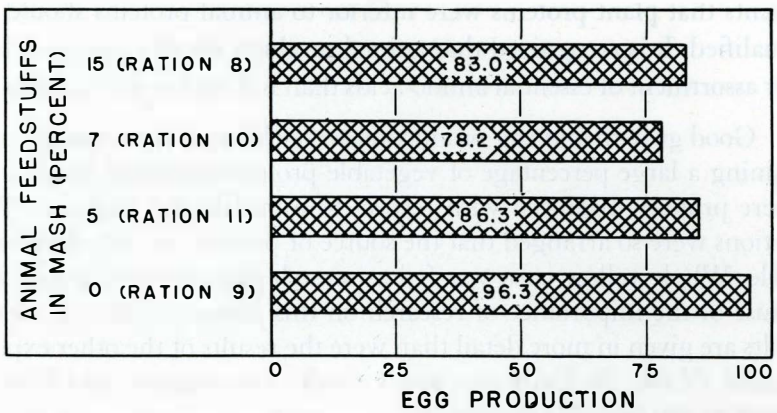

Fig. 5. Egg production from rations not containing animal feedstuffs compared favorably with other laying rations.

satisfactory hatchability of fertile eggs. All of the rations contained less than the recommended amounts of riboflavin for a breeder mash. Egg production is shown in Fig. 5.

The data on egg quality indicate that the hens fed Ration 4 (the control lot) produced eggs with better albumen quality as measured by its height, index, and apparent score. (See Fig. 6.) Very few differences were noted in the other lots. It is doubtful if the difference is significant. As would be expected the eggs from the lot fed corn gluten

Fig. 6. Measuring albumen height. The higher the albumen, the better the egg.

TABLE 3. COMPOSITION OF LAYING MASHES

Mash ingredients	Ration 4 (Control)	Ration 5 (No animal protein)	Ration 6 (No butter milk)	Ration 7 (No meat & bone scraps)
	perct. or lb.	*perct. or lb.*	*perct. or lb.*	*perct. or lb.*
Yellow corn	22.0	40.0	40.0	40.0
Oats	22.0			
Barley		20.0	23.0	20.0
Wheat middlings	20.0			
Meat and bone scraps	10.0		7.0	
Soybean oil meal	6.0	11.0	6.0	11.0
Alfalfa leaf meal	7.0	8.0	7.0	8.0
Corn gluten meal		7.0	5.0	7.0
Dried buttermilk	5.0			5.0
Dried distillers grains*		5.0	5.0	
Bone meal	1.0	5.0	3.0	5.0
Salt mixture	1.0	1.0	1.0	1.0
Ground limestone	4.0	1.0	1.0	1.0
Activated animal sterols†	2.0	2.0	2.0	2.0
Totals	100	100	100	100
Scratch grain (hopper-fed)	corn	corn	corn	corn

* With solubles.
† Vitamin D supplement 100-D.

meal in the ration had darker colored yolks. The yolk color was measured by the Heiman and Carver yolk color rotor. No other differences were found in egg quality. The composition of the rations are given in Table 3.

Summary and Conclusions

Although corn, wheat, and barley are all grown in South Dakota, one of these grains may be more plentiful in certain areas than others. Since all three are used as feeds for poultry, experiments were conducted at the South Dakota Agricultural Experiment Station from 1936 through 1943 to determine the relative feeding values of these grains for starting, growing, and laying rations. Studies were also made of physical measurements of the birds and of mashes containing various percentages of protein.

The principal results of these studies at the South Dakota Station may be summarized as follows:

There does not appear to be any decided difference in feeding value in corn, wheat, and barley as feed for roasters.

The ratio of hopper-fed grains consumed to a 20 percent protein mash was 3:1 (75 percent grain and 25 percent mash). Those who formulate mashes for this region should fortify their mashes with vitamins and minerals to allow for such a ratio instead of the commonly accepted 1:1 ration (50 percent grain and 50 percent mash.)[4]

The amount of grain consumed by growing birds (roasters) was as high as 90 percent of the total feed eaten.

Electrical measurement of fat was attempted in dressed fowls, and the results suggest the need for further work.

The differences between egg production of chickens fed the different rations were not significant when tested statistically. One of the factors influencing variability of egg production was disease.

Hens fed a 20 and 26 percent protein mash were able to balance their protein intake to about 16.5 percent protein. When hens were allowed to choose their own grains, wheat was 51 percent of total intake, corn was 33 percent, and barley was 16 percent. This proportion did not vary with the percentage of protein in the mash.

A laying ration containing no animal feedstuffs was tested and gave results comparable to the control laying ration which contained 15 percent of animal feedstuffs.

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[4] Since this material has been compiled, vitamin-A deficiency has been found in hens fed a 20 percent protein mash containing an adequate quantity of vitamin A. These hens were hopper-fed wheat and were consuming 4 parts of wheat to 1 part of mash.

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