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Bulletin No. 203 - Poultry Feeding, Housing, and Lighting Experiments at the Wyoming Experiment Station

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UNIVERSITY OF WYOMING
AGRICULTURAL
EXPERIMENT STATION

Poultry Feeding, Housing, and Lighting Experiments at the Wyoming Experiment Station

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UNIVERSITY OF WYOMING

Agricultural Experiment Station

LARAMIE, WYOMING

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*In cooperation with U. S. Department of Agriculture.
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References to Part on the Value of Rye in the Chick Ration
SUMMARY OF RESULTS

Cereal Grains for Egg Production and Egg Quality.

Pullets laid equally well and maintained normal health on mash and grain rations containing 65 to 70 per cent of a single cereal grain. Yellow corn, white corn, wheat, oats, rye, and barley were considered.

Birds consumed a larger proportion of mash in the oats lot than in any other.

No differences were noted in the shells of the eggs from the seven lots with respect to porosity, breaking strength, thickness, and percentage of shell to total egg.

The variation in rations produced no differences in percentage of total solids, percentage of proteins, or in odors, or flavors.

In the following measures of quality the different rations produced no significant variations, except as noted: The lot fed rye produced eggs with a lower ration of thick white to thin and a lower yolk index. This caused the eggs from the rye lot to appear aged in spite of the fact that they were strictly fresh. Barley showed a slight tendency to produce a lower ratio of thick white to thin white; yellow corn deepened the yolk color; and wheat increased the number of large islands of fat.

Housing and Lighting for Egg Production.

Insulating the poultry house with a straw loft and a straw pack between the studding was quite efficient for protection against extreme variations in temperature.

Long continued cold lowered egg production, but the hens were little affected by sudden drops in temperature of short duration.

Hens and pullets supplied with continuous dim lighting produced more eggs at the season of higher prices than those supplied with bright morning and evening lights or no lights at all. A given amount of money spent for artificial lighting will produce better results if expended for dim lights throughout the night rather than bright lights in the morning and evening.
The feed consumption was approximately the same for all lots of pullets and all lots of hens, regardless of the system of lighting or number of eggs laid. This was because the birds laying heavily did so at the expense of body weight.

Mortality was higher in the lighted lots than in the unlighted lots.

**Combinations of Rations and Lights.**

There seemed to be a tendency for the birds on a grain-and-mash ration to gain more weight during the course of the tests than those on all-mash.

Feed consumption was highest in the grain-and-mash lots, especially when continuous light was used.

Egg production was greatest from the lot under continuous light and receiving a grain-and-mash ration. The lot so managed laid about 26 per cent more eggs than the two control lots, which received no additional light, one on a grain-and-mash and the other on an all-mash ration.

Not only did the combination of continuous light and grain-and-mash feeding produce a large number of eggs, but early winter egg production was stimulated, resulting in an increase of almost 40 per cent in returns from egg sales over the two control lots.

Any variable in these trials which tended to increase winter egg production did so at the expense of spring production.

Yolks from the grain-and-mash lots were more variable in color than those from the all-mash lots.

**Rye in the Chick Ration.**

Rations containing 20 per cent of rye or less when substituted for other cereal grains were found to be practical for chicks.

Although a ration containing 30 per cent of rye gave satisfactory growth, it caused such a laxative condition that levels of this amount cannot be recommended.

The addition of so much as 40 per cent of rye to the chick ration did not increase the rate of mortality.
CEREAL GRAINS FOR EGG PRODUCTION AND EGG QUALITY

The main factor for valuing a laying ration other than the quantity of eggs it will produce is egg quality. Educational work dealing with better eggs has increased the consumers' demand for a quality product.

Although the method of handling the eggs from the time they leave the farm until they reach consumer channels is a main factor in egg quality, it is not the sole problem. Eggs must be so perfect physically and chemically at the time they are laid that they will deteriorate as little as possible during the time they are handled and be of superior quality when ready for consumption. Any variation found in fresh-laid eggs, caused by differences in the feed, would appear to be the starting point for the improvement of egg quality.

Generally from 50 to 65 per cent of a laying ration is composed of one or more of the cereal grains. Various combinations of these grains are selected mainly on a basis of availability within the region of the producer. Consequently, due to the large proportions of these feeds used in poultry rations, a knowledge of any effect they have on the quality of the eggs produced will be of great value in an egg improvement program.

This study was undertaken to determine what changes, if any, the various cereal grains produce in the physical and chemical make-up of the egg.

EXPERIMENTAL

Procedure. The birds used each year in these experiments were pullets which had been raised on range and fed a mash and grain ration. The composition of the growing ration used is included
here as being of some importance, in consideration of the drastic changes made in the diets when the birds were housed. A supply of the following mash was constantly before the chicks: Ground yellow corn, 20 parts by weight; ground barley, 25; mill run bran, 25; wheat middlings, 5; meat scraps, 18; alfalfa leaf meal, 3; finely ground oyster shell, 3; salt, $\frac{1}{2}$, and cod liver oil, 1. The cod liver oil was discontinued when the chicks were outside daily. After the chicks were three months old some skim milk was fed. A grain mixture of equal parts of whole wheat and whole corn was fed each evening after 8 weeks of age so that the birds had all they would consume.

The experimental procedure was identical for each of the two years, except that one cockerel was kept in each pen the second year. When approximately five per cent of the pullets were laying on the range they were removed to the seven experimental pens. These pens were equipped with roosts, dropping boards, trap nests, open type waterers, trough type feeders with revolving reel for mash, small troughs for grain feeding, and oyster shell hoppers. The birds were confined to these pens under approximately eleven hours artificial light daily throughout the course of the trials. Fifteen pullets of as similar breeding, type, weight, and maturity as could be found were selected for each lot. Inasmuch as this was to be mainly a qualitative study of the eggs rather than a determination of the quantity of eggs produced on each ration, fifteen birds to the pen were believed sufficient. The rations were started October 1, the first year, and September 1, the second, but the collection of statistical data other than those dealing with egg production and feed records was not begun until November 1 of each year. The experiment was discontinued about the first of March following. Fresh mash was supplied daily and all the grain that the birds would consume was fed in the evening. Oyster shell and water were available at all times. Eggs were taken at the intervals mentioned in the following paragraphs and the physical and chemical data collected.
|
|---|---|---|---|
|**Lot No.** | **Basal mash** | **Cereal grain** | **Grain** |
| 1 | 12 | Yellow corn | 9 | Yellow corn |
| 2 | 12 | Yellow corn | 8 | Yellow corn |
| 3 | 12 | White corn | 8 | White corn |
| 4 | 12 | Wheat | 8 | Wheat |
| 5 | 12 | Oats | 8 | Oats |
| 6 | 12 | Rye | 8 | Rye |
| 7 | 12 | Barley | 8 | Barley |

*All grains except the white corn were grown in the vicinity of eastern Wyoming.
†The basal mash consisted of pure wheat middlings 100 parts, pure wheat bran 100 parts, meat and bone meal 75 parts, dried buttermilk 25 parts, salt 5 parts, and cod liver oil 10 parts. (The second year 3 parts of a fortified oil were used.)

**Rations.** The rations fed are given in Table I.

Table I shows that approximately 39 per cent of the mash in Lots 2 to 7 and 43 per cent in Lot 1 consisted of the individual cereal grain. The whole grain received by each lot was the same grain contained in the mash for each respective group. The cereal grains, then, for each would constitute about two-thirds of the entire ration. This approaches closely the maximum amount of a cereal grain a practical ration could contain.

**Egg Production.** Although these trials were not made primarily to test the egg-producing ability of these rations, Table II is believed to be important, for it shows definitely that rye was successfully fed at this station at a level so high that it was within limits of its practical maximum content in a laying ration.

**Gains in Weight.** There seemed to be no observable difference in vitality between the lots. The rye had a slightly laxative effect on the birds, which was more noticeable during the first month than later, but seemed to cause no harmful effects. The mortality during the trials was exceptionally low in all lots. Only one bird died the first year and six the second, the deaths being distributed throughout the different lots. However, no deaths occurred either year in the rye lots.
TABLE II—CEREAL GRAINS AND EGG PRODUCTION

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<tr>
<td>1</td>
<td>Yellow corn</td>
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<td></td>
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<tr>
<td>2</td>
<td>Yellow corn</td>
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<tr>
<td>3</td>
<td>Alf. leaf meal</td>
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<td></td>
<td></td>
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<tr>
<td>4</td>
<td>White corn</td>
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<tr>
<td>5</td>
<td>Alf. leaf meal</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>6</td>
<td>Oats</td>
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</tr>
<tr>
<td>7</td>
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<tr>
<td></td>
<td>Barley</td>
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<td>1933-34</td>
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<td>1</td>
<td>Yellow corn</td>
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<td></td>
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<tr>
<td>2</td>
<td>Yellow corn</td>
<td></td>
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<td>3</td>
<td>Alf. leaf meal</td>
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<td></td>
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<tr>
<td>4</td>
<td>White corn</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Alf. leaf meal</td>
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<td></td>
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</tr>
<tr>
<td>6</td>
<td>Oats</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>7</td>
<td>Rye</td>
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<tr>
<td></td>
<td>Barley</td>
<td></td>
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</tr>
</tbody>
</table>

To further substantiate the belief that the rye fed in these trials was comparable to the other grains and was not detrimental to the health of the birds, the data on gains in weights are presented in Table III.

The ability of birds to gain in weight while under production is a criterion of their health. The gains in weight and the egg production of all lots indicate the rations were quite successful when the health of the birds was considered.

Feed Consumption. Data on feed consumption in the various lots are presented in Table IV.
TABLE III—CEREAL GRAINS AND GAIN IN WEIGHT OF BIRDS.

<table>
<thead>
<tr>
<th>Lot No.</th>
<th>Ration</th>
<th>Ave. weights 1932-33</th>
<th>Ave. weights 1933-34</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yellow corn</td>
<td>2.70</td>
<td>4.06</td>
</tr>
<tr>
<td>2</td>
<td>Yellow corn</td>
<td>2.69</td>
<td>4.12</td>
</tr>
<tr>
<td>3</td>
<td>Alf. leaf meal</td>
<td>2.80</td>
<td>4.02</td>
</tr>
<tr>
<td>4</td>
<td>Wheat</td>
<td>2.77</td>
<td>3.76</td>
</tr>
<tr>
<td>5</td>
<td>Alf. leaf meal</td>
<td>2.75</td>
<td>3.78</td>
</tr>
<tr>
<td>6</td>
<td>Alf. leaf meal</td>
<td>2.88</td>
<td>3.89</td>
</tr>
<tr>
<td>7</td>
<td>Alf. leaf meal</td>
<td>2.74</td>
<td>3.57</td>
</tr>
</tbody>
</table>

*Average of birds completing the trials.
†5 months.
‡6 months.

Although all weights in this publication were originally recorded in grams, conversion to pounds has been made to facilitate the reading of other than scientific workers.

The palatability of any grain for poultry feeding may be measured by the tendency of the birds to consume it. The fact that the mash was before the birds at all times and that once a day all the grain was given that the birds would consume gave ample opportunity to test the palatability of these feeds. Oats was the only whole grain which seemed consistently low in palatability.

TABLE IV—CEREAL GRAINS AND MASH AND GRAIN CONSUMPTION.

<table>
<thead>
<tr>
<th>Lot No.</th>
<th>Ration</th>
<th>Feed per bird per day, 1932-33</th>
<th>Ratio: mash to grain</th>
<th>Feed per bird per day, 1933-34</th>
<th>Ratio: mash to grain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mash lbs.</td>
<td>Grain lbs.</td>
<td>Total lbs.</td>
<td>1.25 : 1</td>
</tr>
<tr>
<td>1</td>
<td>Yellow corn</td>
<td>.107</td>
<td>.087</td>
<td>.194</td>
<td>1.25 : 1</td>
</tr>
<tr>
<td>2</td>
<td>Yellow corn</td>
<td>.109</td>
<td>.081</td>
<td>.190</td>
<td>1.35 : 1</td>
</tr>
<tr>
<td>3</td>
<td>Alf. leaf meal</td>
<td>.091</td>
<td>.080</td>
<td>.171</td>
<td>1.13 : 1</td>
</tr>
<tr>
<td>4</td>
<td>Wheat</td>
<td>.091</td>
<td>.106</td>
<td>.197</td>
<td>.86 : 1</td>
</tr>
<tr>
<td>5</td>
<td>Oats</td>
<td>.123</td>
<td>.072</td>
<td>.195</td>
<td>1.71 : 1</td>
</tr>
<tr>
<td>6</td>
<td>Rye</td>
<td>.113</td>
<td>.095</td>
<td>.208</td>
<td>1.19 : 1</td>
</tr>
<tr>
<td>7</td>
<td>Barley</td>
<td>.107</td>
<td>.094</td>
<td>.201</td>
<td>1.14 : 1</td>
</tr>
</tbody>
</table>
during the two trials, as judged by its low consumption. The fact that normal amounts of oats were not relished forced the birds to consume large amounts of mash. This increased consumption of mash increased the protein content of the total ration and thus gave this lot somewhat of an advantage in this respect. The proportions of mash to grain in the other lots seemed to be little different.

Shell Porosity. The shell porosity was determined by comparing the eggs involved with standards similar to those of Almquist and Holst (1931), but without the use of methylene blue. Comparison was made in this study on the basis of per cent perfect, the absence of the porous condition in shells being given the value of 100.

The porosity of the shell was determined for every egg laid. Any variation occurring in this factor is of considerable importance because of the relationship of texture to breakage through handling. The shells tested ranged for the most part between 30 and 100 per cent, with the majority between 60 and 90. There seemed to be no noticeable differences between the different lots regarding shell texture.

Physical and Chemical Determinations. Once every two weeks an egg from each hen was taken from the seven lots and many physical and chemical determinations were run to determine differences in the quality of the eggs produced on the different rations. The means of some of the physical determinations are given in Table V. The figures given are averages of the means for the eggs measured.

Shell. The figures in Table V representing shell porosity are quite indicative of the slight variation in this characteristic which occurred between the different lots. The fact that the slight variations the first year did not repeat themselves indicates that little significance can be attached to these differences.

Breaking Strength of Shells. Morgan and co-workers (1930) and others have reported that the breaking strength of the shell is closely correlated with weight of the shell and the percentage
of calcium carbonate present in the shell. To complete the data on these eggs the shell strength was determined. The breaking strength was measured by the amount of weight necessary to crack the shell when applied at right angles to the long axis of the egg. This method has given more consistent results at this station than that of breaking the egg at right angles to the short axis. The method employed was to place the egg under one end of a long bar hinged at the other and draw a weight, suspended on rollers, along this bar toward the egg until the shell cracked. A scale was attached to the bar so that the weight could be read directly in grams. The differences were only slight for the seven lots each year. Some increase in breaking strength was noted in the second year, evidently due to the larger-sized eggs. The pullets used the second year were more mature when the trials were begun and they remained on experiment one month longer. There was some correlation between the thickness of the shell, not including shell membranes, and the breaking strength, but there was not enough variation between the lots in this factor to register any significance.

**Parts of the Egg.** The variation in the rations produced no significant variation in the proportions of the three parts of the egg: Shell (including shell membranes), albumen, and yolk. All parts of the eggs were weighed, and all measurements listed in Table V were taken on each egg brought to the laboratory. The percentages of the three parts of the egg were quite consistent for the two trials. This indicates that the proportions of the various parts of the egg were not altered by changes in the cereal grain fed.

**Albumen.** The method employed for the separation of the thick and thin white was that of Holst and Almquist (1931). In this method a small mesh sieve is used which retains the firm but allows the thin portion to run through into a graduated cylinder. Determinations of the albumen were made every two weeks and the resulting data are given in Table V. Certain variations took place in the amount of thick albumen present due to the different rations. There seemed to be no consistent variation either year
<table>
<thead>
<tr>
<th>Lot No.</th>
<th>Ration</th>
<th>Egg weight</th>
<th>Shell</th>
<th>Albumen</th>
<th>Yolk</th>
</tr>
</thead>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Pores</td>
<td>Weight to</td>
<td>Total</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>% Perfect</td>
<td>break shell</td>
<td>c.c.</td>
</tr>
<tr>
<td>1932-33</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Yellow corn</td>
<td>48.51</td>
<td>81.70</td>
<td>3832.5</td>
<td>6.13</td>
</tr>
<tr>
<td>2</td>
<td>Yellow corn</td>
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<td>82.76</td>
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</tr>
<tr>
<td>3</td>
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<td>81.23</td>
<td>3963.0</td>
<td>6.20</td>
</tr>
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<td>48.76</td>
<td>77.40</td>
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</tr>
<tr>
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<td>Alf. leaf meal</td>
<td>48.33</td>
<td>79.09</td>
<td>3732.6</td>
<td>5.99</td>
</tr>
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<td>Alf. leaf meal</td>
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<td>75.92</td>
<td>3783.6</td>
<td>5.96</td>
</tr>
<tr>
<td>7</td>
<td>Alf. leaf meal</td>
<td>49.15</td>
<td>76.43</td>
<td>3987.8</td>
<td>6.18</td>
</tr>
<tr>
<td>1933-34</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Yellow corn</td>
<td>51.62</td>
<td>79.80</td>
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<td>2</td>
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<td>80.76</td>
<td>4000.7</td>
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<td>80.33</td>
<td>3962.4</td>
<td>6.34</td>
</tr>
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<td>79.91</td>
<td>3981.0</td>
<td>6.39</td>
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<td>Alf. leaf meal</td>
<td>52.06</td>
<td>80.09</td>
<td>4010.2</td>
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</tr>
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<td>6</td>
<td>Rye</td>
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<td>81.01</td>
<td>3800.1</td>
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</tr>
<tr>
<td>7</td>
<td>Barley</td>
<td>51.88</td>
<td>81.64</td>
<td>3967.7</td>
<td>6.38</td>
</tr>
</tbody>
</table>

*Includes shell membranes.  †grams.  ‡mm.
August, 1934  Poultry Experiments

in the yellow corn, white corn, wheat or oats lots. However, the
decrease in the thick albumen to 64.84 per cent for the rye lot
in the first trial and to 62.94 per cent in the second indicates that
rye in these tests decreased the amount of thick white over the
other cereal grains. The eggs produced on barley had slightly
less thick white than those produced on the other grains, except,
of course, rye, but it is doubtful if the difference is significant.
A lower proportion of thick white is, according to Holst and
Almquist (1931), an indication of age. The decrease in the
amount of thick white in the rye lot from the average of Lots 1
to 5 inclusive was 5.37 per cent for the first trial and 8.21 per
cent for the second. These eggs, then, displayed characteristics
of eggs which had been held, although they were strictly fresh.
The question, then, as to how much age the eggs from the rye lot
displayed can only be answered roughly. Holst and Almquist
(1931) found that variations took place for different hens in the
decrease in the amount of thick white when the eggs were held.
They recorded variations from approximately 5 to 25 per cent
decrease in the amount of thick white when eggs were held at 64°
F. for 25 days and about the same decrease when the temperature
was 86° F. in only 10 days. It would seem, then, that these eggs
exhibited about the same decrease in thick white as eggs held for
10 to 15 days at 64° F. in the data of Holst and Almquist.

The variations reported appear to be significant, due to the
fact that there were no differences between the seven lots in the
amount of thick white contained in their eggs at the beginning of
the experiment and the further fact that the amount of thick
white in eggs from the rye lot decreased regularly throughout
the trials while the other lots, except the lot receiving barley,
which showed slight decreases, remained fairly constant.

These results are of importance for two reasons. First,
these fresh rye eggs had an aged appearance which would sub-
ject them to discrimination in a quality market. Second, the use
of the proportion of thick and thin white as a criterion for judg-
ing the age of eggs is rendered of doubtful value, because fresh
eggs may show a large degree of liquefaction.
Percentage of Solids in Thick and Thin Albumen. Due to loss of water through evaporation, the percentage of solids in the albumen increases with the age of the egg. Variations in the percentage of solids of the fresh laid eggs from these lots would further indicate differences in the grains. The percentage of solids in the thick and thin white was determined from samples brought into the laboratory every two weeks. These determinations were made after the method of Holst and Almquist (1931), by means of the Spencer Refractometer, Abbe type. The percentage of solids was then taken from a table showing the relation of the reading to the percentage of solids. This table was constructed from data secured by comparing refractometer readings with the percentage of solids determined by drying. The refractometer readings were secured on alternate weeks from which eggs were taken for the data in Table V. The results are presented in Table VI along with the corresponding protein content of the two fractions.

The refractive index readings were between 1.3529 and 1.3594, which were within slightly wider limits than those recorded by Holst and Almquist. No differences could be found in the eggs collected within any one lot in the proportion of solids of the respective thick and thin albumen. This was also in line with the findings of Holst and Almquist. Furthermore, no significant differences between the proportion of solids in either fraction were noticeable in the seven lots comprising the different grains. All lots were approximately equal in these measurements.

The amount of protein in the thick and thin albumen, as determined by the Kjeldahl method, was also the same in the two fractions and the seven lots. Any differences in the protein content of the ration apparently had no effect on the protein in either portion of the albumen.

Yolk. The variations and differences in the yolks of fresh and aged eggs suggest several methods for the determination of differences which might be found in new-laid eggs. Several of these have been employed in these tests.
TABLE VI—SOLIDS AND PROTEIN IN THE THICK AND THIN ALBUMEN IN RELATION TO THE CEREAL GRAINS*

<table>
<thead>
<tr>
<th>Lot No.</th>
<th>Ration</th>
<th>Solids†</th>
<th>Protein†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Thin albumen</td>
<td>Thick albumen</td>
</tr>
<tr>
<td>1932-33</td>
<td></td>
<td>Per cent</td>
<td>Per cent</td>
</tr>
<tr>
<td>1</td>
<td>Yellow corn</td>
<td>11.23</td>
<td>11.19</td>
</tr>
<tr>
<td>1</td>
<td>Alf. leaf meal</td>
<td>12.02</td>
<td>12.04</td>
</tr>
<tr>
<td>2</td>
<td>Alf. leaf meal</td>
<td>11.71</td>
<td>11.86</td>
</tr>
<tr>
<td>3</td>
<td>Wheat</td>
<td>11.55</td>
<td>12.14</td>
</tr>
<tr>
<td>4</td>
<td>Alf. leaf meal</td>
<td>12.01</td>
<td>12.03</td>
</tr>
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<td>5</td>
<td>Alf. leaf meal</td>
<td>12.09</td>
<td>11.96</td>
</tr>
<tr>
<td>6</td>
<td>Alf. leaf meal</td>
<td>12.03</td>
<td>12.37</td>
</tr>
<tr>
<td>7</td>
<td>Alf. leaf meal</td>
<td>11.63</td>
<td>11.51</td>
</tr>
</tbody>
</table>

| 1933-34 |              | Per cent  | Per cent  | Per cent  |
|         | Yellow corn  | 11.63    | 11.51    |           |
| 1       | Alf. leaf meal | 11.98   | 11.72    |           |
| 2       | Alf. leaf meal | 12.03   | 12.05    |           |
| 3       | Wheat        | 12.13    | 12.06    |           |
| 4       | Alf. leaf meal | 11.71   | 12.00    |           |
| 5       | Alf. leaf meal | 12.07   | 12.17    |           |
| 6       | Alf. leaf meal | 12.21   | 12.02    |           |
| 7       | Alf. leaf meal | 11.63   | 11.51    |           |

*Means of bi-weekly means.
†These data collected on different lots of eggs.

Yolk color is thought to be controlled primarily by feed. The relationship between green feed or yellow corn and yolk color is very noticeable. Although the density of the yolk color is no criterion of the food value of the yolk from the vitamin standpoint, it is of importance because of the market specifications which vary in different cities.

Measurements were made every other week upon yolks collected from each lot. These are tabulated in Table V. Densities of yolk colors were matched with standards and recorded as numerals from .5, a light canary color, by half units to 6.5, a deep red, so that averages could be taken.

The presence of such large amounts of yellow corn, which contains xanthophyll, the coloring pigment of yellow corn and egg yolk, deepened the yolk color materially in Lots 1 and 2. The
addition of 5 per cent of alfalfa leaf meal to the mash (Lot 2) did not deepen the color of the yolks over those from Lot 1. It must be remembered that the birds in Lots 1 and 2 received a very large percentage of their ration as yellow corn. There was little variation in yolk colors from Lots 3 to 7 inclusive, but the color was only about half as deep as in the eggs from Lots 1 and 2.

**Yolk Appearance.** The appearance of the yolk as affected by the presence or absence of fat globules is of importance in giving the egg a fresh appearance. This was recorded in numerals from 1, representing no fat globules, to 5, showing the presence of many and large globules, so they might be averaged. These data are recorded in Table V.

Egg yolks from the hens receiving wheat as the major portion of their diet were somewhat freer from fat globules than the others. Hence these eggs looked fresher than those from any of the other six lots. Although both corn and oats contain a high percentage of fat, the yolks from the hens receiving these two grains showed few fat islands on the yolk.

**Yolk Index.** As an indicator of the interior quality of the egg Sharp and Powell (1930) used a yolk index obtained by dividing the height of the yolk by its width when on a flat surface. Yolk indexes were determined every two weeks according to this method. The yolks were placed on a sheet of moist flat glass and readings taken immediately. The results are given in Table V.

The low proportion of the thick white in the egg from the rye lot was also associated with a low yolk index in the same eggs. That these two should be associated is of importance in completing the evidence that both the yolk and albumen presented an aged appearance when the birds were rye fed under the conditions of this experiment.

**Taste.** Many of these eggs were tested for disagreeable flavors and odors but no differences between the eggs could be detected. Furthermore these eggs were sold to the local trade and no complaint was received about any of the eggs. Bad flavors and odors appear to have been absent or so slight they were not noticeable.
Measuring the quality of fresh eggs has considerable importance, for it is known that eggs are variable in quality at the time they are laid. The variations which occurred in eggs due to differences in feed were most noticeable in those coming from the lot receiving rye. However, there seems to be no serious disadvantage from feeding large amounts of rye. This is particularly gratifying to poultrymen in some sections of Wyoming where large amounts of this grain are grown. The egg production and health of the hens on all the diets were more or less similar. The aged appearance of the eggs from hens receiving rye was the only important difference. This, however, was no great defect in these eggs, for it could only be noticed by the closest of observation. These eggs were marketed and commanded the same premium in price as eggs from the other pens, and there is no reason to believe they could not be sold as well from other flocks.

HISTORICAL

This work was planned and written with the following historical background in mind:

Much has been accomplished from a production point of view on the place of the various grains in a laying ration, but little has been done on the relation of these grains to egg quality. Furthermore, various differences have been found in eggs due to variations in the use of feeds other than the cereal grains and in the methods of their production. Atwood (1914) found the diet had a marked influence on the quantity and size of eggs. Morgan and Woodruff (1927) found that Capsanthin, a pigment from pimento peppers, may be used to color the yolk of hens’ eggs. Since then various other chemicals, one of which is Sudan III, have been used for deepening the color of yolks.

Many variations in the iron and copper content of egg yolk have been reported, but some dispute is registered as to the cause of these variations. Erikson and co-workers (1933) report that cod liver oil or direct sunshine produced an increase in both copper and iron, but conflicting results were obtained in some of their experiments. Cunningham (1931) found that the addition of small amounts of copper to the ration was of no value in increasing the copper content of the egg.
That the percentage of iodine in the egg may be increased by increasing the hen’s intake of iodine compounds was reported by Scharrer and Schrop (1932).

The vitamin content of the egg may be easily controlled by varying the intake of the vitamin concerned. Bethke, Kennard, and Sassaman (1927) found that egg yolk may be made unusually rich in vitamin A by feeding a diet rich in this factor. Hart and co-workers (1927) showed that the irradiation of the hen would increase the vitamin D content of the eggs laid.

Most of the research mentioned considers variations in the composition of eggs involving factors which could only be detected in the laboratory. Although these factors present an important part of the picture, those variations which can be easily detected by the consumer are of greater importance in the production of quality eggs. Many of these conditions have been studied and the work reported.

Sherwood (1928, 29, 31), Upp (1932), and Thompson (1929, 30) have shown that large amounts of cottonseed in the diet of laying hens produce olive-colored yolks which darken with age. Mattikov (1932) has recently presented a review of the literature on the coloring matter in egg yolk. Much has been done to show that the xanthophyll-containing feeds play an important part in increasing the density of the yellow color in egg yolk. This increased depth of color is often an indication of an increased supply of carotin, but a pale-colored yolk is not indicative of the absence of this pigment, which is closely associated with vitamin A, and a depth of color is no indication that carotin is present in large amounts.

Titus and co-workers (1933) found that the percentage of protein in the dry matter of the yolks of eggs laid by pullets could be altered by feeding a diet high in crab meat. Sharp and Powell (1931) measured the decrease in the interior quality of eggs by the use of a yolk index, representing the quotient of the yolk height and yolk width as measured when the yolk is placed on a flat surface. A decrease in this index is an indication of age. Holst and Almquist (1931) reported that the “thick white percentage as an expression of egg quality possesses several points of superi-
ority over the yolk index." These same men (1931), furthering their work, separated the thick and thin white and found the percentage of solids was practically the same in each and that the two portions were little different.

Morgan, Mitchell, and Roderick (1930) found that additions of cod liver oil to a ration for laying hens tended to increase the breaking strength of the eggs laid. Later Holst, Almquist, and Lorenz (1932) reported that egg shell translucency (poor shell texture) was caused by the presence of moisture distributed in a non-uniform manner throughout the shell proper.

Hart, Steenbock, and co-workers (1925) showed that the percentage of shell could be altered by minerals and vitamin D. That the percentage of thick white is an index of age was established by Holst and Almquist (1931) when they determined that the percentage of thin white increased with the age of the egg. Almquist and Lorenz (1932, 33) showed that the albumen in the firm white is transferred to the thin white portion by a contraction of fibers, thus squeezing the albumen out, and by rupture of the firm white envelope, the latter due to "shocks and vibrations incident to shipment, or a pressure accompanying a rise or fall of the yolk, or a partial real liquefaction." It would seem that the former was the more important in a study of albumen liquefaction of new-laid eggs, for little chance for "rough handling" occurred.

Rye has long been thought to be of little value as a poultry feed. Lippincott and Card (1934) state "This grain . . . . is not suited for poultry feeding. It seems to contain some ingredient which renders it unpalatable to the fowl. When fowls are compelled to eat it, it has a tendency to cause digestive disorders and is said to affect the flavor of the eggs." Jull (1930) writes "Rye is relatively rich in carbohydrates and fat, the former of which have a relatively high digestion coefficient, but in spite of all this, rye is not palatable and is not a good poultry feed." Working with chicks, Halpin (1932) found that the addition of 30 per cent of rye to a chick ration was detrimental to growth. Similar results have been found at this station (1933).
POULTRY HOUSING AND LIGHTING FOR EGG PRODUCTION

Since Halpin, Hayes, and Swenehart (1925) introduced the straw-loft laying house to the poultry industry, many investigators and users have given approval of its many fool-proof features. The efficiency of poultry houses insulated with straw in furnishing adequate ventilation without drafts, in eliminating moisture, and in preventing temperature variations within the house has been demonstrated in sections of the country where there are less climatic variations than in Wyoming.

These experiments were conducted at Laramie, which is located at an altitude of 7200 feet. No other state experiment station is located at so high an altitude. Furthermore, Laramie is subject to great variation in weather conditions. High wind velocity, long cold winters with wide fluctuations in temperatures, frequent storms, and intense sun make proper housing of vital importance in profitable poultry production in this region.

The data presented here were gathered to test the effectiveness of insulated poultry houses and of two systems of lighting in maintaining egg production throughout the winter months.

EXPERIMENTAL

Procedure. The house used in these experiments was a semimonitor type remodeled with a straw loft. Four inches of straw-pack insulation was also used on the ends and north side. The house has little protection from winds and storms, only a few other farm buildings being in the immediate vicinity. Six pens, each 10 feet wide and 20 feet deep with concrete floor, roosts, dropping boards, etc. were used. The only ventilation possible was obtained by opening windows at the front of the pens. Windows were opened when the weather permitted, but, due to high winds, there were few days during the winter months that this was done.

Plans were made to study the results from the use of the straw loft houses for Wyoming climates and the effect of con-
tinuous lighting, and morning and evening lighting, over normal daylight on both hens and pullets.

Six lots were used in the trials, two of which were equipped with apparatus for continuous lighting by supplying a 15-watt bulb to each lot, two were fitted with a 60-watt bulb each, and two received no artificial light. One lot of pullets and one lot of hens beginning their second laying year were put under each system of lighting. All pens were equipped with trapnests.

Hens were selected for the trials with a view to uniformity between the lots in body weight, first-year egg production, breeding, condition of molt, quality, and type. The pullets used were hatched between May 1 and 7. They were selected and distributed to the three lots according to maturity, weight, quality, and breeding.

All birds were weighed at the beginning and end of the experiment. Other data, including feed consumption records, daily production, and temperature were kept.

The lots were assorted and lights turned on October 15, 1932. The experiment was discontinued February 28, following. Continuous lighting was produced by a 15-watt bulb located directly over the feeder. Approximately twelve hours of light were given the morning and evening lighted lots.

Rations. The same ration was given each lot. It consisted of the following:

Ground yellow corn ........................................... 100 parts by weight
Ground barley .................................................... 100 “
Mill run bran .................................................... 150 “
Meat and bone meal ............................................ 25 “
Dried skim milk ............................................... 25 “
Alfalfa leaf meal .............................................. 25 “
Salt ................................................................. 5 “
Cod liver oil .................................................... 7.5 “

This was fed daily in open trough type feeders on a self feeder plan. All of a grain mixture of equal parts of whole yellow corn and whole wheat that the hens would eat was given in small
troughs once daily in the evening. Water was given to drink and straw was used for litter.

*House Temperatures.* In order to test the ability of the straw insulation to protect the birds from extreme variations in temperature, readings were taken three times daily (6 a.m., 12 noon, and 6 p.m.) both outside the house and inside.

The means of the daily readings inside and outside of the house at 6 a.m., 12 noon, and 6 p.m. are given in Table VII.

**Table VII—Insulated Housing and Temperature Variations.**

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean temperature in degrees Fahrenheit</th>
<th>Mean difference between outside and inside of house</th>
<th>Number of days temperature dropped below freezing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Outside house</td>
<td>Inside house</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 a.m.</td>
<td>12 noon</td>
<td>6 p.m.</td>
</tr>
<tr>
<td>Nov...</td>
<td>29.84</td>
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<td>37.94</td>
</tr>
<tr>
<td>Dec....</td>
<td>12.18</td>
<td>22.19</td>
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<tr>
<td>Jan....</td>
<td>22.64</td>
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<td>27.68</td>
</tr>
<tr>
<td>Feb....</td>
<td>5.90</td>
<td>27.14</td>
<td>20.48</td>
</tr>
<tr>
<td>Total...</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Extreme variations in temperature made this a good winter for the study of housing. Figure 1 shows the daily temperatures inside and outside of the house at 6 a.m. The shaded area is indicative of the differences between these two readings. The continued cold of middle December and the drop in February make it worth while to study the house temperatures during such extremes. Furthermore, the great daily variations give some indication of the weather encountered in this region.

There were 103 mornings when the temperature was below freezing outside the house but only 27 times during this period was it below freezing inside. This indicates the great insulating ability of a straw-loft and straw-packed house. The fact that when extreme drops in outside temperature occurred the drop was not nearly so great inside is further evidence of the practicability
of this type of house. Sudden increases in outside temperature did not increase the inside temperature proportionately. Thus, the straw insulation acted as a buffer against sudden variations in outside temperatures. However, it is quite evident that there are some factors other than the outside temperature which influenced the inside temperature, for there were times when the outside temperature dropped without a corresponding drop in the temperature in the house. In fact, on a number of days a drop outside was followed by a rise inside and vice versa. Although these variations were, for the most part, only a few degrees they indicate that wind velocity, wind direction, cloudiness, and other factors are partially responsible for variations in temperature within the house.

Temperature and Egg Production. Much has been written regarding the critical house temperature for egg production. The material presented in Figure 1 gives an indication of some of the factors which may be responsible in the maintenance of high egg production throughout the winter months. The results with the three systems of lighting with respect to temperature variations on both hens and pullets are presented in this figure.

Of particular importance is a study of the changes taking place in egg production when the sudden drops in temperature occurred. The long continued cold of these months was a good test for the systems of lighting and housing. The continuous lighting aided greatly in increasing the egg production of both hens and pullets but was more effective upon the hens. Due to the fact that egg production was so low for the hens getting morning and evening light and no light, temperature variations during November and December caused no effect. The lengthening of the hours of bright light did not increase the egg production in this lot over the one receiving no additional light until the weather began to turn mild in early January. There was then a steady increase in production until the end of the experiment. The beginning of the cold period of late January and early February immediately started a decrease in egg production, which was not halted until the return of warmer weather in late
Fig. 1. Systems of Lighting and Temperature in Relation to Egg Production.
February. The continuous light brought the hens back into production. Cold weather caused only slight drops in production under this system.

The continuous lighting of the pullets increased egg production from the start. Furthermore, they reached their peak of production earlier than the pullets in the other two lots. Continued cold lowered their production, however, probably because they were under the strain of high production. This system of lighting was very beneficial, however, in its ability to cause the resumption of production after the return of normal temperatures. The December drop in temperature resulted in a drop in production, but an even greater increase followed the return of warmer weather, although two days of low temperature followed within the next two weeks. The early February cold caused another serious drop in production when the daily number of eggs laid was decreasing.

The benefit derived from increasing the length of the day by bright illumination, although not so great as for continuous lighting, was of value. The periods of cold weather caused a drop in production, but this was of short duration, and a return to normal soon followed after the resumption of warmer weather.

Variations in temperature produced inconsistent results upon egg production in the lot which received no artificial light. Although the pullets laid at a very good rate during the relatively warm days of November and early December, later decreases in temperature were particularly disastrous so far as egg production was concerned. The cold weather of December lowered the production of this lot, and the birds never fully recovered throughout the rest of the winter. A sudden drop in temperature, though it was only for one day, consistently lowered the production in this lot so that the number of eggs laid was quite variable and constantly low.

Critical Temperatures. These tests bring out the fact that factors other than house temperature may be responsible for lowering of production during cold spells. A slight drop in temperature caused a drop in production when no additional light was supplied.
Only extreme cold of long duration was detrimental to birds under continuous light or morning and evening light. The sub-zero temperatures of late December and near zero weather of early January caused a drop in egg production of very short duration, probably because the house temperature was not lowered materially. Normal production in these lots was regained within a few days.

There seemed to be no critical house temperature in this study. But long continued cold, which brought the temperature down in the house and held it there for several days, was more detrimental to production than cold snaps of short duration. Many of the birds stopped laying and most of the birds showed a lowered intensity of production during these long continued periods of cold weather.

_Egg Production._ The value of artificial light for modern poultry keeping lies in greater egg production during the months of high egg prices. The peak of egg prices in this region occurs at a somewhat later date than it does in non-mountainous regions, due to the severe winter weather which lowers egg production and tends to increase prices. Table VIII, giving the rates of production during these months, shows that not only was the percentage of production increased by artificial lighting, but the amount returned from egg sales was much greater. About three and one-half times as much money was returned for the sale of eggs from the continuously lighted lot of hens as from the control lot or the lot receiving morning and evening lights. Lighting for the pullet lots also proved profitable. The morning and evening lighting showed a substantial increase in returns from egg sales over no artificial illumination. The expense involved was about the same in the continuously lighted and morning and evening lighted lots, due to the fact that only a dim light was used all night while a very intense light was used at the morning and evening lighting. This amounted to approximately $3.50 for the entire period, at 8 cents per KWH.
<table>
<thead>
<tr>
<th>Average feed consumed per day</th>
<th>Total Feed</th>
<th>Mortality per cent</th>
<th>Eggs sales per cent</th>
<th>Return from hens laying</th>
<th>Percentage production by hen days</th>
<th>Percentage of hens laying during month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mash Grain</td>
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<td></td>
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<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>

**TABLE VII—TYPES AND INTENSITY OF LIGHTING FOR EGG PRODUCTION**

**System of Lighting**

- Continuous lighting
- Morning and evening lighting, no artificial light

**Weights**

- Mean initial weight
- Mean after 2 months

**Hens—**
- Continuous lighting
- Morning and evening lighting, no artificial light

**Pullets—**
- Continuous lighting
- Morning and evening lighting, no artificial light

- Based on 100 birds.
Intensity of Production. Continuous lighting raised the percentage of production in this study by increasing the number of laying hens and by increasing the intensity of production of those hens which were laying, but, for the most part, the increase was due to the greater number of birds forced into production. (Table VIII.)

Feed Consumption. The feed consumption in the three lots of pullets was the same, and only slightly more feed was required for the hens in lighted lots. This indicates, then, that the only additional cost involved was the expense for the lights, which was very small. Although feed consumption was not increased by furnishing additional light, the birds did eat during the period of artificial lighting. Hens and pullets could be seen eating at all periods of the night under continuous light and during the hours light was supplied to lengthen the day.

Weight. The control and the morning and evening lots consumed approximately as much feed as the lots on continuous light and laid fewer eggs, but made greater gains in weight during the course of the experiment. This explains the lack of difference in feed consumption to correspond to differences in production. The increased production was at the expense of body weight.

Mortality. The mortality tended to be greater in the lots of heavy production. This was probably due to the lowered vitality of the birds which were laying heavily.
FEEDING AND LIGHTING FOR EGG PRODUCTION

To secure further information on management and feeding practices for poultry at high altitudes, the practicability of the grain-and-mash and all-mash systems of feeding was tested under varying systems of lighting.

In this region it has been a common practice to feed birds large amounts of grain in the late afternoon, because this is thought to furnish more body heat during the long cold hours of the night. This is a laborious system and could be simplified by feeding a mash in which the grains usually fed whole had been ground and included. If the birds derive any benefit from the afternoon grain feeding because of added warmth to their bodies at night, this should be more noticeable if no artificial light were included in their daily routine, thus providing an additional two to four hour period of darkness. Furthermore, afternoon grain feeding should prove to be less significant in lots on continuous lights.

It is unfortunate for the success of these tests that the winter of 1933-34, the period when they were run, was the mildest on record, but even then below zero temperatures were recorded several times. There were, however, no long continued cold periods.

EXPERIMENTAL

Procedure. Pullets were selected from range-grown stock hatched between March 20 and April 12, 1933. The chicks were fed a growing ration of a mash and grain, the latter consisting of a mixture of whole wheat and whole corn. When approximately five per cent of the pullets were laying they were removed to the laying house.* They were selected for uniformity of maturity, ancestry, weight, body type, and quality, and in the middle of August 42 were distributed to each of the six lots.

The pens were fitted with the same equipment used in the 1932-33 trials. Straw was used for litter and drinking water was

*The pens used are described on page 22.
provided. The birds were allowed outside on gravel yards during April but were housed during the rest of the experimental period.

**Lighting.** Two lots each of continuous lighting, morning and evening lighting, and no lighting were used. The same systems and intensities of light as reported previously were used. However, in these trials the morning and evening lighted lots received about 13 hours of light daily.

**Rations.** Lots 3, 5, and 7 received a grain-and-mash ration and 4, 6, and 8 an all-mash ration. Lots 3 and 4 were under continuous lighting, 5 and 6 morning and evening lighting, and 7 and 8, the controls, received no artificial illumination.

The mash used in the mash-and-grain pens consisted of the following: Ground yellow corn 100 parts by weight, ground Wyoming barley 100 parts, mill run bran 150 parts, meat scraps 75 parts, wheat middlings 50 parts, alfalfa leaf meal 25 parts, dried buttermilk 25 parts, salt 5 parts, cod liver oil (fortified) 1 part. A grain mixture of equal parts by weight of whole yellow corn and whole wheat was fed in troughs about 45 minutes before roosting time. All the grain was given that the hens would consume.

In order that the birds receiving the all-mash ration would have the same feeds in their diet as the lots fed grain and mash, the ratio of grain to mash in the later was calculated weekly for each of the three lots, averaged, and the same ratio of mash to grain (consisting of equal parts of whole corn and whole wheat ground together) was fed to the all-mash lots the following week. Thus, the all-mash lots received the same ration one week that the mash-and-grain lots had the week before, but in a ground form and self fed. This system of feeding did not, however, control feed consumption, but it did give a method by which a comparison of all the lots could be made, for it allowed the same ration to all the lots throughout the period. Besides, it gave a better method for checking the value of feeding whole grain in the late afternoons.
TABLE IX—SYSTEMS OF LIGHTING AND FEEDING FOR GAINS IN WEIGHT.

<table>
<thead>
<tr>
<th>System of lighting</th>
<th>Method of feeding</th>
<th>Lot No.</th>
<th>Mean initial weight lbs.</th>
<th>Mean final weight lbs.</th>
<th>Mean gain in weight lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous lighting</td>
<td>Grain-and-mash</td>
<td>3</td>
<td>3.42</td>
<td>3.75</td>
<td>.33</td>
</tr>
<tr>
<td></td>
<td>All-mash</td>
<td>4</td>
<td>3.48</td>
<td>3.58</td>
<td>.10</td>
</tr>
<tr>
<td>Morning and evening lighting</td>
<td>Grain-and-mash</td>
<td>5</td>
<td>3.52</td>
<td>3.65</td>
<td>.13</td>
</tr>
<tr>
<td></td>
<td>All-mash</td>
<td>6</td>
<td>3.40</td>
<td>3.58</td>
<td>.18</td>
</tr>
<tr>
<td>Control, no lighting</td>
<td>Grain-and-mash</td>
<td>7</td>
<td>3.50</td>
<td>3.73</td>
<td>.23</td>
</tr>
<tr>
<td></td>
<td>All-mash</td>
<td>8</td>
<td>3.50</td>
<td>3.61</td>
<td>.11</td>
</tr>
</tbody>
</table>

*Gain in Weight.* Table IX gives the gains in weight of the birds in the six lots. All lots made gains which indicated that the feeding and management were beneficial to the health of the birds. There seemed to be a tendency for the birds on the grain-and-mash rations to gain more weight than the ones on the all-mash rations. This variation was not consistent with Lots 5 and 6, however.

*Feed Consumption.* Although the proportions of mash and grain were the same in the all-mash and grain-and-mash lots, due to a weekly recalculation of the feed consumed, there was, however, variation in the amount of feed consumed in the different lots. This is shown in Table X. Lot 3 under continuous light and receiving both grain and mash ate more feed than any of the other lots. There was a slight tendency for the birds on the grain-and-mash ration to consume more feed. This was more pronounced when the birds were under artificial illumination.

Feed consumption was much higher for the grain-and-mash lot than for the all-mash lot under the system of continuous lighting. The birds in Lot 3 also laid more eggs (Table XI) and gained more weight (Table IX). A study of Lots 4 and 5, receiving feed similar to Lots 3 and 4 but under morning and evening light, shows that the birds receiving grain and mash were
TABLE X—EFFECT OF SYSTEMS OF LIGHTING AND FEEDING ON FEED CONSUMPTION.

<table>
<thead>
<tr>
<th>System of lighting</th>
<th>Method of feeding</th>
<th>Lot No.</th>
<th>Feed consumed per bird per day</th>
<th>Ratio mash to grain</th>
<th>Feed consumed per doz. eggs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mash</td>
<td>Grain</td>
<td>All-mash</td>
</tr>
<tr>
<td>Continuous lighting</td>
<td>Grain-and-mash</td>
<td>3</td>
<td>.111</td>
<td>.090</td>
<td>....</td>
</tr>
<tr>
<td></td>
<td>All-mash</td>
<td>4</td>
<td>....</td>
<td>....</td>
<td>.170</td>
</tr>
<tr>
<td>Morning and evening lighting</td>
<td>Grain-and-mash</td>
<td>5</td>
<td>.106</td>
<td>.086</td>
<td>....</td>
</tr>
<tr>
<td></td>
<td>All-mash</td>
<td>6</td>
<td>....</td>
<td>....</td>
<td>.180</td>
</tr>
<tr>
<td>Control, no lighting</td>
<td>Grain-and-mash</td>
<td>7</td>
<td>.098</td>
<td>.081</td>
<td>....</td>
</tr>
<tr>
<td></td>
<td>All-mash</td>
<td>8</td>
<td>....</td>
<td>....</td>
<td>.182</td>
</tr>
</tbody>
</table>

greater feed consumers than those having access only to an all-mash ration. The control lots, 7 and 8, ate approximately the same amount of feed, but Lot 7 gained more weight (Table IX). The egg production was approximately the same in the two lots (Table XI).

The ratio of mash to grain in the grain-and-mash lots, 3, 5, and 7, was the same. These data show that artificial lighting, either continuous or by increasing the length of the day, did not influence the ratio of mash to grain consumption. This discredits the theory that hens subjected to long cold nights consume a larger proportion of grain to maintain their body temperatures.

The all-mash lots, 4 and 6, took less feed in proportion to the number of eggs laid than the grain-and-mash lots, 3 and 5. The control lots used a much greater amount of feed.

Egg Production. The ultimate criterion for the value of a ration or a system of management for poultry lies in the egg produc-
### TABLE XI—THE RELATION OF SYSTEMS OF LIGHTING AND FEEDING TO EGG PRODUCTION AND MORTALITY.

<table>
<thead>
<tr>
<th>System of lighting</th>
<th>Method of feeding</th>
<th>Lot No.</th>
<th>Production Per cent by hen days</th>
<th>Return from egg sales*</th>
<th>Mortality per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous lighting</td>
<td>Grain- and- mash</td>
<td>3</td>
<td>12.37</td>
<td>37.06</td>
<td>38.10</td>
</tr>
<tr>
<td></td>
<td>All- mash</td>
<td>4</td>
<td>9.60</td>
<td>29.21</td>
<td>34.95</td>
</tr>
<tr>
<td>Morning and evening lighting</td>
<td>Grain- and- mash</td>
<td>5</td>
<td>12.06</td>
<td>34.84</td>
<td>36.27</td>
</tr>
<tr>
<td></td>
<td>All- mash</td>
<td>6</td>
<td>7.76</td>
<td>28.10</td>
<td>26.73</td>
</tr>
<tr>
<td>Control, no lighting</td>
<td>Grain- and- mash</td>
<td>7</td>
<td>7.83</td>
<td>34.37</td>
<td>33.72</td>
</tr>
<tr>
<td></td>
<td>All- mash</td>
<td>8</td>
<td>9.83</td>
<td>38.02</td>
<td>31.39</td>
</tr>
</tbody>
</table>

*Based on 100 hens.
tion secured. Of greater importance than annual egg production is winter production. This factor is of more value in this mountainous region than in others, for during the cold winters here the production of the flock is brought to a minimum. If some method of management or feeding, or some combination of methods, can be found to increase the number of eggs laid during these months, poultry raisers in this region can realize a larger income from this enterprise, because the peak in egg prices occurs some time during December. This is later than in some other sections and indicates the value of high winter production.

Table XI gives the mean monthly production of the six lots by hen-days and the average for the entire period. The latter takes into consideration the early fall production before many of the birds came into laying and the winter months when production was low due to climatic conditions. Thus, this figure is a mean of the months of lowest production for a flock in this region.

The lots without artificial light laid the fewest eggs, and little difference could be distinguished between the grain-and-mash and all-mash lots. Not only was the total production almost identical, but the periods of high and low production were very similar as shown in Figure 2.

The morning and evening lights increased the total number of eggs laid, but the system of feeding made little difference. However, there was a strong tendency for the mash-and-grain ration to produce more eggs during the early winter months. This was at the expense of spring production during which time the all-mash lot increased greatly in production while Lot 5 increased but little.

The mash-and-grain ration yielded consistently higher production in the continuously lighted lot, but the early winter production of the all-mash lots was improved by the use of continuous lighting instead of morning and evening lights or no lights. However, the spring production of Lot 4 was extremely low, probably due to the high early winter production.

Lots 3 and 4 show higher early winter production but lower spring production than Lots 5 or 6, but about the same as Lots 7 and 8, getting no lights. Furthermore, it is evident from the
curves in Figure 2 that any variable in these experiments which tended to increase winter egg production did so at the expense of spring production. It is, however, better from an economical standpoint, because of increased prices, to have higher winter
than spring egg production, provided the expense involved does not offset the benefit obtained. Continuous light with grain-and-mash feeding (Table XI) resulted in more money from egg sales than any other combination of the factors involved. The continuous lighting with all-mash feed in Lot 4 was quite inferior in this respect, due to the poor production during the spring months. Both lots receiving morning and evening light were about half-way between the high and low lots for income. The two lots receiving no light were quite inferior to the other four.

Mortality. Although the mortality seems rather high for the period (Table XI), it must be remembered that eighty per cent of the deaths in a flock located in this region come during the winter months; spring, summer, and fall mortality is very low. Colds and roup are responsible for many of the deaths during the winter months.

There seemed to be little correlation between mortality and any of the factors studied. Lots 4 and 7 had the lowest mortality.

Yolk Color. Much has been said regarding the suitable yolk color for eggs. The market preference may be either for a light, medium, or dark colored yolk. Benjamin (1925) points out that “The color of the yolk is affected largely by the feed given ...” Mattikov (1932) presented a critical review of the literature regarding the coloring matter of egg yolk. Benjamin also points out that the reason for the preference of light yolked eggs in some large markets is that yolks have been shown to darken with age, and consequently the consumer feels he is getting a fresher product if a light colored yolk is present. It seems, however, that of more importance than the density of color is the uniformity of color. When the consumer sees two yolks of different colors, he concludes that one is inferior but is not sure which. He is, however, soon led to believe one is a superior product and thus a local market preference may arise.

Due to the fact that yellow corn carries the important pigment for coloring egg yolk, it has been suggested that an all-mash ration would produce yolks of more even color than a grain-
TABLE XII—RELATION OF SYSTEMS OF LIGHTING AND GRAIN-AND-MASH AND ALL-MASH SYSTEMS OF FEEDING TO YOLK COLOR.

<table>
<thead>
<tr>
<th>System of lighting</th>
<th>Method of feeding</th>
<th>Lot No.</th>
<th>Mean yolk color</th>
<th>Standard deviation</th>
<th>Coefficient of variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous lighting</td>
<td>Grain and mash</td>
<td>3</td>
<td>2.50±.036</td>
<td>.520±.024</td>
<td>20.8±.946</td>
</tr>
<tr>
<td></td>
<td>All mash</td>
<td>4</td>
<td>2.47±.025</td>
<td>.395±.017</td>
<td>16.0±.703</td>
</tr>
<tr>
<td>Morning and evening lighting</td>
<td>Grain and mash</td>
<td>5</td>
<td>2.42±.036</td>
<td>.439±.026</td>
<td>18.1±1.054</td>
</tr>
<tr>
<td></td>
<td>All mash</td>
<td>6</td>
<td>2.40±.024</td>
<td>.381±.017</td>
<td>15.9±.698</td>
</tr>
<tr>
<td>Control, no lighting</td>
<td>Grain and mash</td>
<td>7</td>
<td>2.56±.018</td>
<td>.314±.013</td>
<td>12.3±.491</td>
</tr>
<tr>
<td></td>
<td>All mash</td>
<td>8</td>
<td>2.43±.021</td>
<td>.301±.015</td>
<td>12.4±.597</td>
</tr>
</tbody>
</table>

and-mash ration, where the grain consisted of part yellow corn and part some other grain. The latter, of course, would contain little yolk-coloring material. It is supposed from this theory that some hens show a preference for yellow corn and others for some other grain (in these trials wheat), and the birds consuming large amounts of yellow corn would produce dark-colored yolks, while the ones eating more of the other grain would lay eggs with light-colored yolks. Thus, the flock as a whole would be producing egg yolks of varying shades.

Table XII shows the effect of the systems of feeding and lighting on the density of yolk color. Yolk colors were matched with the same standards used in other studies of this type. They ranged from 0.5, a light canary color, by half units to 6.5, a deep red. The difference between values of 0.5 was as small as could be determined by the unaided eye.

There seemed to be a slight tendency for the hens under continuous light to produce yolks more variable in color, as measured by the standard deviation and coefficient of variation, than the hens under morning and evening lights or in the control pen. No suggestion for the cause of this fact can be offered.
There was little difference in the mean yolk colors of the six lots, but the variability of the yolk colors within the lots is indicative of the fact that the hens in the grain-and-mash lots were laying eggs with more variable yolk color. The differences in the coefficients of variability between Lots 3 and 4 and 5 and 6 are consistent, while Lots 7 and 8 are similar. They are significant as determined by the relation of the terms to their probable error.

When Lots 3, 5, and 7, receiving grain-and-mash, and 4, 6, and 8, getting an all-mash ration, are grouped together, the data can undergo further treatment statistically, with the results shown in Table XIII. The mean yolk colors are the same for the two groups with a similar error. However, the variations in the yolk colors are significantly different. Both the standard deviation and the coefficient of variation indicate that the two systems of feeding produced significant differences in uniformity of yolk color.

The all-mash system produced yolks with less variation in color, as shown by the coefficient of variation of 18.34±.490 for the grain-and-mash lots and 12.90±.337 for the all-mash lots.

<table>
<thead>
<tr>
<th>System of feeding</th>
<th>Lot Nos.</th>
<th>Mean yolk color</th>
<th>Standard deviation</th>
<th>Coefficient of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain-and-mash</td>
<td>3, 5, 7</td>
<td>2.48±.017</td>
<td>.455±.012</td>
<td>18.34±.490</td>
</tr>
<tr>
<td>All-mash</td>
<td>4, 6, 8</td>
<td>2.41±.012</td>
<td>.319±.008</td>
<td>12.90±.337</td>
</tr>
</tbody>
</table>

TABLE XIII—RELATION OF GRAIN-AND-MASH AND ALL-MASH SYSTEMS OF FEEDING TO YOLK COLOR.
THE VALUE OF RYE IN THE
CHICK RATION

Halpin (1932) showed that the addition of 30 per cent of rye to the chick ration was detrimental to growth. He reported the presence of a sticky condition of the droppings, causing large dung balls on the toes, which interfered with the movement of the chick. The chicks in his trials were reared on shavings litter and sand yards. Others have reported that rye was not suitable for poultry feeding.

The ability of the hens to produce a normal number of eggs when fed large amounts of rye has already been reported in this bulletin.

EXPERIMENTAL

TRIAL NO. I

The amount of Wyoming-grown rye which can be tolerated in a chick ration was tested.

<table>
<thead>
<tr>
<th>Lot No.</th>
<th>When ration was fed</th>
<th>Basal mash</th>
<th>Ground yellow corn</th>
<th>Ground barley</th>
<th>Ground rye</th>
</tr>
</thead>
<tbody>
<tr>
<td>8C</td>
<td>Start to completion</td>
<td>10</td>
<td>6</td>
<td>4</td>
<td>...</td>
</tr>
<tr>
<td></td>
<td>First and second weeks</td>
<td>10</td>
<td>6</td>
<td>4</td>
<td>...</td>
</tr>
<tr>
<td>9C</td>
<td>Third week to completion</td>
<td>10</td>
<td>6</td>
<td>...</td>
<td>4</td>
</tr>
<tr>
<td>10C</td>
<td>Start to completion</td>
<td>10</td>
<td>6</td>
<td>...</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>First and second weeks</td>
<td>10</td>
<td>8</td>
<td>2</td>
<td>...</td>
</tr>
<tr>
<td>11C</td>
<td>Third week to completion</td>
<td>10</td>
<td>8</td>
<td>...</td>
<td>2</td>
</tr>
<tr>
<td>12C</td>
<td>Start to completion</td>
<td>10</td>
<td>8</td>
<td>...</td>
<td>2</td>
</tr>
<tr>
<td>1C</td>
<td>Start to completion</td>
<td>10</td>
<td>8</td>
<td>...</td>
<td>2</td>
</tr>
</tbody>
</table>

Control ration: Ground yellow corn 45, pure wheat bran 15, wheat middlings 15, dried buttermilk 12, meat and bone meal 6, alfalfa leaf meal 3, ground oystershell 3, cod liver oil (fortified) ¾.

*Parts by weight.
Procedure. The chicks used in these trials were Single Comb White Leghorns hatched from eggs produced by the station flock. They were from pedigreed stock and were assorted to the five lots as evenly as possible. The chicks were grown on the rearing tables pictured in Figure 3. These are equipped with hot water pipes and hardware-cloth floors of number two mesh. The warming compartment is situated at one end of the pen and separated by a muslin curtain.

Rations. The chicks were weighed and removed to the brooder where they were fed the all-mash rations given in Table XIV. In these trials rye was substituted for the barley in the mash. The basal mash used consisted of:

- Mill run bran .......... 50 parts by weight
- Meat and bone meal ...... 26 "
- Dried buttermilk .......... 10 "
- Alfalfa leaf meal ......... 8 "
- Ground oystershell ....... 6 "
- Salt .................... 1 "
- Cod liver oil (fortified) .... 0.5 "

Due to its laxative effect, the rye was withheld from the diet of two lots until they were two weeks of age. One lot, 11C, was fed a ration containing 10 per cent rye, and the other lot, 9C, was fed 20 per cent. Lot 11C was compared with Lot 10C which got a 20 per cent rye ration from the start. The control for this group was Lot 8C. Lot 12C was the control for Lot 11C. The ration used in Lot 1C had been shown to promote rapid growth and was used as a check ration.

Growth. Table XV shows the rate of growth. Although the check lot attained the greatest weight the other rations tested seemed quite adequate.
### TABLE XV—RELATION OF RYE IN THE CHICK RATION TO GROWTH AND MORTALITY.

<table>
<thead>
<tr>
<th>Lot No.</th>
<th>Ration</th>
<th>Sex</th>
<th>Mean Weight</th>
<th>Mean weight at 6 wks.*</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Initial</td>
<td>2 weeks</td>
<td>4 weeks</td>
</tr>
<tr>
<td>8C</td>
<td>20% barley start to finish</td>
<td>Male</td>
<td>1.2</td>
<td>2.7</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>1.3</td>
<td>2.6</td>
<td>6.0</td>
</tr>
<tr>
<td>9C</td>
<td>20% barley first 2 weeks 20% rye thereafter</td>
<td>Male</td>
<td>1.2</td>
<td>2.6</td>
<td>5.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>1.3</td>
<td>2.7</td>
<td>5.6</td>
</tr>
<tr>
<td>10C</td>
<td>20% rye start to finish</td>
<td>Male</td>
<td>1.3</td>
<td>2.9</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>1.3</td>
<td>2.6</td>
<td>6.1</td>
</tr>
<tr>
<td>11C</td>
<td>10% barley first 2 weeks 10% rye thereafter</td>
<td>Male</td>
<td>1.3</td>
<td>2.6</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>1.3</td>
<td>2.6</td>
<td>5.9</td>
</tr>
<tr>
<td>12C</td>
<td>10% barley start to finish</td>
<td>Male</td>
<td>1.3</td>
<td>2.6</td>
<td>6.2</td>
</tr>
<tr>
<td>1C</td>
<td>Check</td>
<td>Male</td>
<td>1.2</td>
<td>2.7</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>1.2</td>
<td>2.7</td>
<td>6.4</td>
</tr>
</tbody>
</table>

*Mean mean weight of males and females.
†Not significant.
The mean weights at two weeks show that there was no significant difference between the lots. This indicates that the ration containing either 10 or 20 per cent rye was not detrimental to growth. Any failure of the chicks to consume normal amounts of the feed or any physiological effect of the rye on the digestive tract would have been indicated by the weights reached at two weeks. Lot 10C receiving 20 per cent rye from the start was as heavy as any. Due to the fact that the rye did create a laxative effect on the chicks it seems reasonable to believe that any serious results from the feeding of this grain would be greatest during the first two weeks.

The greatest break in the growth curves of the various lots occurred in Lot 9C when the 20 per cent barley was replaced by the same amount of rye. It is evident that the change of feed had a serious effect upon growth, for the chicks were lower in weight at four weeks than either Lot 8C, getting 20 per cent barley, or 10C, getting 20 per cent rye. At the time the changes in
the ration were made the chicks failed to consume their normal amount of mash. This lasted for only a few days but was evidently long enough to retard growth. The same effect was noticeable, though not so greatly, in Lot 11C in which 10 per cent rye was substituted for 10 per cent barley.

The weights at six weeks are more or less indicative of the changes made in the rations. The chicks receiving 20 per cent of rye or 20 per cent of barley in their mash made comparable gains. Lot 9C in which the substitution of rye in the ration was made was somewhat lower in weight at the completion of the trials than the other two lots. The final weights of Lots 11C and 12C contradict somewhat the results in the three lots mentioned. The change from 10 per cent barley to 10 per cent rye did not retard the growth of Lot 11C and it reached a greater weight than Lot 12C.

Mortality. Mortality was at a minimum in all lots except 8C. Due to the small numbers in the lots and lack of relationship to other lots receiving barley, little significance can be attached to the figure for that group.

TRIAL NO. 2

After the results of the first year's trials had given evidence that 20 per cent of rye in the ration was practical, it seemed of importance to increase this percentage in further trials.

Procedure. The chicks were from stock of the same breeding used in the first trials. They were weighed and distributed as in the previous trial. The same rearing table was used.

Rations. The basal mash given in Trial No. 1 was used again. However, some changes were made in the grains used to supplement this mash. In order to have the amount of carotin in the rations similar, white corn was used in place of yellow corn, and, in order to get two more comparable grains, wheat instead of barley was used as the grain with which the rye was compared. Increased amounts of rye were tested in these experiments, but otherwise the plan was the same as for the previous year. The check ration was the same. The rations fed in these trials are given in Table XVI.
Rye replaced wheat in the ration at levels of 10, 20, 30, and 40 per cent. There were no changes, similar to those made at two weeks in the first trial, from a ration containing no rye to one containing rye.

Gains in Weight. The gains in weight are shown in Table XVII. The substitution of wheat for white corn seemed quite practical, for there were no consistent differences in the weight of the chicks produced by a ration containing 40 per cent corn as compared with one containing 40 per cent wheat. Furthermore, these corn and wheat rations gave excellent growth.

The weight of the chicks in the check group was higher the first year than the other lots but lower in these trials.

The substitution of rye for wheat in the rations again showed that 20 per cent of rye was practical in the ration. Chicks raised on this ration are shown in Figure 4. There were no differences in weight between the lots receiving 10 per cent and those receiving 20 per cent rye. However, the addition of rye beyond 20 per cent seemed to retard growth, although the weight of the
TABLE XVII—RELATION OF RYE IN THE CHICK RATION TO GROWTH AND MORTALITY.

<table>
<thead>
<tr>
<th>Lot No.</th>
<th>Ration</th>
<th>Sex</th>
<th>Initial: Ozs.</th>
<th>2 Weeks: Ozs.</th>
<th>4 Weeks: Ozs.</th>
<th>6 Weeks: Ozs.</th>
<th>Mean weight at 6 weeks: Ozs.</th>
<th>Mortality: Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>5C</td>
<td>10%</td>
<td>Male</td>
<td>1.3</td>
<td>3.6</td>
<td>8.3</td>
<td>14.5</td>
<td>15.2</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>wheat</td>
<td>Female</td>
<td>1.3</td>
<td>3.7</td>
<td>8.9</td>
<td>16.8</td>
<td>14.4</td>
<td>5.6</td>
</tr>
<tr>
<td>6C</td>
<td>10%</td>
<td>Male</td>
<td>1.3</td>
<td>3.0</td>
<td>6.8</td>
<td>12.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>rye</td>
<td>Female</td>
<td>1.3</td>
<td>3.5</td>
<td>8.2</td>
<td>13.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7C</td>
<td>20%</td>
<td>Male</td>
<td>1.3</td>
<td>3.5</td>
<td>8.6</td>
<td>14.9</td>
<td>14.3</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>wheat</td>
<td>Female</td>
<td>1.2</td>
<td>3.6</td>
<td>8.3</td>
<td>13.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8C</td>
<td>20%</td>
<td>Male</td>
<td>1.3</td>
<td>4.1</td>
<td>9.5</td>
<td>16.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>rye</td>
<td>Female</td>
<td>1.3</td>
<td>3.9</td>
<td>8.9</td>
<td>15.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9C</td>
<td>30%</td>
<td>Male</td>
<td>1.3</td>
<td>3.7</td>
<td>8.8</td>
<td>14.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>wheat</td>
<td>Female</td>
<td>1.3</td>
<td>3.6</td>
<td>7.8</td>
<td>13.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10C</td>
<td>30%</td>
<td>Male</td>
<td>1.3</td>
<td>3.8</td>
<td>9.2</td>
<td>16.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>rye</td>
<td>Female</td>
<td>1.3</td>
<td>3.7</td>
<td>8.5</td>
<td>13.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11C</td>
<td>40%</td>
<td>Male</td>
<td>1.3</td>
<td>3.3</td>
<td>7.2</td>
<td>13.3</td>
<td></td>
<td>12.5</td>
</tr>
<tr>
<td></td>
<td>wheat</td>
<td>Female</td>
<td>1.2</td>
<td>3.2</td>
<td>6.6</td>
<td>11.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12C</td>
<td>40%</td>
<td>Male</td>
<td>1.3</td>
<td>3.6</td>
<td>8.9</td>
<td>15.9</td>
<td></td>
<td>13.9</td>
</tr>
<tr>
<td>4C</td>
<td>Check</td>
<td>Male</td>
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<td>3.5</td>
<td>7.4</td>
<td>12.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>1.2</td>
<td>3.6</td>
<td>8.9</td>
<td>15.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Mean, mean weight of males and females

lot receiving 30 per cent rye was but little below the other two lots which received less rye. The addition of 40 per cent of rye gave inferior growth.

The fact that the final weights of Lots 10C, receiving 30 per cent rye, and 12C, getting 40 per cent, are not so much out of line with the other pens is quite startling, for the chicks presented anything but a healthy appearance during the first two weeks of their life. This was due to the pronounced laxative effect of the rye, which was not noticeable at the lower levels. Although the laxa-
tive condition continued, it seemed to cause none of these effects after the first two weeks.

Mortality. There were no significant differences in the mortality of the chicks during the trials.

CONCLUSION

The inclusion of rye in these chick rations seemed to be practical at levels of 20 per cent or less. The ration containing 30 per cent of rye seemed of value when a comparison of the growth data was made, but from observations of the chicks it seemed advisable not to recommend levels higher than 20 per cent. Although the sticky condition of the droppings was very pronounced in the 30 and 40 per cent rye lots, the droppings fell through the wire floors and did not stick to the feet of the chicks.

The most noticeable effect of the rye was diarrhea during the first three weeks. This again was noticeable only when the ration contained 30 per cent or more of rye.
From the experience reported here it is suggested that: (1) the abrupt change from barley to rye in the first trials interfered with growth; (2) large amounts of rye retarded growth but little; (3) if a gradual change to rye were made, starting at four weeks of age, a larger amount of this grain could be utilized in chick feeding.

ACKNOWLEDGMENTS

The writer expresses his appreciation to Professor P. T. Miller and Doctor E. R. Schierz for the use of their chemical laboratories during these experiments. Thanks is also expressed to Mr. H. W. Brettell for his part in the supervision of the birds during the course of the trials.

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