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Nutritive studies on the basic cereal grains,: studies on the individual reactions of pullets fed rations containing a relatively large quantity of a single cereal grain.

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NUTRITIVE STUDIES ON THE BASIC CEREAL GRAINS

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STUDIES ON THE INDIVIDUAL REACTIONS OF PULLETS FED RATIONS CONTAINING A RELATIVELY LARGE QUANTITY OF A SINGLE CEREAL GRAIN

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INTRODUCTION

Although the basic cereal grains - corn, wheat, and oats - are widely used in making up the greatest proportion of the ration, generally sixty to eighty per cent, there is nevertheless considerable variation in the selection of the particular grain or combination of grains that are to be fed to laying hens. In the middle west, where large quantities of corn are available, this particular grain often constitutes as much as eighty per cent of the ration. On the other hand in the Northwestern region where wheat is plentiful, the major portion of the ration consists of wheat and wheat by-products. Here in New England, corn and oats are recommended as supplementary grains. It is apparent, therefore, that there are great differences throughout the country with respect to the selection and use of the particular cereals that are to supply the major portion of the nutrients.

"That this is so should perhaps be obvious"-- quoting Lippincott and Card--" since grains consist for the most part of carbohydrates". The authors continue....."it is logical to make up poultry rations by selecting such grains as are available and reasonable in price and supplementing them in such ways as may be necessary to meet the needs of the fowl". May one infer, therefore, that corn, wheat, and oats are somewhat similar in their comparative nutrient value for poultry?

It should be pointed out that data on the comparative nutrient value of the various cereal grains for laying hens, as determined by feeding trials with poultry are rather limited in amount and scope. An intensive review of the literature failed to reveal a single thorough investigation in which the comparitive nutrient value of corn, wheat, and oats had been definitely established.

During the last twenty years considerable work has been reported on the digestibility coefficients of the various cereal grains as well as on palatability values for these grains. It should be noted, however, that the relative nutrient value of the individual cereals cannot be completely determined by considering digestibility or palatability coefficients, but rather depends on an analysis of all the physiological effects produced when the individual cereal is fed to the laying hen.

The purpose of this investigation is to study the physiological effects of rations containing a relatively large quantity of a single cereal grain upon laying hens confined to a caged environment. Yellow corn, wheat, and oats are the cereals that will be considered in this study.

REVIEW OF LITERATURE

Although the major portion, fifty to eighty-five per cent, of the ration for laying hens is generally composed of the basic cereal grains - corn, wheat, and oats, there is little available data on the comparitive value of the individual cereal grains for laying hens as determined by feeding trials with poultry.

A. General Studies.

Hart and his associates (1917) studied the behavior of chickens fed rations restricted to a single cereal grain. Their experimental work indicates that rations restricted to corn, wheat, or oats, and their respective protein concentrates are able to maintain body weight; permit the chicken to make small gains in weight, and produce fertile eggs. It is interesting to note that these results are in marked contrast to those obtained by the same workers with rats and swine for these rations led to a loss of weight, cessation of oestrum, and with the diet restricted to wheat, a condition resembling polyneuritis. Although they report a somewhat average low egg production for the various groups, this is to be expected because (1) the birds were not of stock bred for egg production, and (2) the protein level of the rations were less than twelve per cent.

Curtis (1917) editor of the Reliable Poultry Journal, conducted a survey among the leading poultry departments of the agricultural colleges with regard to the value of oats for the adult fowl. A shortage of wheat and corn due to the great war had directed attention towards oats as a possible substitute. Although these replies are not based on experimental work, they are of interest because they voice the opinions of leading Poultry Husbandmen

with regard to the value of oats as a poultry feed. The following are characteristic of the type of replies received by the editor. H. L. Kempster (Missouri) ".... on account of the crude fiber contained, we do not believe that more than one-third of the ration should be oats." W. C. Thompson (New Jersey Agricultural Experiment Station) ".... I would suggest feeding of oats as part of the grain ration comprising from twenty to twenty-five per cent of the same. I would also include ground oats as approximately ten per cent of the dry mash ...." It should be noted that these recommendations are based on emergency conditions, and consequently these amounts are in excess of those generally recommended.

Buss (1916) at the Ohio Experiment Station conducted a series of feeding experiments in which two rations were compared; the first containing eighty-one per cent corn and the second eighty-one per cent wheat. Both rations were supplemented with bran, meat scraps, and oil meal, and the birds were all confined for three hundred and sixty-four days to a laying house with access to an outside yard covered with gravel. This investigator reports the following:

a. Feed consumption per pullett was slightly higher in the wheat lot, and the cost of feed per pullet was definitely higher in this lot.

b. Pullets receiving corn showed a greater average gain in weight. In lot 1 (corn), this gain was .46 pound per pullet whereas in lot 2 (wheat) it was .19 pound.

c. Egg production was slightly higher in lot 2 than in the corn group (fifty S. C. White Leghorns in each group).

d. Mortality was heavier in the wheat group.

Russ (1918) repeated the above experiment the following year. His results vary somewhat from those secured in 1915 indicating perhaps (1) different genetic inheritance in the groups and (2) greater individual variation among the birds in each group. A summary of his results are as follows:

a. Feed consumption greater in the corn group. Note: previous year feed consumption was greater in the wheat group.

b. Average gain in weight per pullet was definitely higher in the wheat group. Note: previous year, corn lot showed the greatest gains.

c. Egg production was higher in the corn group. Note: previous report states that egg production was higher in the wheat group.

Quoting from the author's report, "the results of these experiments indicate that corn has a decided advantage over wheat for use as the principal part of the ration for laying hens."

Pintoul and Russ (1922) conducted a series of feeding tests with poultry in order to determine the relative value of the various cereal grains. In these experiments, the cereal grain was fed as a grain supplement. They report after one year of observation that the pen receiving oats showed the highest average egg production. They also state that the group receiving wheat made the greatest gains in body weight. Corn was not included in this comparitive study.

Kennard (1930) as a result of two years of experimental feeding trials, reported on the value of oats for layers. His conclusions in summary form are as follows:

a. Groups of pullets receiving oats in their rations laid fifteen per cent more eggs than those groups receiving the basal ration. Note: the basal ration was composed of coarsely ground corn 70, wheat 20, meat scraps 10, poultry bone 2, and cod-liver oil, 1. In the oat rations, twenty per cent of the corn was replaced by an equal amount of oats.

b. Average weight of pullets in the oat group was three per cent greater than in the non-oat group.

c. Feed consumption was ten per cent greater in the oat group. This increase may be accounted for by the increased egg production as well as the indigestible fibre carried by the oats.

d. Hatchability was the same in both groups.

Branion (1933) studied the effects of rations, containing eighty per cent of a single cereal grain, on laying hens. He reports a variation in egg production and in feed consumed per hen due to the cereal fed. The average egg production per hen in the corn group was fifty-nine eggs, in the wheat group sixty-two, and in the oat group forty. The birds in the wheat group according to his results consumed more feed than those in the oat or corn groups. It should be noted that these results are based on small groups of pullets, and they were not analysed statistically for significant differences.

Tully (1934) reported after two years of observation that rations containing seventy per cent of wheat (both in the ground and unground form) gave good results from an egg production standpoint, as well as from the effects produced on the birds themselves.

North (1934) fed groups of pullets rations containing sixty-five to seventy per cent of a single cereal grain. He reports the following:

a. Pullets in the corn lot made the greatest average gain per bird (1.43 pounds); whereas the pullets in the wheat lot made the smallest average gains (.99 pounds). The average gains in body weight was decidedly less for the following year with the corn group making the greatest average gains, the wheat group making gains slightly less, and the oats birds making the smallest average gain in weight.

b. Feed consumption was greatest in 1932-33 in the oat lot; however in 1933-34 feed consumption per bird was greatest in the corn lot.

c. No observable difference in vitality between the lots.

Note: The results (above) are presented in the published reports in tabular form and are based on small groups of birds. No statistical analysis is presented to substantiate the observed differences.

U. S. D. A. (Poultry Division at Beltsville) (1935) made an intensive studyofthe nutritive properties and deficiencies of yellow corn. One of the primary objects of this study, commonly called The McCollum Feeding Project, was to secure data on how yellow corn can be used to the best advantage as the main ingrediant of a poultry diet. During this investigation, fifty-four different diets were fed to chickens maintained under three different types of environmental conditions. The following are some of the more important conclusions.

a. Diets containing one-hundred per cent corn resulted in excessive mortality (98%). Diets containing eighty per cent corn and twenty per cent dried butter milk gave a comparative average low egg production for the group.

b. Best results in egg production (206.9 ± 8.82) were secured from rations containing forty per cent corn, ten per cent dry butter milk, ten per cent dry gluten meal and two per cent calcium carbonate.

c. Significantly good results in egg production (192.1 ± 5.) were likewise received with sixty-two per cent yellow corn and thirty-eight per cent dried butter milk with one-tenth per cent mineral mixture.

B. Egg Size Studies.

There are no comparitive data published showing the effects of rations containing a large quantity of a single cereal grain upon egg size. It might be of value, however, to cite studies of a more general nature that are concerned with the relationship of feed to egg size.

Atwood (1914) reported that the weight of eggs laid by the domestic fowl may be affected by feeding a poorly balanced diet.

Kistler, Charles, and Knandel (1926) found that the use of condensed and dried milk products increased the size of eggs as compared to meat scraps.

Parkhurst (1927) reported after six years of study that the size of eggs is influenced materially by the ration fed. Among his findings are the following:

a. Sour skim milk has a special value in producing large egg size.

b. Well balanced rations give larger egg size than a poorly balanced one.

Newman (1927) reported that pullets fed on animal protein feeds laid

larger eggs than those fed vegetable protein foods.

Parkhurst and Lomax (1930) compared the effects of peanut meal, fish meal, soybean meal, and meat meal on egg size. They concluded after a two-year study that peanut meal was definitely less satisfactory than the others for large egg size.

Robertson and Puckett (1928) found the addition of two per cent minerals to a cereal mash, when unlimited oyster shell was also fed, gave an increase in egg weight in Wyandotte pullets.

Graham (1932) reported that the protein concentrates fed - butter milk powder, meat meal, tankage, and fish meal, did not have a significant effect on the weight of the eggs produced.

Parkhurst (1933) after an intensive study of nutritional factors affecting egg weight, reported the following:

a. A ration in pullet form gave somewhat larger egg size than the same ration in mash form.

b. Green feed and oyster shell proved of value in increasing egg size.

c. Fish meal proved definitely of greater value in improving egg size than peanut meal.

d. Protein level of the diet is not a significant factor affecting egg weight.

C. Egg Quality Studies.

Data on the effects of the individual cereal grains - corn, wheat, and oats upon the quality of the eggs produced are somewhat limited.

Waite (1911) compared the effects of feeding corn and wheat on the re-

sultant color of the yolks of the eggs produced. He concluded that yellow corn when fed to hens in the proportion of nine parts corn to twelve of mash gives a deep yellow color to the egg yolks. Yellow corn when fed to hens in the proportion of four and a half parts corn to sixteen parts of other feeds produces a noticeable yellow tint in the yolks. Wheat, however, when fed in the same proportion did not impart any yellow color to the yolks of the eggs.

Palmer and Kempster (1919) conducted studies on the influence of specific feeds on the color of the egg yolk of fowls. They concluded that the egg yolks of hens receiving a yellow corn ration were markedly darker than the yolks of hens receiving a wheat or an oat ration. By means of a Bradley color top, they determined the relative intensity of color of the egg yolks, and reported the following:

a. Corn fed group - 70 yolk color intensity,
wheat fed group - 30 yolk color intensity,
oat fed group - 27.5 yolk color intensity.

Newman (1927) an English worker reported that pullets fed on corn lay a higher percentage of first grade eggs than those fed wheat.

A report (1931) of an experiment conducted at Mt. Gravatt, Brisbane, Queensland substantiates Newman's work. This report states that, "in both cases where corn was extensively used the proportion of first grade eggs was greater than that from the wheat ration."

North (1934) made an intensive study of the effect of the basic cereal grains on the quality of the eggs produced. This investigator fed groups of pullets rations containing 65 to 70 per cent of a single cereal grain. He reported the following after two years of experimental feeding trials:

a. No noticeable difference between the lots regarding shell texture.

b. The corn lot produced eggs yolks which were deep orange in color, whereas the oat and wheat lots produce light yellow yolks.

c. Eggs yolks from hens receiving wheat as a major portion of their diet were somewhat freer from fat globules than the others.

d. No significant difference in egg quality as measured by the yolk index, between the various lots.

e. No marked difference in the percentage of thick albumen as measured by the Holst and Almquist Method.

Card and Sloan (1934) report results based on a larger group of hens which are somewhat contrary to North's (1934) finding concerning the effect of the cereal grains on the percentage of thick albumen in the egg. These investigators conducted a five month feeding period with forty-eight S. C. White Leghorn pullets confined to cages. Each group of pullets received an all-mash ration containing seventy-four per cent of a single ground cereal grain. They report that in none of the lots did the percentage of thick white drop low enough to result in eggs of a distinctly inferior quality, but that there is some indication that the proportion of thick white may be influenced by the ration fed. Their results summarized are as follows:

a. Control lot -- 74.90 ± 9. (average per cent thick white),
corn lot -- 67.67 ± 6. (average per cent thick white),
wheat lot -- 66.92 ± 9.(average per cent thick white),
oat lot -- 70.12 ± 8. (average per cent thick white).

D. Fat Deposition and Distribution Studies

Studies concerned with the effect of the individual cereal grains upon the deposition of fat, as well as the distribution of depot fat, have received very little attention from research investigators. An intensive review of the literature reveals but two published papers concerned with the relation of diet to the distribution of depot fat in the body. Note: Depot fat refers specifically to the visible fat deposits.

Effect of Diet on the Deposition and Distribution of Fat

A detailed study of the distribution of fat deposited in the organism has been reported from Mendel's Laboratory. The following factors have been considered: diet, weight, sex, under-nutrition, fasting, exercise, and ovariectomy. According to a report published by Reed, Yamaguchi, Anderson and Mendel (1930), the normal distribution of fat in the various depots of the female rat was approximately as follows:

a. subcutaneous---------50%
genital----------20%
perirenal----------12%
mesenteric----------10%
intermuscular---------5%
omental----------3%

It was found that whereas the total amount of stored fat varied with the nature of the diet, the distribution was practically independent of the type of diet fed. (Note: the difference between groups ranging from three to eleven rats on the various diets was less than the variations among the individuals of any one group.) Approximately twice as much total fat was deposited by rats fed a diet rich in fat as by animals that ate an equicaloric amount of a diet rich in carbohydrate.

Maw and Holcomb (1935) reported results based on chickens somewhat contrary to the above findings. It should be remembered, however, that (1) the metabolism in the chicken is different than in a mammal and (2) the comparison of these two reports is complicated by a dietary variable. The results of the Canadian investigators show that the different cereal grains definitely affected the distribution of fat in the body. They found that corn meal causes a high percentage of the total body fat to be deposited in the flesh and much less fat in the abdominal cavity and in the skin; whereas the cereals, oats and wheat showed a reverse in varying degrees. The individual grains in these experiments were supplemented by six per cent animal protein. Because of the basic importance of this experiment, a summary of the results are presented:

a) Percentage Abdominal Fat

(1) Corn group --- 15% (abdominal fat)

(2) Oat group ---- 21% (abdominal fat)

(3) Wheat group -- 20% (abdominal fat)

b) Percentage of Skin Fat

(1) Corn group --- 55% (skin fat)

(2) Oat group ---- 57% (skin fat)

(3) Wheat group -- 60% (skin fat)

c) Percentage of Flesh Fat

(1) Corn group --- 30%

(2) Oat group ---- 22%

(3) Wheat group -- 20%

Maw and Holcomb (1935) have also studied the effects of the basic grains on the total fat deposited in the body of the chicken. They report the following:

a) Total Fat Deposited

(1) Corn group --- 13.4% (Total Depot Fat)

(2) Wheat group -- 12.9% (Total Depot Fat)

(3) Oat group ----- 12.1% (Total Depot Fat)

PART I, GENERAL STUDIES

a) Conditions and General Set-Up of the Experiment

This experiment was designed to secure data on the comparative value of laying rations containing from sixty-six to seventy-two per cent of a single cereal grain. Yellow corn, wheat, and oats were the cereals considered in these studies.

Thirty-six pullets were selected from the Massachusetts Experiment Station flock, and divided into four groups of nine birds each. Note: the Experiment Station flock of the Massachusetts State College has been bred constantly during the last twenty years for high egg production. Although the number of pullets in each individual group was somewhat small, it was not considered possible to work with larger groups in view of the fact that this study is considering the individual reaction to the various diets fed as well as the group reactions.

Great care was exercised in dividing the thirty-six pullets into four groups as it was essential to secure groups that were nearly alike as possible. The following factors were therefore taken into consideration in grouping the birds: (1) hatching date, (2) date of first egg, (3) body weight, and (4) acclimation to the caged environment. This last factor was determined by (1) feed consumption and egg production of the individual pullets, as well as (2) daily observations during a ten day preliminary feeding period in which all the birds received a similar ration, the New England College Conference Mash. (See Table II)

During the experimental period, October 15 to April 31 inclusive, the four groups of birds were confined to a laying battery thereby making it

possible to keep accurate records of the individual egg production, feed consumption and egg weight. The rations for each of the four groups are given in Table I.

TABLE I - RATIONS

Lot No.	Constant	Parts	Ground Cereal Grain	Parts
1	Basal Mash*	40	Corn Oats Wheat	25 10 25
2	" "	40	Oats	60
3	" "	40	Wheat	60
4	" "	40	Corn	60

*The Basal Mash fraction of this ration was the New England College Conference Mash (See Table II). Note: The rations all contained 1% cod liver oil.

Reference to Table I shows that each ration, with the exception of the check ration, contained 60 parts of a single cereal grain and 40 parts of mash. Since the mash fraction of the ration contained a definite amount of the basic cereal grains: 30 per cent corn, 30 per cent wheat, and 15 per cent oats - , the total quantity of the individual cereal grain in each ration was further increased.

Table II Percentage Composition of the Various Rations Along with their Relationship to the N. E. C. C. Mash.

Ingredients	N.E.C.C. Mash	Lot I Control	Lot II Oat Lot	Lot III Wheat Lot	Lot IV Corn Lot
Corn	31%	37.4	12.4	12.4	72.4
Wheat (Product)	31%	37.4	12.4	72.4	12.4
Oats	15.5%	16.2	66.2	6.2	6.2
Meat Scrap	7.7	3.0	3.0	3.0	3.0
Fish Meal	3.8	1.5	1.5	1.5	1.5
Alfalfa	3.8	1.5	1.5	1.5	1.5
Skim Milk	3.8	1.5	1.5	1.5	1.5
Carbonate	2.2	.8	.8	.8	.8
Salt	.7	.2	.2	.2	.2

Note: Over two-thirds of the ration in Lot II and about three-fourths of the ration in Lots III and IV consisted of the individual cereal grain being compared.

Feed, oyster shell, and water were available to the birds at all times. The laying battery was located in an insulated room, and a fairly regular temperature was maintained during the period of this experiment. Artificial light was not employed either in the fall or winter in the attempt to increase egg production. Feed was freshly mixed at two month intervals.

The analysis of the rations is shown in Table III. Reference to this table will show that the protein level ranged from 13.8 per cent in corn to 15.8 per cent in wheat. This range according to Graham's finding (1934)

Table III, Approximate Analysis of the Rations

	% Protein	% N-free Extract	% Crude Fiber	% Fat	% Ash	% Moisture
CHECK-RATION (Group I)						
Analysis 1	14.76	60.24	4.95	6.09	5.53	8.65
" 2	14.28	59.68	4.36	4.08	4.32	13.28
" 3	14.39	60.36	3.91	4.47	4.39	12.46
Mean	14.47	60.09	4.40	4.88	4.74	11.47
OAT-RATION (Group II)						
Analysis 1	15.06	56.24	8.29	6.28	5.81	8.32
" 2	14.87	54.91	7.88	4.59	5.02	12.73
" 3	15.00	56.20	6.77	5.04	5.12	11.87
Mean	14.97	55.81	7.64	5.30	5.31	10.97
WHEAT-RATION (Group III)						
Analysis 1	15.84	61.54	3.69	4.94	4.90	9.29
" 2	15.79	59.96	3.69	3.40	4.28	12.88
" 3	15.26	60.97	3.27	3.66	4.32	12.50
Mean	15.56	60.82		4.00	4.50	11.55
CORN-RATION (Group IV)						
Analysis 1	13.80	60.37	3.70	6.03	5.30	8.80
" 2	12.67	61.02	3.52	4.46	4.17	14.16
" 3	13.35	60.97	3.13	6.09	4.29	12.22
Mean	13.27	60.77	3.45	6.19	4.58	11.72

Analysis of the rations were made by the Feed Control Service Laboratory of the Massachusetts Agricultural Experiment Station.

Note: Analysis 1 was made in October 1935.
" 2 was made in January 1936
" 3 was made in March 1936.

is adequate for egg production and will permit the birds to make gains in body weight. It is interesting to note that the oat-fed lot received approximately 7.5 per cent fiber. This quantity is much greater than the amount commonly recommended. Cochel and Jackson (1912) have reported that rations carrying 3.5 per cent of the total weight in crude fiber seemed to give better results than those with a lower or higher percentage.

During the period of this Experiment (October 15 to April 31 inclusive) the following records were kept:

(1) sickness and mortality

(2) daily egg production of each pullet

(3) total number of eggs produced weekly by each group

(4) weekly feed consumption in grams for each pullet

(5) weekly body weight of each bird in ounces

b) Results of Experiment

All data in this experiment are based on the reaction of the individual pullet to the type of diet fed. Since the groups were somewhat small, it was necessary to compare differences between the means of the various groups by special methods. The method employed throughout this report is the analysis of variance introduced by R. A. Fisher in 1923. Snedecor's monograph (1934) on the Calculation and Interpretation of Analysis of Variance and Covariance was used as a guide in applying the method of analysis of variance to the data of this experiment.

In the method of analysis of variance, a significant difference between the means of the groups under consideration depends upon the ratio of

(1) variance between the means of the groups and (2) variance within the groups. Note: the word variance is used by Fisher to denote the square of the standard deviation. Snedecor, however, uses mean square instead of variance to denote square of the standard deviation.

It should be noted that the Analysis of Variance is used to test the significance of differences between the means of the whole population and not between any two particular pair of means present in the whole. The "t" factor as determined by Fisher's method was employed therefore to test the significance of difference between <u>any pair of means</u> in the population.

In this report, all results are presented in a standard form. The first page of this form presents the actual data for each bird, the total and means for each group of birds, and the statistical analysis of variance. The second page presents an analysis of the variance under consideration along with a discussion and interpretation of the results obtained. The third page contains a statistical comparison between the means of (1) the control lot and (2) each of the various feed lots. The difference between the means of any particular pair is tested by determining the value of "t". The significance of the value, in turn, depends on "p" ----- the probability of falling outside of the normal distribution. Note: In order to have a highly significant difference between any pair of means, the probability factor "p" must be .033 or less.

a) General Health of the Birds

Since all records depend upon the general health of the birds that are in the population under study, it may be well to first discuss this topic.

As a whole, the health of the pullets on all the rations was uniformly good throughout the 28 week experimental period. One bird, number 1 in the wheat-Lot, however, exhibited signs after the first eight weeks of an internal disturbance. During the next four weeks the pullet lost weight, consumed very little feed, and produced no eggs. It was noted that often this bird would consume less than twenty grams of feed during the whole week. On December 23, 1935, autopsy was performed by Dr. Ballis of the Veterinary Department. He reported the presence of ovarian tumors. Pullet number 1 of the Control group was likewise omitted in the statistical analysis because she exhibited signs of an abnormal condition through the experiment. Although this pullet maintained body weight and made substantial gains in weight, she did not produce many eggs. Throughout the 28 week period, this bird layed but ten eggs indicating a very definite abnormality since she was selected from a flock which has been bred for high egg production for the last twenty-four years.

b) Egg Production

The results in egg production of the various groups are presented in Tables IV, V, and VI. Statistical treatment shows no significant difference between the means of the total egg production for the four lots. The variance within groups was markedly greater than the variance between the means of groups, indicating a wide range in production between the individuals in the groups. The standard deviation ± 15.87 eggs is almost fifteen per cent of the average total egg production, indicating the extent of the variation in egg production that was present in the various groups.

Table IV. CEREAL GRAINS AND EGG PRODUCTION

Statistical Analysis of the Individual Egg Production

in the Various Lots for Twenty-Eight Weeks

Pullet No.	CHECK-LOT		OAT-LOT		WHEAT-LOT		CORN-LOT	
	Eggs Produced		Eggs Produced		Eggs Produced		Eggs Produced	
	1	2	1	2	1	2	1	2
1			110	12,100	142	20,164	111	12,321
2	146	21,316	133	17,689	91	8,281	107	11,449
3	128	16,384	119	14,161			96	9,216
4	121	14,641	108	11,664	104	10,816	104	10,816
5	89	7,921	95	9,025	113	12,769	99	9,801
6	121	14,641	93	8,649	102	10,404	85	7,225
7	106	11,236	146	21,316	138	19,044	120	14,400
8	125	15,625	101	10,201	137	18,769	140	19,600
9	110	12,100	134	17,956	111	12,321	124	15,376
Total	946		1039		938		986	
Mean	116.25		115.44		117.25		109.55	

Note: (1) Weekly egg production for twenty-eight weeks **
(2) Weekly egg production squared

a) Total egg production for the four groups ---------- 3,909

b) Correction factor----------449,420

c) Sum of the squares of the 34 individual egg production totals** ----------459,397

d) Total sum of squares----------9,977

e) Sum of squares between means of feed-lots----------391

f) Sum of squares within feed-lots----------9,586

TABLE V

Analysis of Variance of Egg Production

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squared
Total	33	9,977	302.33
Between means of Feed-lots	3	391	130.33
Within Feed-lots	30	9,586	319.53

$$F = \frac{\text{larger mean squared}}{\text{smaller mean squared}} = \frac{319.53}{130.33} = 2.453$$

Values for F $\frac{4.53}{26.12}$ (Fischer's 5% point) (Fischer's 1% point)

Standard Deviation $\sqrt{319.53} = \pm 18.87$

Standard Error of Mean of the Entire Sample $= \sqrt{\frac{319.53}{37}} = \pm 9.397$

Discussion and Interpretation: - There was no significant difference, as measured by the value of "F" between the means of the total egg production for the four lots. Note: the variance within the feed-lots is markedly greater than the variance between feed-lots.

Note: Mean squared is used by Snedecor (1934) to denote "Variance". "V" is used by Fischer (1933) to denote the square of the standard deviation. In symbols $V = \sigma^2$

Table VI. Statistical Comparison between Means of Feed-Lots.

Test for Significance of Difference Between the Means for Total Egg Production of the Four Lots

Check Lot Average Egg Production	118.25
Oat Lot Average Egg Production	115.44
Difference	2.81
"t"	.3065
"p"	.75
Significant	No
Check Lot Average Egg Production	118.25
Wheat Lot Average Egg Production	117.25
Difference	1.00
"t"	.1060
"p"	.9
Significant	No
Check Lot Average Egg Production	118.25
Corn Lot Average Egg Production	109.55
Difference	8.70
"t"	.9409
"p"	.35
Significant	No

Note: "p" must be .033 or less in order to have a highly significant difference means of feed-lots.

c) Feed Consumption

Tables VII, VIII, IX present the statistical analysis of the feed consumption in the various groups. It will be noted by referring to Table VIII that the variance or means squared between the means of the feed-lots was markedly greater than the variance within feed-lots. This difference proved to be highly significant upon comparison with Fischer's value for "F". Table VII presents the average mean feed consumption for the four lots. It is evident upon comparing the means that the oat group consumed more feed and the corn lot consumed less feed than the average feed consumption in the check-lot. The differences between means were tested for significance by the use of Fischer's formula for "t". The results and the significance of difference between the means of the check lot and means of the various lots are shown in Table IX. It should be noted that the "P" factor for the Difference between the check and the corn lots was approximately .055 indicating a possible significant difference since the odds are 1-18 that the "t" value will be exceeded by chance. The "P" factor for the difference between the mean feed consumption of the check and corn lots was .18. This difference cannot be considered significant since the odds are 1-6 that the "t" value will be exceeded by chance. Note: In order to have a highly significant difference between means, the "P" factor must be .033 or less.

To summarize: Feed consumption between the groups showed significant differences according to Fischer's values for "F". Upon comparing the difference between the (1) mean of the check lot and (2) the means of each of the various lots, no highly significant value was obtained. It should be noted, however that there is a highly significant difference between the means of the Oat Lot and the Corn Lot. The "P" value for this difference

Table VII. CEREAL GRAINS AND FEED CONSUMPTION

Statistical Analysis of the Individual Average Weekly Feed Consumption for 25 Weeks

Pullet No.	CHECK-LOT		OAT-LOT		WHEAT-LOT		CORN-LOT	
	Feed Consumed		Feed Consumed		Feed Consumed		Feed Consumed	
	1	2	1	2	1	2	1	2
1			863	744,769	923	851,929	765	585.225
2	886	784,996	928	861,184	786	617,796	788	620,944
3	850	722,500	865	748,225			839	703,921
4	870	756,900	900	810,000	795	632,025	765	585,225
5	691	477,481	916	839,056	827	683,929	804	646,416
6	920	846,400	901	811,801	913	833,569	775	600,625
7	876	767,376	951	904,401	880	774,400	727	528,529
8	784	614,656	766	586,756	888	788,544	824	678,976
9	792	627,264	936	876,096	899	808,201	863	744,769
Total	6669		8026		6911		7151	
Mean	833.62		891.77		863.87		794.55	

Note: (1) Average weekly feed consumption in grams for twenty-five weeks.
(2) Average weekly feed consumption squared

a) Total weekly feed consumption----------25,757

b) Correction factor ----------24,322,501

c) Sum of the squares of the average weekly feed consumption for the 34 pullets----------24,464,884

d) Total sum of squares ----------142,383

e) Sum of squares between means of feed-lots----------46,468

f) Sum of squares within feed-lots----------95,915

TABLE VIII

Analysis of Variance of Feed Consumption

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squared
Total	33	142,383	4,314.6
Between means of Feed-lots	3	46,468	15,489.3
Within Feed-lots	30	95,915	3,197.6

$$F = \frac{\text{larger mean squared}}{\text{smaller mean squared}} = \frac{15,489.3}{3,197.6} = 4.844$$

Values for $F = \frac{2.92}{4.51}$ (Fischer's 5% point) (Fischer's 1% point)

Standard Deviation $\sqrt{3,197.6} = \pm 56.54$

Standard Error of Mean of the Entire Sample $= \sqrt{\frac{3,197.6}{34}} = \pm 9.697$

Discussion and Interpretation: - There is a highly significant difference between the means of feed consumption for the various groups. Since the "F" factor is greater than Fischer's highly significant 1% value, the difference will be exceeded by chance less than one time in a hundred trials.

Table IX. Statistical Comparison between Means of Feed-Lots.

Test for Significance of Difference between the Means for the Weekly Feed Consumption for the Four Lots

Check Lot Average Weekly Feed Consumed	833.62
Oat Lot Average Weekly Feed Consumed	891.77
Difference	58.15 (-)
"t"	2.1168
"p"	.055
Significant	Possibly (odds 1-15)

Check Lot Average Weekly Feed Consumed	833.62
Wheat Lot Average Weekly Feed Consumed	863.87
Difference	30.25 (-)
"t"	1.07
"p"	.3
Significant	No

Check Lot Average Weekly Feed Consumed	833.62
Corn Lot Average Weekly Feed Consumed	794.55
Difference	39.07 (+)
"t"	1.422
"p"	.16
Significant	No

is less than .01 and the odds that the "F" value be exceeded by chance are less than 1-100.

c) Body Weight Changes

Table X, XI, and XII present a statistical analysis of body weight changes in the various lots for a period of twenty-five weeks. Although reference to table X shows a difference between the arithmetical means of the four groups, statistical analysis (Fisher's Method of Analysis for Variance) showed no significant difference in body weight changes to exist between the various lots.

Summary of Results for Experiment I

a) General health -- uniformly good through the 25 weeks.

2) Egg production -- a) no significant differences as measured by "F" between the means of the various groups.

b) Average egg production for the thirty-four pullets was approximately 60 per cent.

3) Feed consumption -- A highly significant difference as measured by "F" between the means of the various groups.

4) Body weight changes -- No significant difference as measured by "F" or "t" between the means of the four lots.

Table X. CEREAL GRAINS AND BODY WEIGHT CHANGES

Statistical Analysis of the Total Body Weight Changes

** per Pullet in Ounces for Twenty-Five Weeks

Pullet No.	CHECK-LOT		OAT-LOT		WHEAT-LOT		CORN-LOT	
	Body Wgt. Changes		Body Wgt. Changes		Body Wgt. Changes		Body Wgt. Changes	
	1	2	1	2	1	2	1	2
1			12	144	16	256	9	81
2	10	100	8	64	5	25	21	441
3	2	4	5	25			14	196
4	10	100	8	64	25	625	4	16
5	3	9	9	81	8	64	27	729
6	22	484	13	169	20	400	3	9
7	21	441	5	25	17	289	7	49
8	- 9	81	7	49	17	289	9	81
9	13	169	13	169	6	36	25	625
Total	72		80		114		119	
Mean	9		8.8		14.2		13.2	

Note: (1) Total body weight changes for twenty-five weeks
(2) Total body weight changes squared
** Body weight changes in ounces

a) Total body weight changes for the four groups----------385.0

b) Correction factor----------4,359.5

c) Sum of the squares of the 34 individual body weight changes----------6,389.0

d) Total sum of squares----------2,029.4

e) Sum of squares between means of feed-lots----------197.4

f) Sum of squares within feed-lots----------1,832.0

TABLE XI

Analysis of Variance of Weight Changes

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squared
Total	33	2,029.4	61.49
Between means of Feed-lots	3	197.4	65.80
Within Feed-lots	30	1,832.0	61.06

$$F = \frac{\text{Larger mean squared}}{\text{Smaller mean squared}} = \frac{65.80}{61.06} = 1.077$$

Values for F $\quad \begin{matrix} 2.92 \\ 4.51 \end{matrix}$ (Fischer's 5% point)
(Fischer's 1% point)

Standard Deviation $\quad \sqrt{61.06} = \pm 7.814$

Standard Error of
Mean of the Entire Sample $= \sqrt{\frac{61.06}{34}} = \pm 1.339$

Discussion and Interpretation: - There is no significant difference between the means of the body weight changes of the various lots. Although the variance between means was greater than the variance within means, this ratio was not sufficiently greater enough to produce a value for F corresponding to Fischer's 5% point.

Table XII. Statistical Comparison between Means of Feed-Lots.

Test for Significance of Difference between Means for the Total Weight Changes for the Four Lots

Check Lot Average Body Weight Changes	9
Oat Lot Average Body Weight Changes	8.8
Difference	.2
"t"	.0527
"p"	Greater than .9
Significant	No
Check Lot Average Body Weight Changes	9
Wheat Lot Average Body Weight Changes	14.2
Difference	5.2 (-)
"t"	1.33
"p"	.2
Significant	No
Check Lot Average Body Weight Changes	9
Corn Lot Average Body Weight Changes	13.2
Difference	4.2
"t"	1.109
"p"	.25
Significant	No

PART II, EGG WEIGHT STUDIES

a) Conditions of Experiment

This experiment was conducted for the purpose of ascertaining if egg weight is effected by rations containing a relatively large quantity of a single cereal grain.

Eggs were collected during the course of this experiment each day and weighed on a Toledo scale, accurate to one-tenth of a gram. All eggs that were stained with fecal material were recorded as such, and these were omitted in the statistical analysis. The per cent of stained or dirty eggs on the whole, however, was very small. Cracked eggs were likewise omitted in the statistical analysis.

b) Result of Experiment

The data obtained over a period of 25 weeks and based on 3465 eggs were treated statistically and graphically in the same manner as in Experiment I. All averages on egg weights were computed only on birds living at the end of the experiment.

The results are presented in Table XIII, XIV and XV.

Upon comparing the mean egg weight for the four lots, (see Table XIII) there appears to be visible differences in egg weight. Statistical analysis (Fisher's Method) however, does not substantiate any of these visible differences. Although the variance between means of groups is greater than the variance within groups, the value for F obtained was not sufficiently large enough to indicate any significant differences, between the mean egg weights

of the various groups. A comparison of the check lot and the corn lot for significance of difference in the mean egg weight between these two groups (see Table XV) gave a "p" value of .07 indicating that the odds are 1-13 that this difference be exceeded by chance. It is evident that "p" is not sufficiently small enough to place any high degree of confidence in the difference between these means.

Table XIII. CEREAL GRAINS AND EGG WEIGHT

Statistical Analysis of the Average Egg Weight per Pullet for Twenty-Five Weeks

Pullet No.	CHECK-LOT		CAT-LOT		WHEAT-LOT		CORN-LOT	
	Av. Egg Wgt.		Av. Egg Wgt.		Av. Egg Wgt.		Av. Egg Wgt.	
	1	2	1	2	1	2	1	2
1			57.88	3350.09	59.34	3521.23	59.77	3572.45
2	55.42	3071.37	56.48	3181.99	57.57	3314.30	51.17	2618.36
3	58.73	3449.21	57.82	3343.15			53.27	2837.69
4	60.18	3875.79	60.03	3603.60	55.26	3053.66	54.96	3020.60
5	60.32	3648.50	59.15	3498.72	58.51	3423.42	56.87	3234.19
6	64.47	4156.38	60.86	3703.93	63.63	4048.77	56.33	3173.06
7	59.71	3565.28	58.94	3473.92	57.47	3302.80	59.19	3503.45
8	58.75	3451.56	55.69	3101.37	58.00	3364.00	59.75	3570.06
9	56.50	3192.25	54.27	2945.23	60.27	3632.47	57.65	3323.52
Total	473.38		521.12		470.05		508.96	
Mean	59.26		57.90		58.75		56.55	

Note: (1) Average egg weight for twenty-five weeks
(2) Average egg weight squared

a) Total average egg weight for the four groups----------1,974.21

b) Correction factor----------114,632.53

c) Sum of the squares of the 34 individual average egg weights----------114,924.46

d) Total sum of squares----------291.87

e) Sum of squares between means of feed-lots----------36.20

f) Sum of squares within feed-lots----------255.67

TABLE XIV

Analysis of Variance of Egg Weight

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squared
Total	33	291.87	8.84
Between means of Feed-lots	3	36.20	12.06
Within Feed-lots	30	255.67	8.52

$$F = \frac{\text{larger mean squared}}{\text{smaller mean squared}} = \frac{12.06}{8.52} = 1.415$$

Values for F $\frac{2.91}{4.51}$ (Fischer's 5% point)
(Fischer's 1% point)

Standard Deviation $= \sqrt{8.52} = \pm 2.918$

Standard Error of the Mean
of the Entire Sample $= \sqrt{\frac{8.52}{34}} \pm .5005$

Discussion and Interpretation: - Although the variance between means of groups is greater than the variance within groups, the value of "F" obtained was not sufficiently large to indicate any significant differences between the mean egg weight of the various groups.

Table XV. Statistical Comparison between Means of Groups

Test for Significance of Difference between Means of Average Egg Weight

For the Four Groups

Check Lot Average Egg Weight	59.26*
Oat Lot Average Egg Weight	57.83
Difference	1.43
"t"	1.009
"p"	.35
Significant	No
Check Lot Average Egg Weight	59.26
Wheat Lot Average Egg Weight	58.75
Difference	.51
"t"	.349
"p"	.75
Significant	No
Check Lot Average Egg Weight	59.26
Corn Lot Average Egg Weight	56.55
Difference	2.71
"t"	1.912
"p"	.07
Significant	Doubtful (odds 1-13)

Note: Egg Weight in grams

*Average Egg Weight for the twenty-five week period.

PART III, EGG QUALITY STUDIES

Special emphasis was given during the month of April (1936) to a study on the quality of the eggs produced by the various lots of pullets. Approximately six hundred eggs, an average of eighteen eggs for each pullet were opened for study. The following measures of interior quality were individually applied to each egg:

a) open appearance

b) percentage of firm white

c) percentage total solids in thick and thin albumen

d) yolk color

e) taste

It should be noted that the writer is aware that there are other factors namely: 1) genetic inheritance and 2) physiological balance which play an important part in the resultant quality of the eggs produced. It is, nevertheless, desirable to know what effect, if any, the individual cereal grains have on the physical-chemical makeup of the eggs.

a) Open Appearance

Sharp (1934) suggested that the condition of the apparent thick white should be considered as an important factor in studying egg quality. He defines the apparent thick white as "the unruptured jelly-like mass remaining after the outer thin white is removed". He proposed a series of standards for scoring the quality conditions of the apparent thick white. These scores ranged from 1, defined as "firm and upstanding, completely surrounding the well centered yolk" to 5, defined as "no structured thick white

present". Heiman and Carver (1936) modified Sharp's standards which were somewhat complicated by a fractional system. The former standards (Heiman and Carver) were used in grading the open appearance and the quality of the apparent thick white in this study. Plate 1 by courtesy of Heiman and Carver illustrates typical eggs in each of the five grades. Note the increase in surface area and the decrease in the height of the apparent thick white as the observed quality decreases.

Procedure for Examination of Open Appearance

Preliminary to scoring, the egg is broken into a petri dish. It is important that care be exercised in the breaking operation in order that the thick white may not be ruptured. The following method was employed for routine breaking of the eggs.

(1) egg is picked up in the right hand with large end to the left.

(2) it is cracked by striking it gently against the outer rim of the petri dish.

(3) complete contents are removed by a hinge-like movement of the two halves of the shell.

(4) white adhering to the shell is scraped out with a rounded scapel.

Note: It is important that the eggs are held not more than one inch from the dish on which they are broken out.

Immediately after the egg is broken, it is scored for open appearance according to the standards and code illustrated in Plate I. Heiman and Carver (1936) have reported that the coefficient of correlation between the observed grade and the physical measurement of the apparent thick white to be .932 ± .002, thereby indicating that the method for scoring is sufficiently

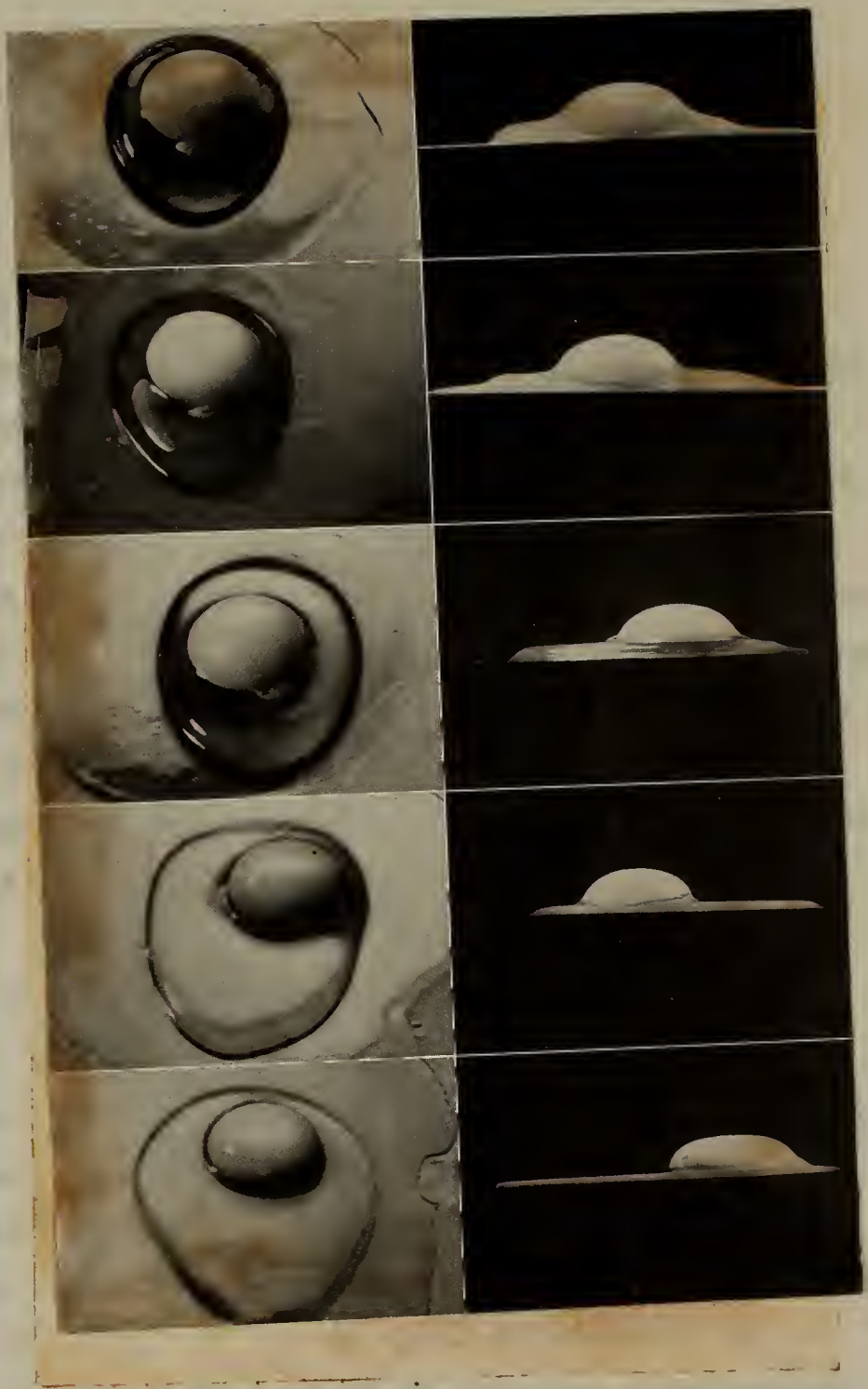

Plate I, Standards Used in Scoring The Condition of the Apparent Thick White. Note: the increase in surface area and the decrease in the apparent thick white as the observed quality decreases. (By courtesy of Heiman and Carver)

accurate to warrant its use in routine analysis.

Results.

Statistical analysis (See Table XV, XVI, XVII) of approximately six hundred eggs showed that no significant differences existed between the open appearance of the eggs produced by the various groups of pullets under observation. Although the variance factor between the means of feed lots was greater than the variance within feed lots, the value for F obtained was not sufficiently large to indicate significant differences between the means of the four feed lots. Reference to table XV will show that there were great variations in the open appearance of the eggs produced by different pullets within the same group. It should likewise be noted that pullets producing high scoring eggs were able throughout the period of observation to maintain a fairly regular level with respect to this particular characteristic.

b) Percentage of Firm white.

Fresh eggs of good quality generally possess a relatively large quantity of firm albumen. A small proportion of thick white (firm albumen) is according to Holst and Almquist (1931) an indication of age. It should be noted that there is considerable variation in the percentage firm albumen in eggs laid by different hens. (Lorenz, Taylor, and Almquist - 1934)

The method employed in this study for the separation of the thick and thin albumen was that of Holst and Almquist (1931) modified somewhat in order to facilitate routine observations on large numbers of eggs. In this method, a small wire sieve is used to retain the firm albumen and allow the thin por-

Table XVI. CEREAL GRAINS AND OPEN APPEARANCE OF THE EGG

Statistical Analysis of the Score for the Condition of the Apparent Thick White

Pullet No.	CHECK-LOT		OAT-LOT		WHEAT-LOT		CORN-LOT	
	Thick White Score		Thick White Score		Thick White Score		Thick White Score	
	1	2	1	2	1	2	1	2
1			2.63	6.91	1.53	2.34	2.91	8.47
2	2.25	5.06	1.77	3.13	1.85	3.42	2.00	4.00
3	2.50	6.25	3.00	9.00			2.28	5.20
4	3.00	9.00	2.08	4.32	1.83	3.34	2.25	5.00
5	3.14	9.85	1.25	1.56	3.64	13.25	2.21	4.88
6	2.27	5.15	2.10	4.41	2.30	5.29	2.20	4.80
7	2.80	7.80	1.46	2.13	2.71	7.34	2.46	6.05
8	2.54	6.45	2.33	5.43	2.91	8.49	2.45	6.00
9	2.71	7.34	2.35	5.52	1.25	1.56	2.00	4.00
Total	21.21		18.97		18.02		20.75	
Mean	2.65		2.10		2.25		2.30	

Note: (1) Average score for the condition of the apparent thick white
(2) Average score squared
Open Appearance is measured in the study by the condition of the apparent thick white during a thirty-day period of observation.

a) Total average score for appearance of the apparent thick white----------78.96

b) Correction factor ----------183.37

c) Sum of the squares of the 34 average scores----------192.80

d) Total sum of squares ----------9.43

e) Sum of the squares between means of feed-lots----------1.31

f) Sum of squares within feed-lots----------8.12

TABLE XVII

Analysis of Variance of the Mean Scores for the Apparent Thick White of Eggs from the Various Lots

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squared
Total	33	9.43	.2857
Between means of Feed-lots	3	1.31	.4333
Within Feed-lots	30	8.12	.2706

$$F = \frac{\text{larger mean squared}}{\text{smaller mean squared}} = \frac{.4333}{.2706} = 1.6012$$

Values for F $\frac{2.91}{4.51}$ (Fischer's 5% point) (Fischer's 1% point)

Standard Deviation $\sqrt{.2706} = \pm .5201$

Standard Error of Mean of the Entire Sample $\sqrt{\frac{.2705}{37}} = \pm .0892$

Discussion and Interpretation: - No significant differences between the mean scores of the apparent thick white of eggs from the various lots.

Table XVIII, Statistical Comparison Between Means of Feed-Lots

Test for Significance of Difference between Means Scored of the Apparent Thick White of Egg from the Various Lots *

Check Lot Average Score for Appearance	2.65
Oat Lot Average Score for Appearance	2.10
Difference	.55
"t"	2.17
"p"	.494
Significant	No
Check Lot Average Score for Appearance	2.65
Wheat Lot Average Score for Appearance	2.25
Difference	.40
"t"	1.53
"p"	.15
Significant	No
Check Lot Average Score for Appearance	2.65
Corn Lot Average Score for Appearance	2.30
Difference	.35
"t"	1.38
"p"	.19
Significant	No

* Average score for appearance of the apparent thick white. Heiman and Carver scoring grades.

tion to run through into a graduated cylinder.

Procedure for the Determination of the Percentage of Firm white.

After scoring by means of the Haiman and Carver proposed grades (1936), the yolks are carefully removed, graded for color and weighted. The remaining material in the petri dish comprises the total albumen and this volume is measured in a fifty cc. graduated cylinders. After determination of the total volume, the albumen is slowly poured into individual perforated sieves (4 inches in diameter; 8 holes to the linear inch, each hole 1/8" wide). Note: The sieve fits securely on a funnel 4 1/8" in diameter which in turn delivers into a fifty cc. graduated cylinder. When the penetration of the thin white has completely stopped, the sieve is then gently rocked five times and allowed to stand two minutes in order to insure complete penetration. The numerical difference between the first volume and the final volume represents the volume of thick white. This expressed as a percentage of the total volume gives the per cent of firm white. Note: different investigators have not always applied the term firm white to the same structural part of the albumen. In this paper, firm white represents the thick albumen along with the inner thin white. In short, firm albumen consists of the apparent thick white.

In this procedure, it is necessary in order to facilitate complete drainage of the thin white, to wet the wire sieve in water and then partially dry them before using. Although there is some thin white lost during this method of examination (on the hands and on the wire sieves) this error is small and assumes constancy for all eggs since the size of the equipment used, and the procedure for handling the egg is similar throughout. The apparatus shown in PlateII was designed to facilitate routine observations on large numbers of eggs.

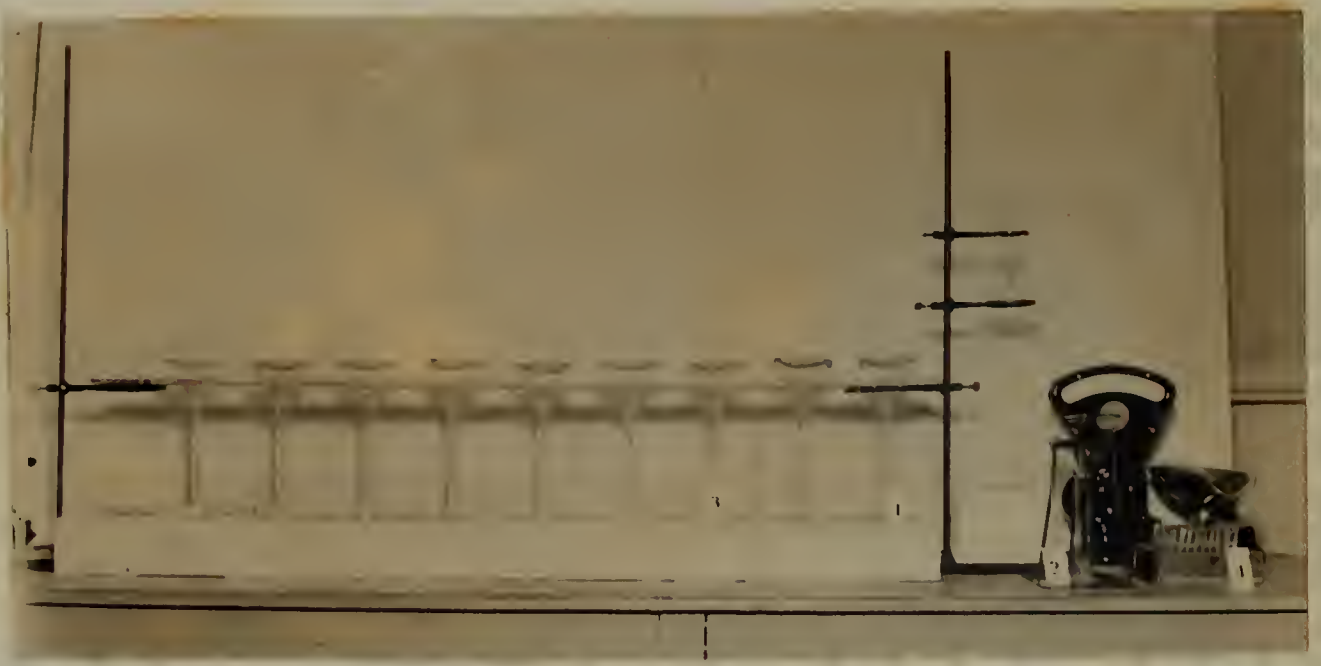

Plate II - Apparatus Used in Routine Egg Quality Studies

1) Petri dishes in foreground used in grading the open appearance of the egg.

2) Large funnel and cylinder used in securing the total volume of the albumen.

3) Cylinder, funnel, and wire mesh combination illustrated in background used in separating the thick and thin albumen.

4) Rack with tubes for holding individual samples of albumen for refractive index determination.

Results:

Although a comparison of the arithmetical means of the percentage firm white in eggs produced by the pullets of the various lots shows visible differences between the means, the application of statistical methods, however, proved these differences to be non-significant. It should be noted that this non-significant difference is somewhat contrary to Card and Sloan's findings (1934)

Reference to table XIX will show that the variance within groups was definitely greater than the variance between the means of the groups, indicating a high degree of variability between pullets of a similar group with reference to the percentage of firm albumen in the eggs produced.

c) Percentage of Total Solids in Thick and Thin Albumen

Studies were made for ten consecutive days during the month of April 1936 on the solid content of the thick and thin portions of the albumen of each egg produced during this period. Approximately 150 eggs were analyzed. The purpose of this study was to note if the individual cereal grains had any effect on the physical chemical make-up of the egg as indicated by the total solids content.

The 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 standard table which presents the relation of the refractive index to the percentage of solids present. The development of this important table is described by Almquist, Lorenz, and Hammester (1932).

Table XVIII. CEREAL GRAINS AND PER CENT FIRM WHITE

Statistical Analysis of the Average Per Cent Firm White in the Various Lots

Pullet No.	CHECK-LOT		OAT-LOT		WHEAT-LOT		CORN-LOT	
	Av. % Firm White		Av. % Firm White		Av. % Firm White		Av. % Firm White	
	1	2	1	2	1	2	1	2
1			61.3	3757.69	58.5	3422.25	59.3	3516.49
2	70.6	4984.36	61.2	3745.44	65.2	4251.40	60.0	3600.00
3	57.4	3294.76	61.3	3757.69			63.7	4057.69
4	54.4	2959.36	59.7	3564.09	65.1	4238.01	60.0	3600.00
5	60.0	3600.00	60.5	3660.25	69.9	4886.01	64.2	4121.64
6	67.8	4596.84	57.3	3283.29	58.4	3410.56	71.8	5155.24
7	56.2	3158.44	69.9	4886.10	59.5	3540.25	62.9	3956.41
8	58.9	3469.21	57.3	3283.29	57.5	3306.25	64.5	4160.25
9	58.7	3445.69	63.6	4044.96	56.4	3180.96	70.2	4928.05
Total	484.0		552.1		490.5		576.6	
Mean	60.5		61.3		61.3		64.1	

Note: (1) Average per cent firm white
(2) Average per cent firm white squared

a) Total average per cent firm white----------2,103.2

b) Correction factor----------130,101.4

c) Sum of the squares of the 34 average percentages of firm white----------130,822.4

d) Total sum of squares----------720.9

e) Sum of squares between means of feed-lots----------26.4

f) Sum of squares within feed-lots----------694.5

TABLE XIX

Analysis of Variance of the Percentage of Firm White from Eggs of the Various Lots

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squared
Total	33	720.99	21.84
Between means of Feed-lots	3	26.41	8.80
Within Feed-lots	30	694.58	23.15

$$F = \frac{\text{larger mean squared}}{\text{smaller mean squared}} = \frac{23.15}{8.80} = 2.63$$

Values for F $\quad \frac{8.53}{26.12}$ (Fischer's 5% point) (Fischer's 1% point)

Standard Deviation $\quad \sqrt{23.15} = \pm\ 4.811$

Standard Error of Mean of the Entire Sample $= \sqrt{\frac{23.15}{34}} = \pm\ .8250$

Discussion and Interpretation: - There is no significant difference between the means of the average percentages of firm white from eggs of the various lots. Since the mean squared within the feed-lots is definitely greater than the mean squared between the means of the feed-lots, it becomes evident that the variation within groups was definitely greater than any variation between groups.

Table XX. Statistical Comparison Between Means of Feed-Lots.

Test for Significance of Difference between Means of the Average Percentage Thick Albumen for the Four Lots

Check Lot Average Percentage Firm White	60.5
Oat Lot Average Percentage Firm White	61.3
Difference	.8
"t"	.343
"p"	.75
Significant	No

Check Lot Average Percentage Firm White	60.5
Wheat Lot Average Percentage Firm White	61.3
Difference	.8
"t"	.343
"p"	.75
Significant	No

Check Lot Average Percentage Firm White	60.5
Corn Lot Average Percentage Firm White	64.5
Difference	3.6
"t"	1.545
"p"	.15 (odds 1-7)
Significant	No

One of the difficulties that the writer met in this study was the lack of a standard routine method of analysis. After preliminary trials, the writer developed the following procedure for routine study:

(1) All samples of albumen are kept in a serological rack holding tubes three inches long and three-eights of an inch wide.

(2) The thin albumen is taken from the graduate cylinders after determination of the total thin white. Note: The cylinder is shaken in order to thoroughly mix the albumen and only a few drops are removed for the analysis.

(3) The thick white is removed from the wire sieve and placed on a small funnel. As the albumen drips through in long strands, small portions of a strand are cut by means of a curved scissors and these small samples are allowed to drop into small tubes. (See Plate II)

(4) Immediately after the tubes are filled, they are plugged with waxed cork.

(5) Samples are analyzed at room temperature 25°C as soon as they are collected.

Note: All analysis on the solids content of the albumen of the eggs produced were made in the late afternoon of each day.

Results:

It may be seen from tables XXI - XXIV that the percentage of solids in egg albumen varies considerably between eggs from the same pullet as well as between eggs from different pullets within the same group. Comparison of group averages were therefore deemed inadvisable since the

Table XXI. The Solids Content of the Thin Albumen of Eggs Produced by Pullets on the Control Ration

Refractive Index Values at 25 Degrees Centigrade

Pullet No.	1	2	3	4	5	6	7	8	9
Date									
April 14				1.3530				1.3540	1.3535
April 15		1.3560		1.3534		1.3540	1.3535		
April 16								1.3518	1.3518
April 17			1.3530	1.3528			1.3535	1.3528	1.3520
April 18		1.3545			1.3534		1.3534		1.3538
April 19		1.3540		1.3520	1.3550			1.3540	1.3533
April 20		1.3568	1.3535	1.3535			1.3560	1.3536	
April 21			1.3533	1.3528	1.3539		1.3545	1.3530	1.3530
April 22		1.3550			1.3535		1.3550		1.3528
April 23			1.3540	1.3530				1.3542	
Mean		1.3552	1.3534	1.3529	1.3534	1.3545	1.3543	1.3533	1.3529
Equivalent Solids Content		12.1	11.2	10.9	11.2	11.7	11.6	11.?	10.9

Table XXII. The Solids Content of the Thin Albumen of Eggs Produced by Pullets on the Oat Rations

Refractive Index Values at 25 Degrees Centigrade

Pullet No.	1	2	3	4	5	6	7	8	9
Date									
April 14									
April 15		1.3530	1.3568	1.3569	1.3560		1.3570	1.3559	
April 16	1.3540	1.3520		1.3560				1.3548	1.3550
April 17			1.3554	1.3565		1.3565	1.3579	1.3560	1.3550
April 18	1.3542		1.3557	1.3552			1.3570	1.3548	1.3548
April 19					1.3515	1.3552	1.3560		1.3550
April 20	1.3548	1.3530	1.3560	1.3558	1.3540			1.3534	1.3558
April 21	1.3540	1.3540	1.3540	1.3552	1.3548		1.3558		
April 22	1.3540				1.3542				1.3548
April 23			1.3554				1.3570		
Mean	1.3542	1.3532	1.3555	1.3559	1.3541	1.3558	1.3567	1.3549	1.3550
Equivalent Solids Content	11.6	11.1	12.3	12.4	11.5	12.4	12.8	12.0	11.9

Table XXIII. The Solids Content of the Thin Albumen of Eggs Produced by Pullets on the Wheat Ration

Refractive Index Values at 25 Degrees Centigrade

Pullet No.	1	2	3	4	5	6	7	8	9
Date									
April 14		1.3560				1.3550	1.3530		
April 15	1.3542	1.3560		1.3550	1.3565		1.3550		1.3535
April 16	1.3520	1.3555		1.3532	1.3571	1.3550		1.3521	1.3539
April 17	1.3531	1.3535		1.3541			1.3536		
April 18		1.3535		1.3540	1.3555	1.3546	1.3547	1.3525	1.3530
April 19		1.3546		1.3546	1.3543	1.3542	1.3525		
April 20	1.3520	1.3550		1.3541	1.3555	1.3553	1.3549	1.3515	1.3541
April 21	1.3522	1.3542		1.3543	1.3555	1.3542	1.3533	1.3515	
April 22	1.3520				1.3542			1.3521	
April 23		1.3560				1.3550		1.3526	
Mean	1.3526	1.3547		1.3542	1.3555	1.3547	1.3547	1.3521	1.3536
Equivalent Solids Content	10.8	11.9		11.5	12.3	11.9	11.4	10.5	11.3

Table XXIV. The Solids Content of the Thin Albumen of Eggs Produced by Pullets on the Corn Rations

Refractive Index Values at 25 Degrees Centigrade

Pullet No.	1	2	3	4	5	6	7	8	9
Date									
April 14	1.3550		1.3540		1.3540			1.3557	
April 15	1.3542		1.3542	1.3542	1.3550	1.3558	1.3530		
April 16			1.3525	1.3526	1.3526	1.3541	1.3530	1.3538	
April 17	1.3542		1.3548		1.3540	1.3540	1.3539	1.3539	1.3539
April 18			1.3538	1.3534		1.3545	1.3535		1.3535
April 19	1.3541		1.3530		1.3530	1.3538	1.3526		1.3526
April 20	1.3542		1.3530		1.3515	1.3542		1.3548	
April 21	1.3532	1.3530	1.3532		1.3527		1.3541	1.3535	1.3530
April 22	1.3540	1.3532				1.3550	1.3535		
April 23			1.3538		1.3530			1.3548	1.3542
Mean	1.3541	1.3531	1.3536	1.3534	1.3532	1.3546	1.3533	1.3544	1.3534
Equivalent Solids Content	11.5	11.05	11.3	11.2	11.1	11.7	11.2	11.7	11.2

percentage solids content of the egg appears to be a highly variable characteristic that is peculiar for the individual pullet. It should be noted that the total solids content of the thick albumen varied somewhat from that for the thin albumen, however, this range in variation was not generally as great as the range between eggs from different pullets.

The refractive index range for all eggs tested was between 1.3515 to 1.3571 which is slightly smaller than that reported by North (1934).

d) Egg Yolk Color

Although the density of the yolk color is no true indication of the quality of the egg, it is, nevertheless, an important factor demanding consideration because of certain standards commonly possessed by the homemaker in regard to yolk color. The general concensus of opinion among this class of buyers seems to be that pale-colored yolks are of a superior quality. Eggs possessing deeper yolk colors are consequently often discriminated against on certain markets.

Observations on yolk color were made after the scoring of the open appearance of the egg. Densities of yolk colors were matched with standards and recorded as numerals ranging from 1----a light canary color to 9-----a deep orange red-color.

Results:-

The presence of large amounts of yellow corn in the ration of group 4 (corn lot) materially deeped the yolk color of eggs produced by the pullets in this group. The oat group and the wheat group produced egg yolks which were significantly lighter than the Control Group. It should be noted that although the oat group and the wheat group received the same amount of corn

(the "xanthophyll-carrier"), the yolk color of eggs from the oat birds were somewhat lighter than the yolk color of eggs from the pullets receiving the wheat ration. This observation agrees with the findings of Palmer and Kempster (1919) who report that an oat fed group of pullets produced eggs with a slightly lighter yolk color intensity than a wheat fed group. The average yolk color intensity for the four groups, as measured by a yolk color standard ranging from one to nine, is shown in table (XXV).

TABLE XXV, YOLK COLOR INTENSITY FOR THE FOUR LOTS.

Lot no.	Rations Fed	Yolk Color Intensity
1	Control	4-5
2	Oat	1
3	Wheat	2
4	Corn	7

Note: Yolk color intensity was observed for a period of twenty days (April 1 to April 20, 1936). Yolk color measured by a color standard ranging from one to nine.

c) Taste

Samples of eggs from individual pullets were tested for disagreeable flavors and odors after the per cent of thick white had been determined. The following method of scoring for taste was employed in this study:

Score 1 - pleasing odor and taste

Score 2 - slightly off in odor and taste

Score 3 - definitely off in odor and taste

Score 4 - badly off in odor and taste

Results:

No difference between the groups with regard to taste or flavor were observed. Some of the eggs possessed a somewhat "flat" taste, however, this peculiarity was not limited to any particular group but rather to certain individuals within a group.

Summary of Results.

1) Open Appearance -- no significant differences between the mean scores of the apparent thick white of eggs from the various lots.
2) Percentage of Firm White -- no significant differences between groups with respect to this particular characteristic.
3) Percentage of Total Solids in Thick and Thin Albumen -- no apparent differences between groups.
4) Yolk Color -- Pullets in the corn lot produced yolks that were markedly darker than the yolks produced in the various other lots. The oat group produced somewhat lighter yolks than the wheat group although both groups received the same amount of corn.
5) Taste -- no observable difference between groups.

There was no apparent indication, considering the above five factors as measures of egg quality, that eggs produced by the corn-fed lot were of a superior quality than eggs from the wheat-fed lot. It should be noted that this observation is contrary to the findings of Newman (1927) and a report from the Mt. Cravatt, Queensland Experiment Station.

A general analysis of the results indicate that egg quality is an individual characteristic that is not effected by the rations fed as long as the consituents of the diet are of a balanced composition.

Part IV. FAT DEPOSITION AND DISTRIBUTION STUDIES

Part IV of the Experimental Work on the nutritive value of the basic cereal grains for laying hens is concerned with the effects of the individual cereals - corn, wheat, and oats - on the deposition and distribution of fat in the body of the fowl. It should be noted that these studies possess a practical significance in that superior poultry meat quality depends on "a proper deposition of fat distributed in all parts of the body". The degree of internal fat, that is fat laid down between the muscle tissues, is according to Maw the most important factor in determining the quality of the flesh.

a) Conditions of the Experiment

This study was conducted for the purpose of securing data on the effects of the various cereals fed (See Table I) on the deposition and distribution of fat in the body of the pullet. It should be noted that at present there is very little information available regarding the normal distribution of the reserve fat or its variation due to nutritive differences.

Reports of Maw state that in his work on fat distribution, five chickens were analyzed from each feeding lot. Since the number of pullets in the various lots of this experiment was somewhat smaller than that employed by Maw, four pullets were chosen to represent each group. It should be noted that great care was exercised in selecting these representatives and the following procedure was used as a guide. The pullets, prior to killing, were all weighed and then divided into three groups: a) light weight, b) medium weight, and c) heavy weight. One bird was then selected from the

light group, two from the medium group, and one from the heavy group. Note: The heaviest and the lightest as well as the poorest egg producers in each group were omitted from selection. It was possible by this method of selection to obtain a fairly representative sample of each group.

After selection of the samples, the birds (a total of sixteen) were starved for twenty-four hours. The birds were then killed and dressed by the dry pick method. Note: Killing was accomplished by piercing the brains with a small bladed knife and then cutting the jugular vein. The birds were placed after dressing, in a refrigerator having a temperature range of approximately 35 to 40 degrees Fahrenheit. After a seventy-two hour chilling period, the pullets were removed from the refrigerator and weighed in grams. Each pullet was then placed in a dissecting tray and cut open. The reserve fat (adipose tissue) was removed by dissection from the three main depots. Note: In animals as well as in birds, fats are widely distributed in the organs and tissues of the body; however, certain regions apparently serve as storehouses for in these large accumulations of fat are normally found.

Preliminary study revealed that the chief deposits of adipose tissue in the body of the pullet are found in the following regions:

1) Subcutaneous - fat deposited between the superficial fascia of the skin.

2) Abdominal - fat deposited in the posterior part of the abdominal cavity ("Pelvic cavity").

3) Intermuscular - fat deposited between the muscle sheets of the body.

The following routine method for removing and rendering the fat from the various regions of the body was employed in this study.

Plate III - Dissection of a Pullet showing the General Location of the Fat Depots Considered in this Study

1. Procedure for the Quantitative Determination of Total Fat Deposited Subcutaneously.

The subcutaneous fat commonly called panniculus adiposes was first removed. This was accomplished by cutting the skin directly in front of the Sartorius muscle. The superficial fascia (the connective tissue which forms a continuous covering over the whole body and serves to attach the skin to the underlying structures) was exposed by lifting the cut edges of the skin with forceps. A sharp scapel was then inserted into the incision, and the fascia were completely severed, thereby making it possible to remove the entire skin of the bird. Note: The skin of the forearm (wing) was omitted in these studies. It is important that the fascia have a certain degree of firmness in order to facilitate rapid removal of the skin and attached subcutaneous fat. This firmness is probably best secured by a seventy-two hour chilling of the carcass.

The entire skin and attached fat upon removal is weighed on a gram scale. This material was then cut into strips about two inches square and finally placed into glass jars containing three hundred cubic centimeters of distilled water. This procedure was repeated until the skin from the carcass of each individual pullet had been completely removed, weighed and deposited in a labeled jar. These containers were then sealed and placed in a vertical steam retort (See Plate II). Preliminary investigation has shown that eight to ten pounds pressure per square inch for a period of three hours was most satisfactory for complete rendering of all depot fat. Since further extractions failed to yield more fat, the writer has assumed that the rendering period employed gave a complete extraction of all depot fat present. The temperature maintained in the pressure retort during

rendering was approximately 235 to 250 degrees Centigrade.

After the rendering period, the jars were allowed to cool. Note: Since it is advisable to prevent precipitation of fat crystals, the temperature during cooling must not be allowed to drop below 50 degrees Centigrade. The rendered fat now in a liquid state (See Plate I) was separated from the distilled water by means of a modified separatory funnel. The fat obtained was weighed in grams and then placed in a drying oven having a temperature of 90 degrees Centigrade for approximately six to seven hours. This drying period was for the purpose of removing invisible water particles that were held between the globules of fat. The final step in this procedure consists of weighing the "dehydrated" fat. Note: This weight represents the total depot fat deposited in the subcutaneous region.

2. Procedure for the Quantitative Determination of Total Fat Deposited in the Abdominal Cavity.

The abdominal depot fat was removed by cutting transversally into the abdominal muscles namely Rectus Abdominis and Transversalis.Abdominis and exposing the posterior part of the abdominal cavity. The fat in this depot is found in a thick layer somewhat ellipsoid in form. The gizzard and intestines which are located centrally in this fat depot were removed and discarded. It should be noted that fat deposited in the folds of the mesentary has been omitted in this analysis.

After the total fat has been dissected out of the abdominal cavity, it is weighed and then placed in glass jars containing 300 cc. of distilled water. This material is rendered in a manner similar to that described

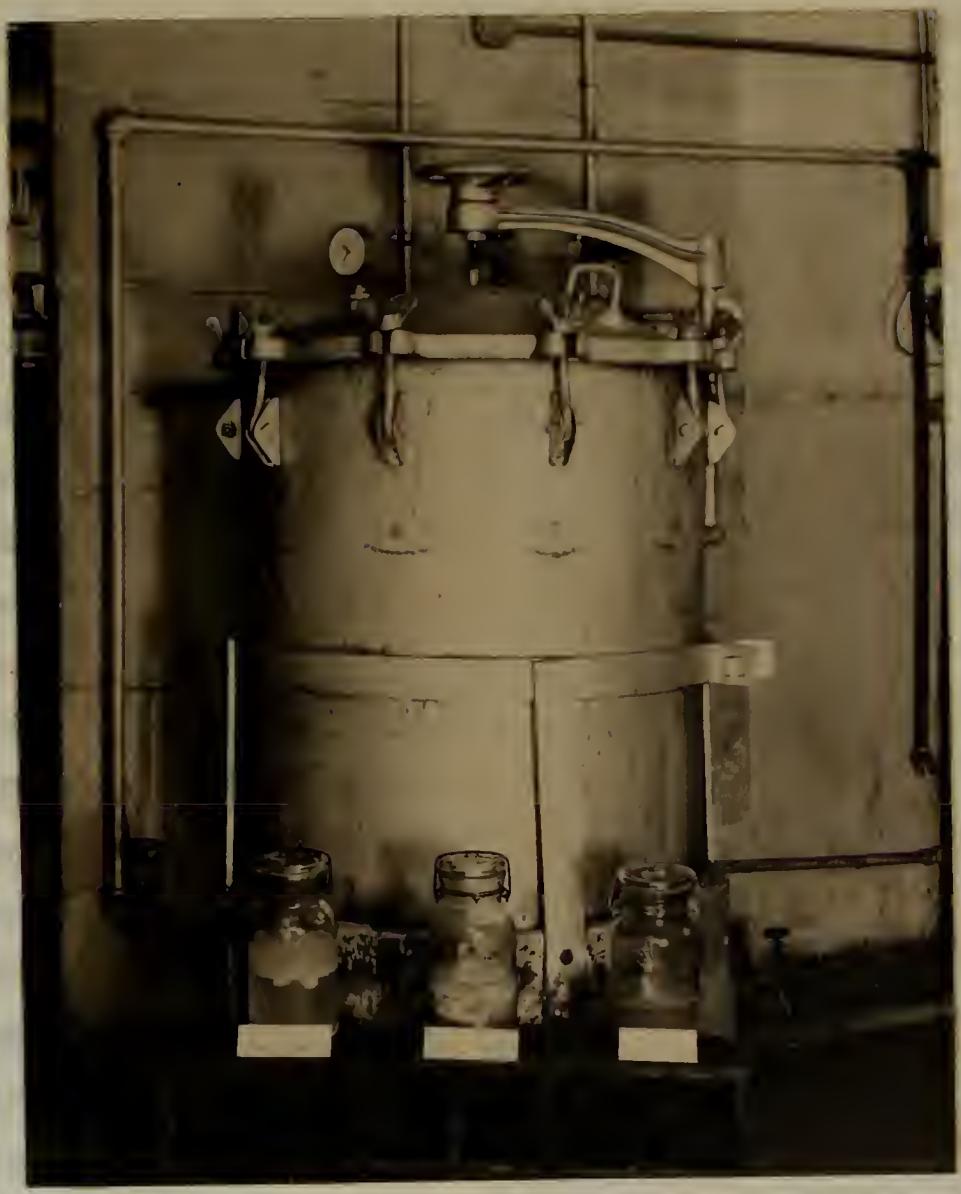

Plate IV - Vertical Steam Pressure Retort Employed in Rendering Dissected Adipose Tissues. Note the Relative Proportion of Fat obtained from the Three Depots Studied. Left - Abdominal Fat; Center - Subcutaneous Fat; Right - Intermuscular Fat.

under the procedure for the determination of total fat deposited in the subcutaneous region.

3. Procedure for the Quantitative Determination of Total Intermuscular Fat Deposited in the Dark Meat of the Pullet.

Preliminary study revealed that intermuscular fat is present in quantities large enough to be dissected out in a rather limited amount in the body of the pullet. The breast muscles, the neck muscles, as well as the muscles of the forearm (wing) were found to be practically devoid of visible depot fat. The only region of the body which contained reasonably large quantities of intermuscular fat were the posterior limbs. (See Plate III) The writer has therefore limited the scope of the analysis on total intermuscular fat to the adipose tissues found between the muscles of the posterior limbs (the dark meat).

The total intermuscular fat is obtained from the dark meat (thighs and legs) by carefully separating each muscle and removing by dissection all visible fat. Because of the small quantity of fat deposited intermuscularly, it was advisable, in order to secure the greatest possible accuracy in this quantitative determination to dissect both limbs of each pullet instead of a single limb.

The following muscular regions of the posterior limb were found to be the chief storehouses for intermuscular depot fat:

a) The largest intermuscular depot was found between the Sartorius and Glutens primus. In the early phases of this study, there was some question as to whether or not

this depot actually consisted of intermuscular fat. Dissection of approximately forty thighs showed that this fat is definitely intermuscular as it apparently originates between the Sartorius muscle and the Glutens primus muscle.

b) Between Glutens primus and Cruraus, there is generally a large amount of fat deposited. This depot is in the shape of a triangle.

c) A long strand of fat is found between Semitendinosus and Glutens primus. This strand of fat is similar in shape to that found in the anterior region of the Femur, however, it is somewhat smaller in size.

d) Between Semimembranosus and Adductor magnus; as well as between Femoro-Caudal and Abductor longus, there was also considerable depot fat present.

Note: All muscle positions and terminology are based on Knapp's Anatomy of the Domestic Fowl (1918).

All the intermuscular fat dissected out from each pullet was individually weighed and placed in glass jars containing three hundred cubic centimeters of distilled water. The procedure for rendering, separating, and drying the fat is similar to that described under (a) of Part IV.

b) Results

Reference to tables 27, 30, and 33 show the percentages of rendered fat obtained from the three main fat depots in the pullets analysed. In table 36, a complete summary of these findings is presented. It will be

noted that the pullets receiving the corn ration deposited the greatest amount of depot fat, whereas the oat fed birds showed upon analysis the smallest amount of depot fat. The difference between the corn and the oat samples with reference to the total amount of fat deposited was approximately six and one-half per cent. Note: The total depot fat represents the sum of the rendered fat obtained from the subcutaneous, abdominal and intermuscular regions.

Analysis of the data for each specific fat depot studied showed that the pullets in the corn lot definitely deposited more fat in the subcutaneous region than any of the other pullet samples analysed. The differences between the various lots were readily substantiated by statistical analysis (See tables 27-28-29). The value for F obtained was 10.37 which is definitely greater than Fischer's 1% point, thereby indicating a markedly significant difference between the means of the four lots with reference to this particular characteristic. Analysis for significance of difference between any pair of the means is presented in table 29. Definitely significant differences, as measured by Fischer's "t" value, were obtained between the mean percentages of fat found in the subcutaneous region for the Check and Oat lots; the Check and Wheat lots; the Check and Corn lots; and the Corn and Wheat lots. The pullet representatives from the Oat lot definitely showed less subcutaneous depot fat than any of the other samples analysed. The 3.16% of fat obtained from this group was less than one-half the amount of subcutaneous fat found in the corn fed pullets.

It will be noted in tables 30-31-32 that the pullets representing the corn and wheat groups deposited a greater amount of fat in the abdominal region than did the representatives of the oat or control groups. No signi-

Table XXVII. CEREAL GRAINS AND FAT DISTRIBUTION

Statistical Analysis of the Mean Per Cent of Fat Deposited Subcutaneously in the Four Lots

Body Weight	CHECK-LOT		OAT-LOT		WHEAT-LOT		CORN-LOT	
	% Skin Fat		% Skin Fat		% Skin Fat		% Skin Fat	
	1	2	1	2	1	2	1	2
Heavy	5.06	25.60	2.90	8.41	6.89	47.47	8.40	70.56
Medium	5.76	33.17	1.71	2.92	6.18	38.19	7.02	49.28
Medium	4.48	20.07	4.23	17.87	5.95	35.40	6.71	45.02
Light	3.44	11.93	3.87	14.97	3.53	12.46	7.63	58.21
Total	18.74		12.71		22.55		29.76	
Mean	4.68		3.18		5.64		7.44	

Note: (1) Per Cent fat rendered out of the subcutaneous region.
(2) One squared

a) Total per cent skin fat----------83.76

b) Correction factor ----------438.48

c) Sum of the squares of the 16 individual percentages---------491.45

d) Total sum of squares----------52.97

e) Sum of squares between means of feed-lots----------38.23

f) Sum of squares within feed-lots----------14.74

TABLE XXVIII

Analysis of Variance of Per Cent Fat Deposited Subcutaneously

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squared
Total	15	52.97	3.531
Between means of Feed-lots	3	38.23	12.740
Within Feed-lots	12	14.74	1.228

$$F = \frac{\text{Larger mean squared}}{\text{Smaller mean squared}} = \frac{12.740}{1.228} = 10.37$$

Values for F $\frac{3.49}{5.95}$ (Fischer's 5% point) (Fischer's 1% point)

Standard Deviation $\sqrt{1.228} = \pm 1.108$

Standard Error of the Mean of the Entire Sample $\sqrt{\frac{1.228}{16}} = \pm .876$

Discussion and Interpretation:- There is a highly significant difference between the mean percentages of fat deposited in the subcutaneous region. The value of F obtained was almost twice as large as Fischer's 1% point indicating the existance of highly significant differences between the means of the four lots with reference to this particular characteristic.

Table XXIX. Statistical Comparison Between Means of the Samples Analysed For the Various Lots

Check Lot Average % Subcutaneous Fat	4.68
Oat Lot Average % Subcutaneous Fat	3.18
Difference	1.50
"t"	6.114
"p"	.01 (less)
Significant	Yes
Check Lot Average % Subcutaneous Fat	4.68
Wheat Lot Average % Subcutaneous Fat	5.64
Difference	.96
"t"	3.913
"p"	.01 (less)
Significant	Yes
Check Lot Average % Subcutaneous Fat	4.68
Corn Lot Average % Subcutaneous Fat	7.44
Difference	2.76 (-)
"t"	11.251
"p"	.01 (less)
Significant	Yes
Corn Lot Average % Subcutaneous Fat	7.44
Wheat Lot Average % Subcutaneous Fat	5.64
Difference	1.80
"t"	7.337
"p"	.01 (less)
Significant	Yes

Table XXX, CEREAL GRAINS AND FAT DISTRIBUTION

Statistical Analysis of the Mean Per Cent of Fat

Deposited in the Abdominal Region

Body Weight	CHECK-LOT		OAT-LOT		WHEAT-LOT		CORN-LOT	
	% Abdominal Fat		% Abdominal Fat		% Abdominal Fat		% Abdominal Fat	
	1	2	1	2	1	2	1	2
Heavy	7.23	52.05	7.74	59.90	10.34	106.91	7.50	56.25
Medium	6.87	47.19	6.08	36.96	7.38	54.46	8.82	77.79
Medium	6.35	40.32	6.38	40.70	8.25	68.06	9.70	94.09
Light	4.22	17.80	5.03	25.30	8.35	69.72	8.03	64.46
Total	24.67		25.23		34.32		34.05	
Mean	6.17		6.31		8.58		8.51	

Note: (1) Per cent fat removed from the abdominal cavity.
(2) One squared.

a) Total per cent abdominal fat----------118.27

b) Correction factor----------874.23

c) Sum of the squares of the 16 individual percentages----------911.98

d) Total sum of squares----------37.75

e) Sum of squares between means of feed-lots----------21.45

f) Sum of squares within feed-lots----------16.30

TABLE XXXI

Analysis of Variance of Per Cent Fat Deposited in the Abdominal Region

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squared
Total	15	37.75	2.51
Between means of Feed-lots	3	21.45	7.15
Within Feed-lots	12	16.30	1.35

$$F = \frac{\text{Larger mean squared}}{\text{Smaller mean squared}} = \frac{7.15}{1.35} = 5.296$$

Values for F $\frac{3.49}{5.95}$ (Fischer's 5% point) (Fischer's 1% point)

Standard Deviation $\sqrt{1.35} = \pm 1.16$

Standard Error of the Mean of the Entire Sample $\sqrt{\frac{1.35}{16.0}} = \pm .918$

Discussion and Interpretation:- There is a significance difference between the mean percentages of fat deposited in the abdominal cavity. The value of F obtained was 5.296 which is slightly less than Fischer's highly significant value of 5.95.

Table XXXII. Statistical Comparison Between Means of the Samples Analysed for the Various Lots

Check Lot Average % Abdominal Fat	6.17
Oat Lot Average % Abdominal Fat	6.31
Difference	.14
"t"	.548
"p"	.6
Significant	No
Check Lot Average % Abdominal Fat	6.17
Wheat Lot Average % Abdominal Fat	8.58
Difference	2.41 (-)
"t"	9.443
"p"	.01 (less)
Significant	Yes
Check Lot Average % Abdominal Fat	6.17
Corn Lot Average % Abdominal Fat	8.51
Difference	2.34 (-)
"t"	9.161
"p"	.01 (less)
Significant	Yes
Corn Lot Average % Abdominal Fat	8.51
Wheat Lot Average % Abdominal Fat	8.58
Difference	.07 (-)
"t"	.274
"p"	.8
Significant	No

ficant difference as measured by "t" was obtained between the Corn and Wheat lots. Likewise, no significant difference as measured by "t" was obtained between the Oat and control lots. Definitely significant differences, however, in the per cent abdominal fat were obtained between the Check and Wheat lots, and the Check and Corn lots. The value for F obtained was 5.296 which is slightly less than Fischer's 1% value of 5.95. It is evident that the degree of variation or difference between the means of the lots was less with reference to the per cent of fat deposited abdominally than with the per cent of fat deposited subcutaneously.

Tables 33, 34, 35 show the per cent of fat deposited intermuscularly along with the statistical treatment of the data. A highly significant differences between the mean percentages of fat deposited intermuscularly was found. (See table 34) The test for significance of differences between the means of the various samples analysed showed that there were significant differences between the Check and Oat lot, Check and Wheat lot, Check and Corn lot, and the Corn and Wheat lot. The birds receiving the Wheat ration apparently deposited more fat in the intermuscular region than any of the other pullet samples analysed. The pullets in the Oat lot deposited the smallest amount of intermuscular fat.

If a deposit of intermuscular fat adds to the flavor and texture of poultry meat, the somewhat limited data from these studies indicate that the wheat-fed group might be superior for meat purposes.

In table 37, data are presented on the relative distribution of fat in the representatives analysed from the various lots. It will be noted that apparently the individual cereals fed affected the total deposition of fat as well as the distribution of the depot fat. The oat fed birds

Table XXXIII, CEREAL GRAINS AND FAT DISTRIBUTION

Statistical Analysis of the Mean Per Cent of Fat

Deposited Intermuscularly

Body Weight	CHECK-LOT		OAT-LOT		WHEAT-LOT		CORN-LOT	
	% Intermuscular Fat		% Intermuscular Fat		% Intermuscular Fat		% Intermuscular Fat	
	1	2	1	2	1	2	1	2
Heavy	1.01	1.02	.84	.70	1.00	1.00	1.07	1.14
Medium	1.00	1.00	.82	.67	1.31	1.72	.94	.88
Medium	.82	.67	1.08	1.16	1.18	1.39	1.01	1.02
Light	1.00	1.00	.77	.59	1.29	1.66	.92	.84
Total	3.83		3.51		4.78		3.94	
Mean	.96		.88		1.19		.98	

Note: (1) Per cent fat deposited intermuscularly.
(2) One squared.

a) Total per cent intermuscular fat ----------16.06

b) Correction factor----------16.12

c) Sum of the squares of the 16 individual percentages--------16.46

d) Total sum of squares----------.34

d) Sum of squares between means of feed-lots----------.219

f) Sum of squares within feed-lots----------.121

TABLE XXXIV

Analysis of Variance of Per Cent Fat Deposited Intermuscularly

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squared
Total	15	.340	.0226
Between means of Feed-lots	3	.219	.0730
Within Feed-lots	12	.121	.0100

$$F = \frac{\text{larger mean squared}}{\text{smaller mean squared}} = \frac{.0730}{.0100} = 7.3$$

Values for F $\begin{matrix} 3.49 \\ 5.95 \end{matrix}$ $\begin{matrix} \text{(Fischer's 5\% point)} \\ \text{(Fischer's 1\% point)} \end{matrix}$

Standard Deviation $\sqrt{.01} = \pm .1$

Standard Error of the Mean of the Entire Sample $\sqrt{\frac{.01}{16}} = \pm .025$

Discussion and Interpretation:- There is a highly significant difference between the mean percentage of the fat deposited in intermuscular region.

Table XXXV. Statistical Comparison Between Means of the Samples Analyzed For the Various Lots

Check Lot Average % Intermuscular Fat	3.83
Oat Lot Average % Intermuscular Fat	3.51
Difference	.32
"t"	14.54
"p"	.01
Significant	Yes
Check Lot Average % Intermuscular Fat	3.83
Wheat Lot Average % Intermuscular Fat	4.78
Difference	.95
"t"	43.18
"p"	.01
Significant	Yes
Check Lot Average % Intermuscular Fat	3.83
Corn Lot Average % Intermuscular Fat	3.94
Difference	.11
"t"	5.00
"p"	.01
Significant	Yes
Corn Lot Average % Intermuscular Fat	4.78
Wheat Lot Average % Intermuscular Fat	3.94
Difference	.84
"t"	38.18
"p"	.01
Significant	Yes

SUMMARY OF DATA ON FAT STUDIES

Table XXXVI
Per Cent Fat Deposited in the Various Regions of the Body

	Per Cent Subcutaneous Fat	Per Cent Abdominal Fat	Per Cent Intermuscular Fat	Total Fat Per Cent
Control	4.68	6.17	.967	11.75
Oats	3.18	6.31	.877	10.34
Wheat	5.64	8.58	1.196	15.43
Corn	7.44	8.51	.985	16.93

Table XXXVII
The Relative Distribution of Fat in the Body

	Per Cent Total Fat	Per Cent Subcutaneous Fat	Per Cent Abdominal Fat	Per Cent Intermuscular Fat
Control	11.75	39.80	51.96	8.22
Oats	10.34	30.63	60.88	8.47
Wheat	15.43	36.54	55.72	7.74
Corn	16.93	43.93	50.25	5.91

although depositing the smallest amount of total depot fat, showed a greater percentage of total fat deposited abdominally and intermuscularly. The corn fed pullets showed the greatest percentage of total fat deposited subcutaneously. It is apparent that the greatest variation or difference between the four lots was found in the percentage of total fat deposited subcutaneously.

It should be noted that the results presented in Part IV on fat deposition and distribution do not agree with Maw's findings. Attention is called to the fact that Maw in his studies used a different method for removing the fat and studied chickens instead of laying pullets.

GENERAL SUMMARY OF RESULTS

Part I. Cereal Grains and General Studies

a. Pullets laid equally well and maintained a good physical condition when fed on all-mash ration containing 65-75% of a single cereal grain. Yellow corn, oats, and wheat were the cereals considered in this study.

b. Pullets receiving the oat ration definitely consumed more feed than the pullets of the various other lots.

c. No significant differences were found in the body weight changes between pullets in the Control, Oat, Wheat, or Corn lots.

Part II. Cereal Grains and Egg Weight

a. No significant differences were noted in the weight of eggs produced by the four lots of pullets under observation.

Part III. Cereal Grains and Egg Quality

a. No significant differences were found between the various lots of pullets with reference to (1) open appearance of the egg; (2) percentage of firm white; (3) percentage of total solids in the thick and thin albumen; and (4) taste.

b. The egg yolks produced by pullets receiving the corn ration were markedly darker than the yolks produced by the pullets of the Control, Oat, or Wheat lots.

Part IV. Cereal Grains and Fat Deposition and Distribution

a. The different cereals fed apparently affected the total

amount of fat deposited, as well as the distribution of the depot fat.

1) The corn fed birds showed the greatest total amount of depot fat.

2) The control and oat fed birds were found to have the smallest total quantity of depot fat.

3) Pullets receiving the corn ration deposited a greatest percentage of the total fat subcutaneously than any of the other lots.

4) Pullets receiving the wheat ration possessed the greatest amount of intermuscular fat.

5) Both the wheat and corn fed birds showed a larger quantity of fat deposited abdominally than pullets from the Control and Oat lots.

6) No significant difference was found with reference to the per cent of abdominal fat deposited between the Corn or Wheat birds analyzed.

BIBLIOGRAPHY

Almquist, H. J., F. W. Lorenz, and E. R. Burmester 1932

Determination of Solid Matter and Density of Egg White by the Refractometer.

Ind. Eng. Chem. Annal. Ed. 4: 305-306

Atwood, H. 1914

Some Factors Affecting the Weight, Composition, and Hatchability of Hens' Eggs.

W. Va. Agr. Exp. Sta. Bul. 145: 71-102

Branion, H. D. 1933

The Role of Cereal Grains in Avian Nutrition.

Proceedings Fifth World's Poultry Congress, Rome 2: 595-602

Buss, W. J. 1918

Feeding Experiments with Laying Hens.
Comparison of Corn and Wheat.

Ohio Agr. Exp. Sta. Bul. 322: 228-231

Card, L. E. and H. J. Sloan 1934

Effect of Different Diets on Interior Egg Quality.

Poultry Sci. 13: 313-314

Cochel, W. A. and H. W. Jackson 1912

Poultry Experiments
Crude Fiber in the Ration of Laying Hens.

Penn. State College Agri. Exp. Sta. Bul. 120: 15-16

Curtis, C. M. 1917

Value of Oats for Adult Fowls

Rel. P. J. 24: 85

Fisher, R. A. 1930

Statistical Methods for Research Workers, 3rd Edition

Oliver and Boyd, London

Graham, J. C. 1934

Individuality of Pullets in Balancing the Ration.

Poul. Sci. 13: 34-39

Graham, W. R. Jr. 1932

Some Factors Affecting the Weight of Egg in the Domestic Fowl.

Scientific Agr. 12: 427-445

Hart, E. B., J. G. Halpin, and E. V. McCollum 1917

The Behavior of Chickens Fed Rations Restricted to the Cereal Grains.

Jour. Biol. Chem. 29: 57-67

Hart, E. B., J. G. Halpin and H. Steenbock 1917

The Behavior of Chickens Restricted to the Wheat and Maize Kernel.

Jour. Biol. Chem. 31: 415-420

Heiman, V. and J. C. Carver 1936

The Albumen Index as a Physical Measurement of Observed Egg Quality.

Poultry Sci 15: 141-148

Holst, W. F. and H. J. Almquist 1931

Measurement of Deterioration in the Stored Hen's Egg

Hilgardia 6: 46-60

Knupp, B. F. 1918

The Anatomy of the Domestic Fowl.

W. B. Saunders Company, Philadelphia

Knupp, B. F. and J. E. Ivey 1923

Digestion coefficients of Poultry Feeds and Rapidity of Digestion and Fate of Grit in the Fowl.

North Carolina Agr. Exp. Sta. Tech. Bul. 22: 3-143

Kennard, D. C. 1930

Oats for Layers.

Ohio Exp. Sta. Bimonthly Bul. 146: 152-154

Lippincott, W. A. and L. E. Card 1935

Poultry Production.

Lea and Febiger, Philadelphia

Lorenz, F. W., L. W. Taylor, and H. J. Almquist 1934

Firmness of Albumen as an Inherited characteristic.

Poul. Sci. 13: 14-17

Kistler, P. T., T. B. Charles, and H. C. Knandell 1926

Effects of Various Sources of Animal Protein on Egg Production.

Penn. Agr. Exp. Sta. Bul. 206: 1-23

Maw, W. A. 1935

The Cereal Grains and their Use in Poultry Nutrition. II. Influence on Live Weight Gains and Distribution of Fat in Fattening Stock.

Scientific Agriculture 16: 77-78

Newman, T. 1927

Small Egg Size

Eggs, Mar. 16: 153-154

North, M. O. 1934

Cereal Grains for Egg Production and Egg Quality

Wyoming Agri. Exp. Sta. Bul. 203: 1-22

Palmer, L. S. and H. L. Kempster 1919

Influence of Specific Feeds and Certain Pigments on the Color of the Egg Yolk and Body Fat of Fowls.

Jourl. Biol. Chem. 39: 331-338

Parkhurst, R. T. 1927

Weight of Egg and Weight and Growth of Chick.

Idaho Agr. Exp. Sta. Bul. 149: 35-39

Parkhurst, R. T., and E. B. Lonax 1930

Comparitive Value of Various Protein Feeds on Laying Hens.

Nat. Inst. Poul. Hus. Bul. 4: 1-20

Parkhurst, R. T. 1933

Some Factors Affecting Egg Weight in the Domestic Fowl

Poult. Sc. 12: 97-111

Reed, L., F. Yamaguchi, W. Anderson, and L. Mendel

Factors Influencing the Distribution and the Character of Adipose Tissue in the Rat.

Jour. Biol. Chem. 87: 147-157

Report on McCollum Poultry Nutrition Investigation
Prepared by John C. Hammond 1935

Effect of Diet on the Growth, Fattening and Egg Production of Poultry.

U. S. Egg and Poult. Mag. 40: 30-37

Report from the Queensland Exp. Sta. 1931

Wheat and Maize for Laying Hens.

Mt. Gravatt, Brisbane, Queensland

Rintoul, A. V. D. and W. C. Boggs 1922

Poultry Feeding Experiment

Jour. Dept. Agr. Victoria 20: 244-247

Robertson, G. and E. Beckett 1926

The Influence of Certain Nutritional Factors on the Size of the Egg and the Condition of the Birds.

Scottish J. Agr. 11 (2): 1-8

Sharp, P. F. 1934

The Condition of the Apparent Thick White as an Important Factor in Studying the Quality of Eggs.

U. S. Egg and Poult. Mag. 40: 33-37

Snedecor, G. W. 1934

Calculation and Interpretation of Analysis of Variance and Covariance.

Collegiate Press, Inc. Ames, Iowa.

Tully, W. C. 1934

Wheat and Wheat By-Products for Laying Hens.

S. D. Agr. Exp. Sta. Bul. 284: 2-7

White, R. H. 1911

The Effect of Feeding Corn on the Color of the Yolks of Eggs.

Mi. Exp. Sta. Bul. 157: 94-95

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