



.144
925
THS

THE SIG



This is to certify that the

thesis entitled

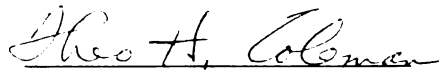
THE COMPARISON OF ROCKSHELL TO OYSTERSHELL
AND LIMESTONE AS A SOURCE OF CALCIUM ON
THE PERFORMANCE OF LAYING HENS AND LAYING PULLETS

presented by

Pamela Head

has been accepted towards fulfillment
of the requirements for

MS degree in Animal Science


Major professor

Date 8/14/81



OVERDUE FINES:

25¢ per day per item

RETURNING LIBRARY MATERIALS:

Place in book return to remove
charge from circulation records

SEP 27 1993

192

MAY 30 1996

6121614

THE COMPARISON OF ROCKSHELL TO OYSTERSHELL
AND LIMESTONE AS A SOURCE OF CALCIUM ON
THE PERFORMANCE OF LAYING HENS AND LAYING PULLETS

By

Pamela Head

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Animal Sciences

1981

ABSTRACT

THE COMPARISON OF ROCKSHELL TO OYSTERSHELL
AND LIMESTONE AS A SOURCE OF CALCIUM ON
THE PERFORMANCE OF LAYING HENS AND LAYING PULLETS

By

Pamela Head

6115620

An experiment to compare rockshell to oystershell and limestone as a source of calcium was conducted for a period of sixteen weeks. The experiment consisted of 12 experimental treatments with four replicates in each. There were two trials conducted. The first trial consisted of 192 laying pullets with four hens assigned to each replicate. The second trial consisted of 144 laying hens with three hens assigned to each replicate. The experiment was designed to investigate the effect of varying levels and sources of calcium on body weight gains, feed conversion, egg weights, feed consumption and eggshell thickness. The different experimental groups received the same basal diet supplemented with varying levels and sources of calcium. All data collected were subjected to statistical analysis.

In respect to shell thickness, birds receiving diets containing rockshell, as a source of calcium, produced eggs with significantly thicker eggshells compared to birds receiving diets containing oystershell and limestone at the 3.5% calcium level for laying hens and 2.75% calcium level for laying pullets. There was a significant influence found for egg production favoring oystershell at the 3.5% and

2.75% calcium level for both laying hens and laying pullets.
No significant differences in feed consumption, body weight gain or feed efficiency for either laying hens or laying pullets resulted from different sources of calcium.

113. "The first of the great things that we have
to do is to get the people to understand that
the only way to get the best of the world
is to get the best of the people."

ACKNOWLEDGMENTS

The author wishes to express her sincere appreciation to Dr. T.H. Coleman, Dr. Cal Flegal, and Dr. Lawrence Dawson for their assistance in constructing the manuscript.

Special thanks is given to my major professor, Dr. T.H. Coleman for his guidance, counseling and suggestions throughout my graduate program.

Appreciation is also extended to Dr. Cal Flegal and the Oystershell Company for their assistance while conducting this project for my graduate program.

Thanks are expressed to the members of the Poultry Farm Staff and graduate students in the Department of Poultry Science for their assistance.

Finally, thanks to my mother for all her sacrifice and encouragement throughout my graduate program.

Sincere thanks to Dr. John Gill and Margaret Connelly for their statistical advice.

TABLE OF CONTENTS

	Page
LIST OF TABLES.	iv
INTRODUCTION.	1
REVIEW OF LITERATURE.	2
OBJECTIVES.	12
PROCEDURE & METHODS	13
RESULTS & DISCUSSION.	17
SUMMARY	42
REFERENCES.	43
APPENDIX	

LIST OF TABLES

Table	Page
1. Average Feed Consumption of the Different Experimental Groups (kilograms) for a 16 Week Period (Trial 1).	18
2. Analysis of Variance of Average Feed Consumption of Pullets for a 16 Week Period (Trial 1)	19
3. Average Shell Thickness (mm) for Eggs Laid by Pullets for a 16 Week Period (Trial 1)	20
4. Analysis of Variance of Shell Thickness (mm) for Eggs Laid by Pullets for a 16 Week Period (Trial 1).	21
5. Analysis of Variance for Body Weight Gain for Pullets for a 16 Week Period (Trial 1)	23
6. Average Egg Production per Pullet (%) for a 16 Week Period (Trial 1)	24
7. Analysis of Variance of Egg Production for Pullets for a 16 Week Period (Trial 1).	26
8. Average Egg Weight (grams) for Pullets for a 16 Week Period (Trial 1)	27
9. Analysis of Variance of Egg Weight for Pullets for a 16 Week Period (Trial 1).	28
10. Average Feed Conversion for Pullets for a 16 Week Period (Trial 1) (lbs feed/doz eggs).	29
11. Analysis of Variance of Feed Conversion for Pullets for a 16 Week Period (lbs feed/doz eggs) (Trial 1)	30

1. The first step in the process of identifying a problem is to recognize that a problem exists. This involves gathering information about the situation and identifying the specific issue that needs to be addressed.
2. Once a problem has been identified, the next step is to define the problem clearly. This involves stating the problem in a concise and specific manner, and identifying the goals that need to be achieved.
3. The third step in the process is to generate potential solutions. This involves brainstorming ideas and considering different approaches to solving the problem.
4. The fourth step is to evaluate the potential solutions. This involves comparing the different solutions and determining which one is the most feasible and effective.
5. The fifth step is to implement the chosen solution. This involves putting the solution into action and monitoring its progress.
6. The final step in the process is to evaluate the results. This involves assessing the effectiveness of the solution and determining whether the problem has been solved.
7. It is important to note that the process of problem-solving is often iterative. This means that you may need to go back to earlier steps in the process as you learn more about the problem and the solutions.
8. Another important aspect of problem-solving is communication. This involves sharing information about the problem and the solutions with others who may be involved in the process.
9. Finally, it is important to be flexible and open-minded when solving a problem. This means being willing to consider different approaches and being able to adapt to changing circumstances.
10. In conclusion, the process of problem-solving involves identifying a problem, defining it, generating potential solutions, evaluating them, implementing the chosen solution, and evaluating the results. It is an iterative process that requires communication and flexibility.

Table	Page
12. Average Feed Consumption of the Different Experimental Groups (kilograms) for a 16 Week Period (Trial 2).	31
13. Analysis of Variance of Feed Consumption of Layers for a 16 Week Period (Trial 2).	32
14. Average Shell Thickness (mm) for Eggs Laid by Layers for a 16 Week Period (Trial 2)	34
15. Analysis of Variance of Shell Thickness (mm) for Eggs Laid by Layers for a 16 Week Period (Trial 2). . .	35
16. Analysis of Variance of Body Weight Gain for Layers for a 16 Week Period (Trial 2)	36
17. Average Egg Production per Layer (%) for a 16 Week Period (Trial 2)	38
18. Analysis of Variance of Egg Production for Layers for a 16 Week Period (Trial 2).	39
19. Average Feed Conversion for Pullets for a 16 Week Period (Trial 2) (lbs feed/doz eggs)	40
20. Analysis of Variance of Feed Conversion for Layers for a 16 Week Period (Trial 2).	41

Appendix

1. Composition of the 2.75% calcium level diet
used in the experiment in pounds
2. Composition of the 3.0% calcium level diet
used in the experiment in pounds
3. Composition of the 3.25% calcium level diet
used in the experiment in pounds
4. Composition of the 3.5% calcium level diet
used in the experiment in pounds

INTRODUCTION

It has been stated by S. Shane from the Poultry Tribune May 1981, "Losses due to defective eggshells amount to \$33 million for each 1% lost at farm level." The egg industry can ill afford such tremendous cost due to shell damage. Therefore, it is imperative to find better methods of producing stronger eggshells to decrease this loss.

From a review of existing literature, it can be seen that much research regarding the effectiveness of oystershell and limestone improving eggshell quality has been carried out. A relatively new product, rockshell, is now available as a source of calcium for poultry. An experiment was designed to compare different levels of rockshell, oystershell and limestone as sources of calcium in the diet of laying hens and laying pullets.

LITERATURE REVIEW

For many years researchers have been investigating ways to improve eggshell quality. Collier (1892) indicated that oystershell might be soluble in the gizzard of the chicken. This was the basic step leading others to investigate oystershell as a calcium source.

Scott et al (1976) stated that symptoms of calcium deficiency include: 1) retardation of growth, 2) decreased food consumption, 3) high basal metabolic rate, 4) reduced activity and sensitivity, 5) osteoporosis or low calcium rickets, 6) abnormal posture and gait, 7) susceptibility to internal hemorrhage, 8) a large increase in the volume of urine, 9) a reduced span of life, and 10) thin eggshells and reduced egg production.

There have been numerous researches conducted to determine the most effective sources of calcium for use in the diet of laying chickens. Pratt and Gutteridge (1944) found no significant differences in specific gravity of eggs from hens fed eggshell and those fed oystershell. However, a difference was found in the calcium content. Quisenberry et al (1969) found in comparing two different calcium sources, calcium carbonate and oystershell flour, that birds fed oystershell flour as a source of calcium laid larger eggs and had better livability than those fed calcium carbonate. Later, Quisenberry and Walker (1970) reported that the source of calcium had no effect upon egg production, feed efficiency and mortality. However, a significant

difference was found in the shell quality measurements due to the calcium source; oystershell resulting in superior shell weight and thickness.

Johnston and Tzyy (1973) used five different diets with calcium sources as follows: Fine calcite, hen size calcite, hen size oystershell, two-thirds hen size oystershell with one-third fine calcite, two-thirds hen-sized calcite with one-third fine calcite. Results showed no difference in eggshell thickness or in egg production between treatments.

Harris et al (1975) reported a study using five calcium sources at a level of 3% calcium. The sources were: 1) limestone, 2) aragonit, 3) oystershell, 4) macra clam shell, and 5) eggshell. Results indicated no significant difference in shell thickness or egg weight.

Parkhurst and Garlich (1975) in their used three treatments consisting of the following sources of calcium: 1) 2/3rd hen size oystershell and 1/3rd hard shell, 2) 2/3rd hen size oystershell and 1/3rd oystershell meal, 3) 2/3rd hen size cage cal meal. The birds receiving 2/3rd hen size oystershell and 1/3rd oystershell meal consumed less feed and produced a dozen eggs with the least amount of feed. It was concluded that hens fed oystershell produced eggs with significantly thicker shells and fewer cracks.

Charles (1978) did a special study using Shell Aid at a 0.25% to 1% level in the diet of older hens. His results indicated that older hens can benefit substantially

from the use of Shell Aid.

Several problems have occurred regarding the calcium distribution in hen diets. Researchers have found that some calcium sources are distributed in the diets better than other sources. Margruder (no date) reported a study involving calcium dispersion in relation to the calcium source. He found that when at least 50% of hen size oystershell has been added to the diet as a calcium source, a better distribution of calcium in the diet may be obtained. This helps eliminate the problem of having a calcium deficiency in feed formulation.

It has been found by researchers that laying hens can receive a higher level of calcium during the night by supplementing oystershell into the diets; whereas, other sources of calcium will not provide the hens with enough dietary calcium during the night. Scott et al (1971) reported that supplying calcium in the ratio of two-thirds oystershell and one-third pulverized limestone in the diets of laying hens improved eggshell quality. They also reported that oystershell particles were retained in the gizzard after 12 hours of fasting. However, no particles were found in the gizzard of hens receiving only the pulverized limestone diet.

Roland and Harms (1973) found that the digestive system of the laying hen contained more calcium in the late afternoon compared to the early morning. They also found that it contained the smallest amount from 12 midnight to 4 am.

Wilhelm (1940) found that the rate of production and shell thickness are not dependent on each other. He also stated that there is a definite seasonal trend in eggshell thickness which is related with temperature.

Sullivan and Kuhl (1974) conducted a research project to compare oystershell and limestone as large particle calcium supplements in rations for laying chickens. Their results indicated that crushed oystershell at the 5% level in the diet of laying chickens increased hen-day egg production by 1.8%, decreased cracked and checked eggs by 3.1% and reduced the feed required per dozen eggs by 0.3 lbs.

Gleaves and Ivy (1974) reported a study using three levels of egg production which were 0, 50 and 75% along with four levels of dietary calcium which were 0.5, 2.0, 4.0 and 6.0 percent. Each of the four diets was supplied with and without supplemental oystershell. Their results indicated that hens fed oystershell continuously consumed approximately the same energy and protein content at the 50.2% and 72.5% production levels, but consumed more oystershell at the higher production level.

Sanford (1974) conducted a study using pulverized calcium carbonate and hen size oystershell as sources of supplemental calcium. His results indicated that supplying at least one-half of the supplemental calcium as hen size oystershell helped to improve egg size and shell quality as compared with the use of all pulverized calcium.

There have been several reports on the effect of

calcium level added to the diet on egg production, egg weight, shell thickness and feed consumption. Hurwitz and Grimminger (1959) fed laying hens rations containing calcium levels of 1.85% and 2.7%. Their results showed that shell thickness and shell weight were improved with higher levels of calcium.

Petersen et al (1959) conducted a study involving the calcium and phosphorus level in the diet. The experiment consisted of using calcium at 2.25%, 3.75%, 4.50% and 5.25% levels. The results indicated a significant improvement in shell quality at the 3.75% level.

Hurwitz and Bar (1966) conducted a study involving two experiments. The first experiment involved restricting the calcium in the diet to observe the changes in shell and bone calcium. The second experiment consisted of a high or low calcium diet with gypsum and limestone during a 5-day depletion diet. The calcium content of eggshells and bones was measured during this period and a subsequent 3-week repletion period. Their results proved that the dietary calcium depletion resulted in a progressive decrease in blood and eggshell calcium. They observed that following a 5-day depletion with 1.7% calcium diets, eggshell calcium returned to normal after 6-8 days on a high calcium regime.

Berg et al (1951) conducted a study to test the hypothesis that during certain seasons shell quality decline may be caused by a decrease in the ability of the birds to assimilate shell-forming material from their food. This could result in an increase of the requirement for calcium and/or Vitamin D as the laying hen ages. The experiment

consisted of feeding birds the recommended level of 2.25 percent calcium along with 450 units of vitamin D per pound of feed. The birds were given the National Research Council's recommendation for three 28-day periods. At the end of the third 28-day period the calcium level was increased to 2.625% with the vitamin D level unchanged for the first group. The second group was supplied with an increase of vitamin D to 675 units per pound of feed with the calcium level unchanged. For the third group, both the calcium and vitamin D were increased to 2.625% calcium along with 675 units of vitamin D. Their results indicated that increasing the level of calcium and/or vitamin D did not affect egg production or egg weight, nor did it prevent the seasonal decline in thickness and smoothness of eggshells.

McKinney and Gholston (1972) found that highest production and shell thickness were obtained with 3.7% calcium from oystershell followed by 4.8% calcium from limestone.

Sauveur and Mongin (1974) conducted an experiment to determine the effect that time of day oystershell was available to birds had on eggshell quality. The three time periods used were afternoon, early morning and late afternoon. Their results indicated that oystershell supplied in the morning and early afternoon resulted in a lower shell quality compared to that from oystershell distributed during the late afternoon. They also found that feed consumption was lower during the late afternoon compared to the morning and early afternoon.

Charles (1972) conducted an experiment to evaluate the effect on eggshell breaking strength of using various dietary treatments with two strains of birds. There were five dietary treatments consisting of six replicates. Each replicate consisted of five hens from strain A and strain B. The dietary treatment consisted of a basal ration with different calcium supplementation: (1) granulated calcium carbonate, (2) oystershell, (3) finely ground marble flour, (4) oystershell in combination with calcium carbonate, (5) oystershell in combination with marble flour. Calcium from oystershell did not improve shell strength in strain A, nor did marble flour seem to depress breaking strength. In strain B, breaking strength was significantly depressed with marble flour, but was significantly improved by the use of oystershell in combination with finely ground calcium carbonate.

Massengale and Platt (1930) conducted an experiment to determine the effect of calcium from different sources on the growth and egg production of poultry. Five groups of chicks were used in the experimental procedure. Treatments were as follows: (1) 1.5% calcium in the form of oystershell plus basal ration, (2) 1.5% calcium in the form of limestone plus basal ration, (3) 1.5% calcium in the form of C.P. calcium carbonate plus basal ration, (4) 1.5% calcium in the form of precipitated tri calcium phosphate and (5) basal ration with no added calcium. Their results indicated that birds receiving oystershell and limestone were larger and

had better appearance than any other groups. However, the birds receiving precipitated $\text{Ca}(\text{PO})_2$ gained as much weight as those that received limestone and oystershell. The eggs produced by the groups receiving C.P. calcium carbonate were larger than those from the other groups. Shell percentage was the same for birds receiving oystershell, limestone and $\text{Ca}_3(\text{PO}_4)_2$.

EGG PRODUCTION

Arvat and Hinnars (1973) reported that in their experiment, egg production on a hen housed basis was not significantly affected by levels or sources of calcium in the diet. Calcium sources failed to result in significant differences in shell thickness. However, shell thickness was significantly better at the 5.7% calcium level than at the 3.7% level.

Tremere et al (1972) found that the level or sources of dietary calcium did not affect egg production, expressed on hen day basis, nor feed consumed per dozen eggs produced.

FEED CONSUMPTION AND EFFICIENCY

Scott et al (1971) found that a calcium intake of 2.8g of calcium per hen per day was inadequate and caused an increase in feed consumption and a significant decrease in eggshell quality.

Holder and Sullivan (1973) found that neither calcium level nor particle size had any consistent or great influence on percent egg production, egg weight, or feed efficiency.

Watkins et al (1976) reported that the highest level of dietary calcium (3.25%) in their diets resulted in a significant improvement in feed efficiency and egg weight; however, egg production and eggshell breaking strength for hens fed 2.5% calcium were equal to that of hens fed 3.25% calcium and significantly better than for those fed 1.75% calcium.

Charles (1975) conducted a study using 2.5% and 3.5% calcium in the diet. All diets were isonitrogenous and isocaloric. His results indicated that birds receiving 2.5% calcium consumed more feed than did birds receiving 3.5% calcium. Harms et al (1961) found that a level of 5.5 percent calcium in the diet of hens for a period of ten months did not affect feed consumption nor performance as indicated by egg production, shell thickness or mortality.

SHELL THICKNESS

In the experimental procedure of Berg et al (1947) there were three pre-laying rations given to each group of birds. Ration 1 contained 0.68 percent calcium without limestone flour. Ration 2 calcium level was increased to .93 percent and ration 3 to 3.02 percent. They determined the effect of calcium level on egg production and shell thickness with higher and lower levels of calcium in the diets. Other birds were placed on rations 4 and 5 after reaching sexual maturity and the diets contained 1.03 and 2.93 percent calcium, respectively. Their results indicated that shell thickness and egg production are not influenced

by the level of calcium during the pre-laying period, however, they are affected by the level of calcium fed during the laying period.

Bletner et al (1975) found that increasing the levels of calcium throughout the laying year had no significant effect on egg shell quality or other production parameters.

Roberson and Francis (1965) reported an experiment using two ascorbic acid levels, two calcium levels and three levels of reserpine to observe the affect on egg production, egg weight and shell thickness. They indicated that there was no significant difference found in egg production or egg weight measurements due to the calcium level. However, their data did indicate a significant difference in shell thickness due to the level of calcium in the diet.

the first of these is the fact that the
the second is the fact that the
the third is the fact that the
the fourth is the fact that the
the fifth is the fact that the
the sixth is the fact that the
the seventh is the fact that the
the eighth is the fact that the
the ninth is the fact that the
the tenth is the fact that the
the eleventh is the fact that the
the twelfth is the fact that the
the thirteenth is the fact that the
the fourteenth is the fact that the
the fifteenth is the fact that the
the sixteenth is the fact that the
the seventeenth is the fact that the
the eighteenth is the fact that the
the nineteenth is the fact that the
the twentieth is the fact that the
the twenty-first is the fact that the
the twenty-second is the fact that the
the twenty-third is the fact that the
the twenty-fourth is the fact that the
the twenty-fifth is the fact that the
the twenty-sixth is the fact that the
the twenty-seventh is the fact that the
the twenty-eighth is the fact that the
the twenty-ninth is the fact that the
the thirtieth is the fact that the
the thirty-first is the fact that the
the thirty-second is the fact that the
the thirty-third is the fact that the
the thirty-fourth is the fact that the
the thirty-fifth is the fact that the
the thirty-sixth is the fact that the
the thirty-seventh is the fact that the
the thirty-eighth is the fact that the
the thirty-ninth is the fact that the
the fortieth is the fact that the
the forty-first is the fact that the
the forty-second is the fact that the
the forty-third is the fact that the
the forty-fourth is the fact that the
the forty-fifth is the fact that the
the forty-sixth is the fact that the
the forty-seventh is the fact that the
the forty-eighth is the fact that the
the forty-ninth is the fact that the
the fiftieth is the fact that the
the fifty-first is the fact that the
the fifty-second is the fact that the
the fifty-third is the fact that the
the fifty-fourth is the fact that the
the fifty-fifth is the fact that the
the fifty-sixth is the fact that the
the fifty-seventh is the fact that the
the fifty-eighth is the fact that the
the fifty-ninth is the fact that the
the sixtieth is the fact that the
the sixty-first is the fact that the
the sixty-second is the fact that the
the sixty-third is the fact that the
the sixty-fourth is the fact that the
the sixty-fifth is the fact that the
the sixty-sixth is the fact that the
the sixty-seventh is the fact that the
the sixty-eighth is the fact that the
the sixty-ninth is the fact that the
the seventieth is the fact that the
the seventy-first is the fact that the
the seventy-second is the fact that the
the seventy-third is the fact that the
the seventy-fourth is the fact that the
the seventy-fifth is the fact that the
the seventy-sixth is the fact that the
the seventy-seventh is the fact that the
the seventy-eighth is the fact that the
the seventy-ninth is the fact that the
the eightieth is the fact that the
the eighty-first is the fact that the
the eighty-second is the fact that the
the eighty-third is the fact that the
the eighty-fourth is the fact that the
the eighty-fifth is the fact that the
the eighty-sixth is the fact that the
the eighty-seventh is the fact that the
the eighty-eighth is the fact that the
the eighty-ninth is the fact that the
the ninetieth is the fact that the
the ninety-first is the fact that the
the ninety-second is the fact that the
the ninety-third is the fact that the
the ninety-fourth is the fact that the
the ninety-fifth is the fact that the
the ninety-sixth is the fact that the
the ninety-seventh is the fact that the
the ninety-eighth is the fact that the
the ninety-ninth is the fact that the
the hundredth is the fact that the

OBJECTIVES

1. To compare rockshell (a form of calcium containing 38% calcium, .17% magnesium and .10% phosphorous) with limestone and oystershell as a source of calcium in rations for laying hens and laying pullets.
2. To determine the response of laying hens and laying pullets to increasing levels of rockshell compared to limestone and oystershell.

The parameters studied were:

- a. Shell quality
- b. Egg Production
- c. Feed conversion
- d. Body weight
- e. Egg weight

PROCEDURES AND METHODS

The experiment was carried out at the Poultry Science Research and Teaching Center, Michigan State University. Data were collected during four 28-day periods from September 22, 1980 to January 12, 1981.

The experiment consisted of two trials. Trial one involved 192 laying pullets 18 weeks of age. There were twelve treatments consisting of four birds assigned to each replicate. Trial two consisted of 164 laying hens between 48-56 weeks of age. There were twelve treatments consisting of four replicates with three birds assigned to each replicate. Prior to the start of the experiment, the birds used in trial two had been housed on the floor and had been receiving approximately fourteen hours of light. On June 24, 1980 the birds were moved from floor pens to cages. Birds were given the same amount of light (14 hours) they had formerly received. After the sudden change of environment the birds started molting. The experimental procedure started after all birds had gone through a complete molt.

All diets were mixed prior to the start of the experiment. Feed cans were provided individually for each replicate for each treatment. All birds were placed in individual cages with replicates from all treatments distributed evenly throughout the house. Water and feed troughs were connected to the front of all cages. Water and feed were provided ad libitum. Birds were fed their

dietary treatment carefully and accurately throughout the entire experiment. Temperature was recorded daily for the house during the coldest months of the experiment.

The initial weights of all birds were obtained on August 22, 1980. Birds were assigned to each dietary treatment according to their initial weight. All cages were labeled to designate each replicate treatment for every group.

The experimental treatment consisted of the following levels and sources of calcium:

- 1) 2.75% calcium from oystershell and Basal Ration
- 2) 2.75% calcium from limestone and Basal Ration
- 3) 2.75% calcium from rockshell and Basal Ration
- 4) 3.0% calcium from oystershell and Basal Ration
- 5) 3.0% calcium from limestone and Basal Ration
- 6) 3.0% calcium from rockshell and Basal Ration
- 7) 3.25% calcium from oystershell and Basal Ration
- 8) 3.25% calcium from limestone and Basal Ration
- 9) 3.25% calcium from rockshell and Basal Ration
- 10) 3.5% calcium from oystershell and Basal Ration
- 11) 3.5% calcium from limestone and Basal Ration
- 12) 3.5% calcium from rockshell and Basal Ration

During this study the following traits were measured:

1. Egg Production

Egg production was recorded daily for four 28-day periods beginning September 22, 1980. A record was posted to account for all eggs produced daily and was summarized every 28-day period.

2. Egg Weights

All eggs were marked and collected from each group on a four-day basis during the four 28-day periods. Eggs were weighed to the nearest .5 gram using a Toledo weighing scale.

3. Shell Thickness

Shell thickness was measured with a micrometer (Ames Thickness Gauge Model 25 ME, B.C. Ames Co., 131 Lexington St., Waltham, Ma. 02154). A specific portion was measured on the egg approximately $\frac{1}{4}$ " away from the apex. There was a four month average used to determine shell thickness. All shells were washed and air dried for a period of 48 hours. There was a three-day period used for egg collection for every 28-day period.

4. Feed Consumption

At the start of each four 28-day periods, the feed given to each treatment replicate group was weighed to the nearest 0.01 kg. Feed consumption was summarized at the end of every 28-day period. All feed cans were labeled. The remaining feed in troughs and

storage can of each replicate was weighed back at the end of each 28-day period to determine the amount of feed consumed.

5. Mortality

A record for mortality was kept for every treatment group and was summarized at the end of every 28-day period.

6. Body Weight Gain

The initial weight and final weight were obtained to determine the weight gain for all experimental treatments.

7. Feed Conversion

Feed conversion was calculated by the amount of feed consumed per dozen of eggs produced.

Data obtained were subjected to statistical analysis, and two statistical tests (F-test and Dunnet's test) were employed to compare the effects of the sources of calcium on shell quality, egg production, feed conversion, body weight gain, feed consumption and egg weight.

RESULTS AND DISCUSSION

Experiment 1 (Pullets)

(A) Feed Consumption

It appears that as the level of calcium was increased, feed consumption tended to decrease (Tables 1 and 2). The birds receiving 2.75% and 3.0% calcium consumed significantly ($P < .05$) more feed compared to the birds that were receiving 3.25% and 3.5% calcium. This agrees with Charles (1975) who reported that birds receiving 2.5% calcium consumed more feed than birds receiving 3.5% calcium. In the present experiment there were no interactions found for source by level. Period was highly significant and caused an interaction for source by period to be significant ($P < .01$).

(B) Shell Thickness

From observing the data it can be seen that birds receiving the diets containing rockshell as a source of calcium produced eggs with the highest value for shell thickness (Tables 3 and 4). This was probably due to the shell measurement at the 2.75% calcium level. Oystershell and rockshell values were similar. However, eggs from birds receiving diets containing rockshell showed a decline in shell thickness at the 3.5% calcium level, whereas, eggs from birds fed oystershell showed an increase in shell thickness. Eggs from birds fed limestone showed a decline in shell thickness at the 3.25% and 3.5% calcium levels. The data from this experiment indicated a highly significant

Table 1 - Average Feed Consumption of the Different
Experimental Groups (kilograms) for a 16
week period (Trial 1)

Calcium Source	Level of Calcium in Diet				Mean
	2.75%	3.0%	3.25%	3.5%	
Oystershell	11.94	12.60	10.57	11.25	11.55
Limestone	12.05	11.52	10.31	11.06	11.23
Rockshell	12.79	12.34	11.06	11.66	11.81
Mean	12.26Aa	12.15Aa	10.6Bc	11.32Ab	

+ Any two means having the same letter are not significantly different: means not having the same letter are significantly different. Small letters indicate significance at the .05 level: large letters at the .01 level.

• *Staphylococcus aureus* (Staph aureus)

• *Staphylococcus epidermidis* (Staph epidermidis)

• *Staphylococcus saprophyticus*

• *Staphylococcus carnosus*

• *Staphylococcus* spp. (Staphylococcus spp.)

• *Staphylococcus* spp. (Staphylococcus spp.)

• *Staphylococcus* spp. (Staphylococcus spp.)

• *Staphylococcus* spp. (Staphylococcus spp.)

• *Staphylococcus* spp. (Staphylococcus spp.)

• *Staphylococcus* spp. (Staphylococcus spp.)

• *Staphylococcus* spp. (Staphylococcus spp.)

• *Staphylococcus* spp. (Staphylococcus spp.)

• *Staphylococcus* spp. (Staphylococcus spp.)

• *Staphylococcus* spp. (Staphylococcus spp.)

Table 2 - Analysis of Variance of Final Average Feed
Consumption of Pullets for a 16 week period
(Trial 1)

Source of Variation	D.F.	S.S.	M.S.	F
Source	2	10.7837	5.39189	3.3447*
Level	3	73.69172	24.56391	15.25768**
(S/L)	6	14.32546	2.38758	1.48100
Rep/(S/L)E ₁	36	58.03391	1.61205	
Period	3	787.40859	262.46933	55.1479**
P/S	6	73.94812	12.32469	25.8956**
P/L	9	105.19184	11.69798	2.4585*
P/SL	18	214.82136	11.93452	2.5075**
(Rep/P)E ₂	108	514.0124	4.759	

* Significant.05 level

** Significant .01 level

Table 3 - Average Shell Thickness (mm) for Eggs Laid by
Pullets for a 16 week period (Trial 1)

Calcium Source	Level of Calcium in Diet				Mean
	2.75%	3.0%	3.25%	3.5%	
Oystershell	.46	.45	.46	.47	.46Yzz
Limestone	.48	.47	.37	.35	.42Yy
Rockshell	.55	.47	.47	.44	.48Zw
Mean	.50Bc	.46Ab	.43Aa	.42Aa	

+ Any two means having the same letter are not significantly different: means not having the same letter are significantly different. Small letters indicate significance at the .05 level: large letters at the .01 level.

**Table 4 - Analysis of Variance of shell thickness for Pullets
for a period of 16 weeks (Trial 1)**

Source of Variation	D.F.	S.S.	M.S.	F
Source	2	.0425	.021125	1.847
Level	3	.008	.00267	.232
S/L	6	.4177	.06962	6.054**
Rep/(SL)E ₁	36	.4144	.0115	
Period	3	.01595	.00532	1.004
P/S	6	.0624	.0104	2.08
P/L	9	.07287	.0081	1.62
S/L/P	18	0.378	.021	4.2**
(Rep/P)E ₂	108	.53818	.0050	

**** Significant at .01 level**

difference ($P < .01$) for the interaction source by level. There was also a significant difference found for the interaction source by level by period ($P < .01$). For shell thickness this report disagrees with Roberson and Francis (1965) and Hurwitz and Grimminger (1959); however, this report agrees with Bletner et al (1975) that increasing the levels of calcium throughout the laying year had no significant effect on eggshell quality for laying pullets. The data of Roberson and Francis (1965) indicated a significant difference in shell thickness due to the level of calcium in the diet. Hurwitz and Grimminger (1959) reported that shell thickness was improved with higher levels of calcium distributed in the diet.

(C) Body Weight Gain or Loss

There were no significant differences found between treatments for body weight gain or loss over the 16 week period (Table 5).

(D) Egg Production

The highest production rate occurred at the 2.75% calcium level with the lowest occurring at the 3.0% calcium level (Table 6). These data disagree with Arvat and Hinnens (1973) and Holder and Sullivan (1973) who reported that egg production was not significantly affected by sources or levels of calcium in the diet. Holder and Sullivan (1973) suggested that calcium level had no great influence on egg production. Charles' (1978) results indicated that clamshell was superior to or equal to oystershell in its effect on egg

**Table 5 - Analysis of Variance for Body Weight Gain for
Pullets for a 16 week period (Trial 1)**

Source of Variation	D.F.	S.S.	M.S.	F
Source	2	2986.87	14793.44	.4456
Level	3	97915.55	32638.52	.1605
S/L	6	613953.36	102325.56	.0031
Error	35	625780.60	17879.45	

Table 6 - Average Production for Pullets (%) for a 16
week period (Trial 1)

Calcium Sources	2.75%	3.0%	3.25%	3.5%	Mean
Oystershell	81.18	73.21	74.29	78.32	76.75Zz
Limestone	81.86	62.36	81.5	69.53	73.81Yz
Rockshell	72.92	59.54	70.39	72.82	68.92Yy
Mean	78.65Bb	65.04Aa	73.39Bb	73.56Bb	

+ Any two means having the same letter are not significantly different: means not having the same letter are significantly different. Small letters indicate significance at the .05 level; large letters at the .01 level.

production. There was a significant difference found for source by level interaction ($P < .05$) (Table 7).

(E) Egg Weight

In this study, egg weights showed a highly significant difference due to sources of calcium in the diet (Tables 8 and 9). Differences due to calcium level were also highly significant ($P < .01$). The 3.0% and 2.75% levels resulted in eggs that were significantly ($P < .01$) heavier than those from hens receiving the 3.25% and 3.5% levels of calcium. This does not agree with Holder and Sullivan (1973) who suggested that calcium level had no great influence on egg weight.

(F) Feed Conversion

There was no significant difference in feed conversion between birds fed diets containing calcium from different sources (Tables 10 and 11). However, there was a significant difference found for levels and the interaction source by level ($P < .01$). This report agrees with Parkhust and Garlich (1975) that birds fed oystershell consumed less feed compared to other treatments, and produced a dozen eggs by utilizing the least amount of feed. This report agrees with Holder and Sullivan (1973) that calcium level did not have any great influence on feed efficiency.

Experiment 2 (layers)

(A) Feed Consumption

In this experiment no significant differences were found in feed consumption that could be attributed to source or level of calcium in the diet (Table 12 and 13). There was a significant difference found for the interaction source

Table 7 - Analysis of Variance of Production for Pullets
for a 16 week period (Trial 1)

Source of Variation	D.F.	S.S.	M.S.	F
Source	2	27.79	13.9	.716
Level	3	287.47	95.8	4.94**
S/L	6	387.93	64.66	3.33*
Rep/(SL)E ₁	36	698.92	19.41	
Period	3	513.313	171.10	15.18**
P/S	6	37.61	6.27	.556
P/L	9	94.12	10.46	.928
P/S/L	18	173.4	9.63	.854
(P/Rep)E ₂	108	1217.57	11.27	

* Significant at the .05 level

** Significant at .01 level

Table 8 - Average Egg Weight (grams) for Pullets for a
16 week period (Trial 1)

Calcium Source	Level of Calcium in Diet				Mean
	2.75%	3.0%	3.25%	3.5%	
Oystershell	54.13	54.13	54.81	55	54.51Zz
Limestone	54.44	55.68	47.87	53.56	52.89Yy
Rockshell	51.63	54.13	54.38	47.13	51.83Yy
Mean	53.43Bb	54.65Bb	52.35Aa	51.90Aa	

+ Any two means having the same letter are not significantly different: means not having the same letter are significantly different. Small letters indicate significance at the .05 level; large letters at the .01 level.

Table 9 - Analysis of Variance of Egg Weight for Pullets
for a 16 week period (Trial 1)

Source of Variation	D.F.	S.S.	M.S.	F
Source	2	1266	633	111.56**
Level	3	101.76	33.92	5.978**
S/L	6	75.75	12.63	2.25
Rep/(SL)E ₁	36	204.278	5.674	
Period	3	1643.94	547.98	.6363
P/S	6	387.10	64.52	.0434
P/L	9	2952.17	328.02	.2208
P/L/S	18	2733.48	1485.59	1.73*
(Rep/P)E ₂	108	775.07	861.12	

*Significant at .05 level

**Significant at .01 level

Table 10 - Average Feed Conversion for Pullets for a
16 week period (Trial 1) ($\frac{\text{Pounds feed}}{\text{Doz. eggs}}$)

Calcium Source	Level of Calcium in Diet				Mean
	2.75%	3.0%	3.25%	3.5%	
Oystershell	1.576	2.208	1.875	2.0298	1.92
Limestone	2.001	1.672	1.989	2.442	2.00
Rockshell	1.84	2.208	1.973	1.97	2.00
Mean	1.803Aa	2.027Ab	1.70Aa	2.147Ab	

+ Any two means having the same letter are not significantly different: means not having the same letter are significantly different. Small letters indicate significance at the .05 level; large letters at the .01 level.

1. The first step in the process of creating a new product is to identify a market need. This involves conducting market research to determine what consumers want and what problems they are trying to solve.

2. Once a market need has been identified, the next step is to develop a concept for a product that meets that need. This involves brainstorming ideas and selecting the most promising one.

- The third step is to create a prototype of the product. This allows the designer to test the product and make any necessary adjustments.
- The fourth step is to conduct a feasibility study. This involves determining whether the product can be manufactured and sold at a profit.
- The fifth step is to develop a business plan. This involves determining the costs of production and marketing, and the potential revenue from sales.
- The sixth step is to secure funding. This can be done through a variety of methods, including crowdfunding, venture capital, and bank loans.

7. Once funding has been secured, the next step is to manufacture the product. This involves finding a manufacturer and negotiating terms of production.

- The eighth step is to launch the product. This involves marketing the product and getting it into the hands of consumers.
- The ninth step is to monitor the product's performance. This involves tracking sales and customer feedback to determine if the product is meeting its goals.
- The tenth step is to iterate on the product. This involves making improvements based on customer feedback and market trends.

Table 11 - Analysis of Variance Feed Conversion for Pullets
for a 16 week period (Trial 1) ($\frac{\text{Pounds Feed}}{\text{Doz. eggs}}$)

Source of Variation	D.F.	S.S.	M.S.	F
Source	2	.08625	.04312	.6455
Level	3	.8375	.2792	4.180**
S/L	6	2.435	.4058	6.0748**
Error	36	2.403	.0668	

** Significant at .01 level

1. The first part of the document is a list of the names of the persons who have been appointed to the various offices of the city of New York.

2. The second part of the document is a list of the names of the persons who have been appointed to the various offices of the city of New York.

3. The third part of the document is a list of the names of the persons who have been appointed to the various offices of the city of New York.

4. The fourth part of the document is a list of the names of the persons who have been appointed to the various offices of the city of New York.

Table 12 - Average Feed Consumption of the Different
Experimental Groups (kilograms) (Trial 2)

Calcium Sources	Level of Calcium in Diet				Mean
	2.75%	3.0%	3.25%	3.5%	
Oystershell	9.74	9.83	11.42	9.60	10.15
Limestone	10.37	10.73	8.78	9.50	9.84
Rockshell	10.08	8.80	9.11	11.32	9.83
Mean	10.06	9.78	9.77	10.14	

+ Any two means having the same letter are not significantly different: means not having the same letter are significantly different. Small letters indicate significance at the .05 level; large letters at the .01 level.

Table 13 - Analysis of Variance of Feed Consumption of
Layers for a 16 week period (Trial 2)

Source of Variance	D.F.	S.S.	M.S.	F
Source	2	4.1211257	2.06078	1
Level	3	5.11818	1.70606	1
S/L	6	128.74123	21.45687	5.6635**
Rep/(SL)E ₁	36	136.39058	3.78863	
Period	3	496.85862	165.61954	56.086**
P/S	6	21.0993	3.51665	1.19088
P/L	9	125.2514	13.91680	4.7128**
P/SL	18	152.50484	8.47249	2.86914
(P/Rep)E ₂	108	318.9211	2.952973	

** Significant at the .01 level

by level ($P < .01$). Period was highly significant ($P < .01$).

(B) Shell Thickness

In the present experiment a highly significant difference in shell thickness was found for both source of calcium and the diet and level ($P < .01$) (Tables 14 and 15). Eggshells from hens receiving limestone had the lowest mean average thickness and those from hens fed rockshell had the highest average thickness. This increase in shell thickness for rockshell was due to the 70 value at the 3.5% calcium level. No significant difference was found between oystershell and limestone. No significant difference was found for level with the exception of the 3.5% calcium level which resulted in significantly thicker eggshells. This report agrees with Petersen et al (1959) who reported a significant improvement in shell quality at the 3.75% calcium level. Quinsenberry and Walker (1970) found a significant difference in shell quality measurements due to the calcium source with oystershell producing superior shell thickness. Berg et al (1974) indicated that shell thickness is not influenced by the level of calcium during the pre-laying period; however, they reported that shell thickness is affected by level during the laying period.

(C) Body Weight Gain

No significant differences were found between treatments for body weight gain over the 16 week period (Table 16).

(D) Egg Weight

There were no significant differences in average weights of eggs produced by hens on the different treatments.

• Die Bedeutung der Sprache ist in der Literatur und in der Kunst von zentraler Bedeutung. Die Sprache ist das Medium, durch das wir unsere Gedanken und Gefühle ausdrücken können. Sie ist das Werkzeug, mit dem wir unsere Welt wahrnehmen und verstehen. In der Literatur wird die Sprache oft auf eine Weise verwendet, die über den reinen Informationsaustausch hinausgeht. Sie wird genutzt, um Emotionen zu wecken, Bilder zu malen und die Leser in eine fiktive Welt zu ziehen. In der Kunst ist die Sprache ebenfalls ein wichtiges Element. Sie kann die Bedeutung eines Werkes vertiefen und neue Perspektiven eröffnen. Die Kunst der Sprache ist eine Kunst, die sich ständig weiterentwickelt und neue Formen annimmt.

• Die Rolle des Autors ist ebenfalls von großer Bedeutung. Der Autor ist der Schöpfer des Textes, der die Worte wählt und die Sätze aufbaut. Er ist derjenige, der die Botschaft des Textes bestimmt und die Leser dazu bringt, sich mit dem Text auseinanderzusetzen. Der Autor ist auch derjenige, der die Verantwortung trägt, wenn der Text Missverständnisse oder Verletzungen verursacht. Die Rolle des Autors ist also eine verantwortungsvolle Aufgabe, die viel Können und Einfühlungsvermögen erfordert.

• Die Wirkung der Literatur ist ein weiterer wichtiger Aspekt. Literatur hat die Fähigkeit, Menschen zu verbinden und ihnen neue Einsichten zu vermitteln. Sie kann Menschen dazu bringen, ihre eigenen Gedanken und Gefühle zu reflektieren und sie in einen größeren Kontext zu setzen. Literatur kann auch dazu beitragen, gesellschaftliche Probleme zu thematisieren und Lösungen zu finden. Die Wirkung der Literatur ist also vielfältig und reicht von der individuellen Selbstreflexion bis hin zur gesellschaftlichen Veränderung.

• Die Kunst der Sprache ist ein weiterer wichtiger Aspekt. Die Kunst der Sprache ist die Kunst, die Worte so zu verwenden, dass sie eine maximale Wirkung erzielen. Dies erfordert ein tiefes Verständnis der Sprache und ihre Regeln. Die Kunst der Sprache ist auch die Kunst, die Worte so zu verwenden, dass sie eine neue Welt erschaffen. Die Kunst der Sprache ist eine Kunst, die sich ständig weiterentwickelt und neue Formen annimmt.

• Die Bedeutung der Sprache ist in der Literatur und in der Kunst von zentraler Bedeutung. Die Sprache ist das Medium, durch das wir unsere Gedanken und Gefühle ausdrücken können. Sie ist das Werkzeug, mit dem wir unsere Welt wahrnehmen und verstehen. In der Literatur wird die Sprache oft auf eine Weise verwendet, die über den reinen Informationsaustausch hinausgeht. Sie wird genutzt, um Emotionen zu wecken, Bilder zu malen und die Leser in eine fiktive Welt zu ziehen. In der Kunst ist die Sprache ebenfalls ein wichtiges Element. Sie kann die Bedeutung eines Werkes vertiefen und neue Perspektiven eröffnen. Die Kunst der Sprache ist eine Kunst, die sich ständig weiterentwickelt und neue Formen annimmt.

Table 14 - Average Shell Thickness for Layers (mm) for
a 16 week period (Trial 2)

Calcium Source	Level of Calcium in Diet				Mean
	2.75%	3.0%	3.25%	3.5%	
Oystershell	.47	.49	.49	.51	.49Yy
Limestone	.49	.49	.48	.46	.48Yy
Rockshell	.48	.50	.49	.70	.542Zz
Mean	.48Aa	.49Aa	.49Aa	.56Bb	

+Any two means having the same letter are not significantly different: means not having the same letter are significantly different. Small letters indicate significance at the .05 level; large letters at the .01 level.

Table 15 - Analysis of variance of Shell Thickness for
Layers for a 16 week period (Trial 2)

Source of Variation	D.F.	S.S.	M.S.	F
Source	2	0.944	.472	48.16**
Level	3	.4836	.1612	16.44**
SS _E	86	0.084	.00098	

** Significant at the .01 level

Table 16 - Analysis of Variance Body Weight Gain for Layers
for a 16 week period (Trial 2)

Source of Variation	D.F.	S.S.	M.S.	f
Source	2	85288.80	42644.40	.49011
Level	3	17801.58	5933.86	.95875
S/L	6	346028.48	57671.41	.45064
SS _E	35	2050618.43	58589.10	

(E) Egg Production

There was a significant difference in egg production of birds receiving different levels of calcium with those on the 3.5% level favored (Tables 17 and 18). This report agrees with Quisenberry and Walker (1970) who reported that the source of calcium had no effect upon egg production. This report disagrees with Tremere et al (1972) who found that the level or sources of dietary calcium did not affect egg production, expressed on a hen day basis.

(F) Feed Conversion

There were no significant differences found for source. However, a significant difference was found for level and the interaction source by level ($P < .01$) (Tables 19 and 20).

Table 17 - Average Egg Production per Layer for a 16
week period (%) (Trial 2)

Calcium Source	Level of Calcium in Diet				Mean
	2.75%	3.0%	3.25%	3.5%	
Oystershell	44.78	36.18	31.12	52.14	41.06Zz
Limestone	29.12	36.46	44.79	28.12	34.62Yy
Rockshell	33.68	37.64	28.46	48.43	37.05Yy
Mean	35.86Aa	36.76Aa	34.79Aa	42.90Bb	

+ Any two means having the same letter are not significantly different: means not having the same letter are significantly different. Small letters indicate significance at the .05 level; large letters at the .01 level.

1. The first step in the process of creating a new product is to identify a market need. This involves conducting market research to determine what consumers want and what problems they are trying to solve.

2. Develop a Business Plan

2. Once a market need has been identified, the next step is to develop a business plan. This plan should outline the company's goals, the products it will offer, the target market, and the marketing strategy. It should also include financial projections and a timeline for development and launch.

3. The third step is to secure funding. This can be done through a variety of sources, including venture capitalists, angel investors, and crowdfunding.

4. Once funding has been secured, the next step is to develop the product. This involves hiring a team of engineers and designers to create a prototype and then refining it based on feedback from potential customers. The final step is to launch the product and begin marketing it to the target market.

Table 18 - Analysis of Variance Layers Production 16 week
period (Trial 2)

Source of Variation	Degrees of Freedom	Sum of Square	Mean Square	F Stastic
Source	2	9.398	4.70	.2016
Level	3	2622	874	37.49**
SS _E	469	10934.16	23.31	

** Significant at the .01 level

Table 19 - Average Feed Conversion 16 week period
(Trial 2)

Calcium Source	Level of Calcium in Diet				Mean
	2.75%	3.0%	3.25%	3.5%	
Oystershell	3.968	5.208	7.961	3.864	5.25
Limestone	3.732	6.492	5.764	6.89	5.72
Rockshell	7.057	4.246	6.259	3.791	5.34
Mean	4.919Aa	5.31Aa	6.661Bb	4.848Aa	

+ Any two means having the same letter are not significantly different: means having the same letter are significantly different. Small letters indicate significance at the .05 level; large letters at the .01 level.

Figure 1. The effect of the concentration of the solution on the adsorption of the dye. The concentration of the solution was 0.01, 0.02, 0.04, 0.06, 0.08, 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 2.0, 4.0, 6.0, 8.0, 10.0, 20.0, 40.0, 60.0, 80.0, 100.0 mg/L. The concentration of the adsorbent was 0.1 g/L. The adsorption time was 24 h. The temperature was 25 °C.



Figure 2. The effect of the concentration of the adsorbent on the adsorption of the dye. The concentration of the solution was 0.01, 0.02, 0.04, 0.06, 0.08, 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 2.0, 4.0, 6.0, 8.0, 10.0, 20.0, 40.0, 60.0, 80.0, 100.0 mg/L. The concentration of the adsorbent was 0.1, 0.2, 0.4, 0.6, 0.8 g/L. The adsorption time was 24 h. The temperature was 25 °C.

Table 20 - Analysis of Variance of Feed Conversion for
Layers for a 16 week period (Trial 2)

Source of Variation	Degrees of Freedom	Sum of Square	Mean Square	F Stastic
Source	2	2.394	1.197	.345
Level	3	26.025	8.675	2.51
S/L	6	99.32	16.55	4.78**
SS _E	36	124.731	3.46	

** Significant at the .01 level

SUMMARY

This Report has indicated that:

(1) At the 3.5% calcium level for laying hens and the 2.75% calcium level for laying pullets, rockshell is superior to oystershell and limestone in its effects on eggshell thickness.

(2) Calcium sources and levels have a significant influence on egg production. At the 3.5% and 2.75% calcium level,... for both laying hens and laying pullets, birds receiving the diet containing oystershell produced more eggs than did birds receiving either limestone or rockshell as a source of calcium.

(3) Calcium sources have no significant influence on feed consumption, body weight gain or loss, or feed efficiency for either laying hens or laying pullets.

REFERENCES

- Arvat, V. and S. W. Hinners, 1973. Evaluation of eggshells as a low cost calcium for laying hens. Poultry Science 52:1976.
- Berg, L. R., G. E. Bearse and V. I. Miller, 1947. The effect of the pre-laying level of calcium on the performance of white leghorn pullets. Poultry Science 54:1332.
- Berg, L. R., G. E. Bearse and V.I. Miller, 1951. The effect of periodically increasing the level of calcium and/or vitamin D on the performance of laying pullets. Poultry Science 30:799.
- Bletner, L.G.G., McCraney and G. C. McGhee, 1975. Constant rate calcium increases in laying diets. Poultry Sci. 54:1735.
- Charles, O.W., 1972. The economic effect of calcium source on laying hen performance. Extension Poultry Science Dept., Athens, Georgia.
- Charles, O.W., 1975. Further studies on the calcium requirement of laying hens. Poultry Sci. 54:1332.
- Charles, O.W., 1978. The response of leghorn breeders to continuous dietary shell aid. Mimeograph, University of Georgia, Athens, Georgia.
- Collier, P., 1892. Oystershells as food for laying hens. New York Agri. Exp Sta (Geneva) Bul 38:1-10.
- Gleaves, E.W. and R.E. Ivy, 1974. The effects of various levels of dietary calcium and egg production upon the regulation of feed consumption in laying hens. Poultry Sci. 53:1927.
- Harris, P.C., R.W. Gerry and F.V. Muir, 1975. The comparative value of five calcium sources for laying hens. Poultry Sci. 54:1772.
- Harms, R.H., C.R. Douglas and P.W. Waldroup, 1961. The effects of feeding various levels and sources of phosphorous to laying hens. Florida Agri. Exp. Sta Bul 644.
- Holder, D. P. and T.W. Sullivan, 1973. Influence of levels and particles size of calcium supplement on performance of laying hens. Poultry Sci. 52:2041.
- Hurwitz, S. and P. Grimminger, 1959. Calcium balance and eggshell strength. Poultry Sci. 38:1214.

- Hurwitz, S. and A. Bar, 1966. Calcium depletion and repletion in laying hens. Poultry Sci. 45:352.
- Johnston, N.P. and J.D.Y. Tzyy, 1973. Relation of source and particle size of dietary calcium carbonate to eggshell thickness and egg production in laying hens. Poultry Science 52:2045.
- Margruder, N.B. Calcium distribution and environmental studies. Cargill Inc.
- Massengale, O.N. and C.S. Platt, 1930. Effect of calcium from different sources on growth and egg production. Poultry Science 9:240.
- McKinney, C.W. and J.T. Gholston, 1972. A study of calcium sources for laying hens. Poultry Science 51:1835.
- Parkhurst, C.R. and J.D. Garlich, 1975. A comparison of hens fed oystershell, hardshell and cage cal. Poultry Science 54:1803.
- Petersen, C.F., E.A. Sauter, A.C. Wiese and D.J. Lumjarvi, 1959. Influence of calcium and other nutrients upon shell quality of high producing white leghorn hens. Poultry Science 38:1236.
- Pratt, J.M. and H.S. Gutteridge, 1944. Eggshells as a source of calcium for laying birds. Poultry Science 24:87.
- Quisenberry, J.H., J. C. Walker and J. W. Bradley, 1969. Calcium levels, sources and methods of feeding. Poultry Science 48:1861.
- Quisenberry, J. H. and J. C. Walker, 1970. Calcium sources for egg production and shell quality. Poultry Science 49:1429.
- Roberson, R. H. and D.W. Francis, 1965. Egg quality factors as affected by calcium, ascorbic acid and reserpine levels of the ration. Poultry Science 44:1409.
- Roland, D.A., Sr. and R. H. Harms, 1973. Calcium metabolism in layers. Poultry Science 52:369.
- Sanford, P. E., 1974. Particle size of calcium for laying hens. Poultry Science 53:1974.
- Sauveur, B. and P. Mongin, 1974. Effects of time-limited calcium meal upon food and calcium ingestion and egg quality. British Poultry Science J. 15:305.

the first of these is the fact that the system is not a simple one, but a complex one, in which the various parts are interrelated and interdependent. The second is that the system is not a static one, but a dynamic one, in which the various parts are constantly changing and evolving. The third is that the system is not a closed one, but an open one, in which the various parts are constantly interacting with the environment. The fourth is that the system is not a linear one, but a non-linear one, in which the various parts are constantly interacting with each other in a non-linear fashion. The fifth is that the system is not a deterministic one, but a probabilistic one, in which the various parts are constantly interacting with each other in a probabilistic fashion. The sixth is that the system is not a simple one, but a complex one, in which the various parts are interrelated and interdependent. The seventh is that the system is not a static one, but a dynamic one, in which the various parts are constantly changing and evolving. The eighth is that the system is not a closed one, but an open one, in which the various parts are constantly interacting with the environment. The ninth is that the system is not a linear one, but a non-linear one, in which the various parts are constantly interacting with each other in a non-linear fashion. The tenth is that the system is not a deterministic one, but a probabilistic one, in which the various parts are constantly interacting with each other in a probabilistic fashion.

- Scott, M. S., I. Hull and P. A. Mullenhoff, 1971. The calcium requirements of laying hens and effects of dietary oystershell upon eggshell quality. Poultry Science 50:1063.
- Scott, M. S., M. C. Nesheim and R. J. Young, 1976. Nutrition of the chicken. M. L. Scott and Associates, Publishers, Ithaca, New York 1976.
- Shane, S. The influence of cage and equipment design on eggshell quality. Poultry Tribune. May 1981.
- Sullivan, T. W. and H. J. Kuhl, 1974. Comparative value of oystershell and limestone as large particle supplements in rations for laying chickens. University of Nebraska, Lincoln, Nebraska.
- Tremere, A. W., J. F. Standish and W. D. Morrison, 1972. Effect of levels and sources of dietary calcium on the performance of laying hens. Poultry Science 51:1880.
- Watkins, R. M., J. McNaughton, B.C. Dilworth and E.J. Day, 1976. Effect of dietary calcium level, particle size and feed restriction on egg shell quality and the performance of cage layers. Poultry Science 54:1348.
- Wilhelm, L. A., 1940. Some factors affecting variation in eggshell quality. Poultry Science 19:246.

(E) Egg Production

There was a significant difference in egg production of birds receiving different levels of calcium with those on the 3.5% level favored (Tables 17 and 18). This report agrees with Quisenberry and Walker (1970) who reported that the source of calcium had no effect upon egg production. This report disagrees with Tremere et al (1972) who found that the level or sources of dietary calcium did not affect egg production, expressed on a hen day basis.

(F) Feed Conversion

There were no significant differences found for source. However, a significant difference was found for level and the interaction source by level ($P < .01$) (Tables 19 and 20).

Table 17 - Average Egg Production per Layer for a 16
week period (%) (Trial 2)

Calcium Source	Level of Calcium in Diet				Mean
	2.75%	3.0%	3.25%	3.5%	
Oystershell	44.78	36.18	31.12	52.14	41.06Zz
Limestone	29.12	36.46	44.79	28.12	34.62Yy
Rockshell	33.68	37.64	28.46	48.43	37.05Yy
Mean	35.86Aa	36.76Aa	34.79Aa	42.90Bb	

+ Any two means having the same letter are not significantly different: means not having the same letter are significantly different. Small letters indicate significance at the .05 level; large letters at the .01 level.

the $\mathbb{Z}_2$ -invariant $\mathbb{Z}_2$ -equivariant cohomology of the space of n -tuples of points in $\mathbb{C}P^1$ is

$$H_{\mathbb{Z}_2}^*(\mathbb{Z}_2\text{-}C_n(\mathbb{C}P^1)) = \mathbb{Z}_2[x, y, z].$$

where x, y, z are generators of degree 1. The $\mathbb{Z}_2$ -invariant $\mathbb{Z}_2$ -equivariant cohomology of the space of n -tuples of points in $\mathbb{C}P^1$ is isomorphic to the $\mathbb{Z}_2$ -invariant $\mathbb{Z}_2$ -equivariant cohomology of the space of n -tuples of points in $\mathbb{C}P^1$. The $\mathbb{Z}_2$ -invariant $\mathbb{Z}_2$ -equivariant cohomology of the space of n -tuples of points in $\mathbb{C}P^1$ is isomorphic to the $\mathbb{Z}_2$ -invariant $\mathbb{Z}_2$ -equivariant cohomology of the space of n -tuples of points in $\mathbb{C}P^1$.

where x, y, z are generators of degree 1. The $\mathbb{Z}_2$ -invariant $\mathbb{Z}_2$ -equivariant cohomology of the space of n -tuples of points in $\mathbb{C}P^1$ is isomorphic to the $\mathbb{Z}_2$ -invariant $\mathbb{Z}_2$ -equivariant cohomology of the space of n -tuples of points in $\mathbb{C}P^1$.

The $\mathbb{Z}_2$ -invariant $\mathbb{Z}_2$ -equivariant cohomology of the space of n -tuples of points in $\mathbb{C}P^1$ is isomorphic to the $\mathbb{Z}_2$ -invariant $\mathbb{Z}_2$ -equivariant cohomology of the space of n -tuples of points in $\mathbb{C}P^1$. The $\mathbb{Z}_2$ -invariant $\mathbb{Z}_2$ -equivariant cohomology of the space of n -tuples of points in $\mathbb{C}P^1$ is isomorphic to the $\mathbb{Z}_2$ -invariant $\mathbb{Z}_2$ -equivariant cohomology of the space of n -tuples of points in $\mathbb{C}P^1$.

Table 18 - Analysis of Variance Layers Production 16 week
period (Trial 2)

Source of Variation	Degrees of Freedom	Sum of Square	Mean Square	F Stastic
Source	2	9.398	4.70	.2016
Level	3	2622	874	37.49**
SS _E	469	10934.16	23.31	

** Significant at the .01 level

APPENDIX TABLE 1 - Composition of the 2.75% calcium level
diet used in the experiments

Ingredient	%
Corn, ground yellow	69.7
Soybean Meal, 45% protein	18.1
Alfalfa	.1784
Dical	.60152
*Calcium Carbonate	5.536
Salt	.2992
Methionine DL	.03485
M& B Meal	5.124
Premix	.4

* Indicates the source of calcium used in the
experimental diets. Source was oystershell, calcium
carbonate or rockshell.

APPENDIX TABLE 4 - Composition of the diet 3.5% calcium
level used in the experiments

Ingredient	%
Corn, ground yellow	68.98
Soybean Meal, 45% protein	17.85
Alfalfa	.175
Dical	.60512
*Calcium Carbonate	6.76
Salt	.294
Methionine DL	.03429
M&B Meal	5.044
Premix	.400

* Indicates the source of calcium used in the
experimental diets. Source was oystershell, calcium
carbonate or rockshell.

MICHIGAN STATE UNIV. LIBRARIES



31293008226775