MANAGEMENT AND HOLDING CONDITIONS AS THEY AFFECT THE INTERIOR QUALITY OF EGGS

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MANAGEMENT AND HOLDING CONDITIONS AS THEY AFFECT

THE INTERIOR QUALITY OF EGGS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

INTRODUCTION

The interior quality of an egg is at its maximum immediately after being laid. It cannot be improved, as deterioration begins immediately. This deterioration will continue at a rate which is dependent upon several factors, two of the most important being time and temperature. Temperature refers to the egg storage room temperature, and time to the frequency of marketing. Other factors contributing to rate of quality deterioration include management and handling practices. Contradicting results have been obtained by the research reported in this field, and it is felt that some of the general recommendations made to farmers are without basis.

For most farmers in Oklahoma, production of eggs is a sideline business, but, even with this being the case, management and holding practices should be used that will give to the farmer maximum income. In a survey of 139 farmers near ten randomly selected towns in Oklahoma, egg marketing and management practices were determined as follows (Newell and Fry, 1955):

1. Frequency of gathering -- 40.4% gathered only once daily, 47.1% twice daily, and 12.5% more often than twice daily.

2. Location of egg storage -- 60.3% cave or cellar, 14.5% egg room, 7.6% basement, 5.3% porch, and 12.3% other.

3. Frequency of marketing -- 47.1% marketed eggs weekly, 43.5% twice weekly, and 9.4% more often than twice weekly.

The present study was undertaken to provide a basis for recommendations to farmers by which they might maximize their income and by which eggs of the highest quality might be placed in Oklahoma market channels. Investigations were conducted to determine:

1. The effect of management practices (frequency of collection, method of cooling, and frequency of marketing) on interior quality.

2. The time-temperature relationship in quality deterioration at selected temperatures.

REVIEW OF LITERATURE

Management

For several years recommendations to farmers have included: gather eggs frequently, cool eggs in a wire basket overnight, and market eggs at least twice weekly. The small amount of research reported has resulted in contradictory conclusions.

Skoglund and Tomhave (1941) held eggs in the laying house at 83° to 90° F., four, six, and eight hours after laying. When broken immediately after removal, they found the average decrease in height of albumen for eggs held four hours to be 0.863 mm., for the six hour period 0.973 mm., and 1.041 mm. for the eight hour period. Eggs held in a refrigerator at 40° F. for corresponding periods of time resulted in negligible decreases in albumen height, indicating that temperature was the important factor.

In a study of the egg quality on thirty-eight poultry ranches in California, Lorenz and Newlon (1944) could show no significant effect of number of egg collections per day, use of ventilated baskets, or casing at once vs. first cooling for several hours in baskets, on albumen height. Egg room temperatures and frequency of delivery to market were found to be the important factors affecting egg quality. In trials conducted by Dawson and Hall (1954), the container in which eggs were gathered, cooled, or held for six days did not significantly affect broken out albumen quality.

Stadelman and Jensen (1951) determined the quality of eggs produced on farms in the Spokane, Washington, area. There was no relationship between percentage of Grade AA eggs at the one day period and the frequency of collection. They found it impossible to determine whether the increased quality at the end of the holding period was actually caused by the greater frequency of collection or by the fact that farmers who gather more frequently have better holding conditions than those who collect less frequently.

Humidity

Jeffrey and Darago (1940) found that relative humidities of 78-98 percent for winter temperatures and 62-93 percent for summer temperatures had no effect on the interior quality as measured by the height of the thick albumen. Funk (1944) found that the humidity of the atmosphere surrounding shell eggs had limited influence on the deterioration of the albumen, but did affect to a great degree the amount of evaporation from eggs.

Van Wagenen, Hall, and Altmann(1939) found that a relative humidity of approximately 60 percent produced satisfactory results for short holding periods.

Temperature-Time

Temperature and time are the two most important factors affecting the rate of interior quality deterioration. Jeffrey and Darago (1940) found that eggs held 14 days at 80° F. and a humidity of 93 percent showed a 52.5% decrease in height of albumen, whereas eggs held for the same period of time at 42° F. and a humidity of 82 percent showed a decrease of only 11.1% in height of the thick albumen. Funk (1944) determined that thick albumen was converted to thin albumen very slowly at temperatures of 30° F. and 50° F., but quite rapidly at temperatures of 80° to 100° F.

Van Wagenen, Hall, and Altmann (1939) concluded that a short time farm holding temperature should approximate 45° F. The quality of eggs stored at 45° for ten days was practically the same as for those stored at 80° F. for four days.

The importance of moving eggs to market within a few days was conclusively proven by Tower and Upp (1950). Eggs held for 1, 2, 3, 4, 5, 6, and 7 days graded 76, 68, 64, 56, 53, 43, and 35 percent Grade A, respectively. Stadelman and Cyrus (1952) found no apparent benefit from cooling below 60° F. for three day storage. For one week storage, 50° F. was better than higher temperatures, but no worse than 45° F. For storage periods longer than a week, 45° F. gave best results.

Jensen and Stadelman (1952) found that eggs refrigerated at 30° to 38° F. for more than a week had essentially the same quality as when placed in storage. They also found that there was a rapid decline in quality during the normal marketing procedure with this decline being closely associated with the temperature of egg-holding rooms. Dawson and Hall (1954) found the greatest decline in albumen quality occurred during the first three days regardless of temperature. Temperatures of 60° F. or lower were found to be practical for normal farm holding of eggs. Gayvert (1955) determined that the rate of quality deterioration was greatest during the first week for all temperatures tested except 35° F. For storage periods of 72 hours or longer, deterioration rates were lowest with a temperature of 35° F.

A storage temperature of 30° F. was found by Wilhelm and Heiman

(1938) to retard albumen loss markedly after a 30 percent loss had occurred. Temperatures of 50°, 70°, and 90° F. were increasingly less desirable for holding market eggs. Eggs of varying quality were found to stand up under storage conditions in proportion to their original quality. Almquist and Lorenz (1935) found that eggs with higher percentages of firm white showed a lower percentage of liquefaction of the firm white during storage.

Measurement

Many ways have been proposed for measuring the quality of broken out eggs. For this study an objective measurement was desired so only measurements of this type will be reviewed. Heiman and Carver (1936) determined quality by the albumen index score, which was obtained by dividing the height of the thick white by its mean width. It was shown that the weight of the egg did not materially affect the accuracy of the albumen index, but this measurement has the disadvantage that measurement of the diameter of the thick albumen may be difficult and inaccurate if the firm albumen sac is ruptured, and if the eggs have albumen with irregular or indistinct outlines. Wilgus and Van Wagenen (1936) found the height of the albumen, obtained by taking the average of two measurements of the thick albumen with a tripod micrometer, to be an accurate as well as rapid means for determining the condition of the firm albumen.

Haugh (1937 a & b) presented formulas for finding Haugh unit values based on the height of the thick albumen, obtained with a tripod micrometer, and corrected for the weight of the egg. In an effort to standardize methods for measuring broken out quality, Brant, Otte, and

Norris (1951) recommended the Haugh unit as the simplest and most applicable quantitative measurement of interior quality.

In studies of repeatability estimates of albumen quality, both Godfrey, Goodman, and Newell (1954), and Nordskog and Cotterill (1953) determined that observations based on three eggs would give 93% of the maximum information which could be obtained if all eggs were measured.

METHODS AND MATERIALS

Experiment 1 - Effect of Management Conditions

Eggs used in this experiment were obtained at selected times from December 1953 to August 1955 from New Hampshire hens on the Oklahoma A & M College poultry farm. The collection times were determined by the following outside maximum temperatures: 40° F. (three replicates), 60° F. (three replicates), and 90° F. (two replicates). Each of the replicates for all three of the temperatures was conducted in the same manner. The eggs were gathered hourly, identified by hen number, and divided into four groups. One group was removed from the house and placed in the poultry plant egg room hourly, one group at 10 a.m., 12 noon, and 5 p.m., one group at 12 noon and 5 p.m., and one group at 5 p.m. Those eggs not removed hourly were kept in nests in the laying house with one nest for each of the three groups.

Upon arrival at the egg storage room, the eggs from each group were divided equally into two groups. One-half was cased immediately and one-half was placed in a wire basket, cooled overnight, and cased the next morning. Division was again made by breaking out one-half of each of these groups at the end of three days to simulate twice a week marketing, and one-half at the end of seven days to simulate once a week marketing. A design of the entire procedure for one replicate at one temperature is shown in Figure 1.

The egg storage room was not of the controlled-temperature type

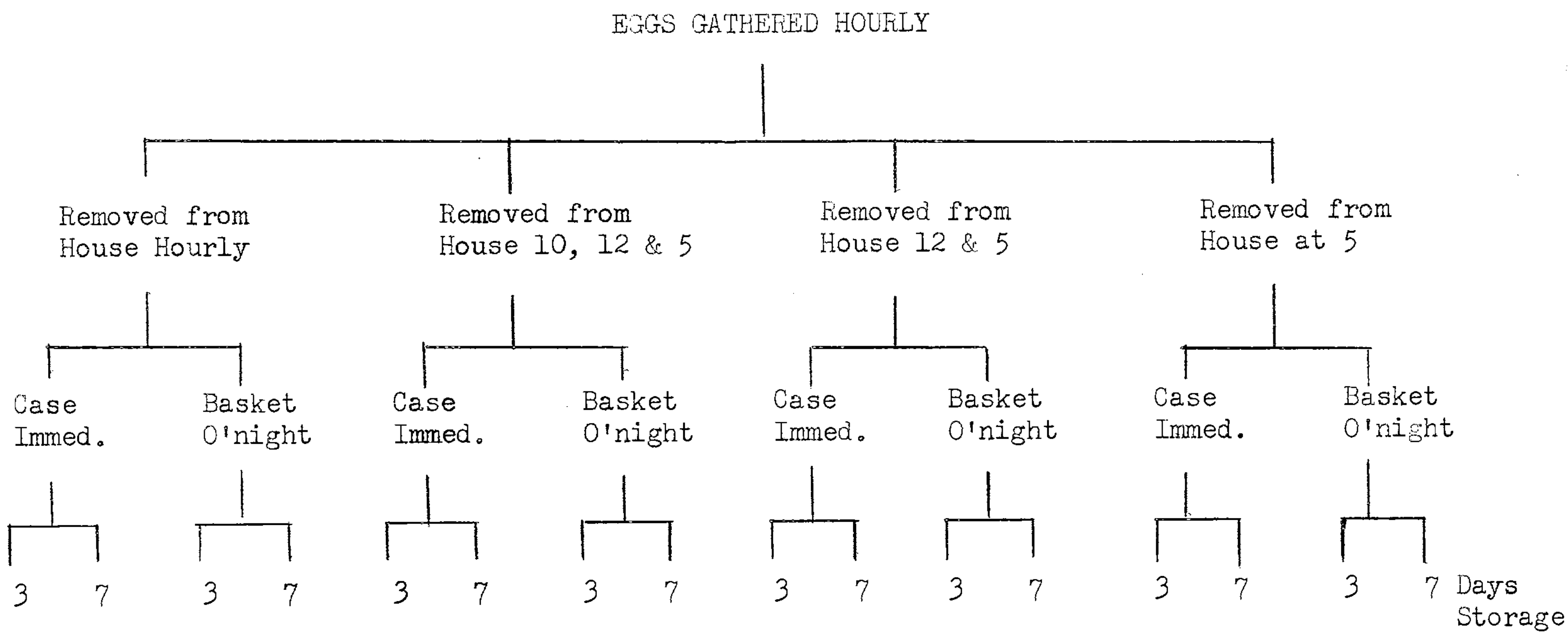


Figure 1. Design of Procedure and Conditions Used in Determining Management Effects on Interior Quality Deterioration

and was, therefore, affected by the outside temperature. The temperature for the week following collection was not always the same as the day of collection and not exactly the same for each replicate. For the eggs collected at 90° F., an evaporative cooler was in use and egg room temperatures averaged approximately 75°-85° F. The temperature of the egg room averaged 50°-60° F. for the eggs collected at 60° F., and 40°-50° F. for the eggs collected at 40° F.

Prior to each collection of eggs the initial or average I. Q. for each hen was determined by breaking out 3 consecutive eggs. These eggs were broken out early in the morning of the day after they were laid. Interior quality, both for initial I. Q. and for the I. Q. of different treatments, was evaluated in Haugh units. Eggs were weighed to the nearest gram, and albumen height was read to the nearest .001 inch on a tripod micrometer (Plate I). The albumen height was converted to mm., and Haugh units were computed on the Haugh unit computer (Brant, Otte, and Norris, 1951).

The Haugh unit value for each egg in each treatment was then subtracted from the Haugh unit value of that hen's initial interior quality to give a change in interior quality. These changes were averaged for each treatment and the resulting means used for statistical analysis.

Experiment 2 - Time-temperature Relationship

The importance of frequency of marketing in Experiment 1 prompted an additional experiment on the time-temperature relationship at selected temperatures.

Eggs were collected hourly, identified by hen number, and broken out immediately. The breaking of these eggs was so arranged that no

Plate I. Determination of Interior Quality of Broken Out Eggs

egg had been held longer than two hours at the time of breaking. The eggs for Experiment 2 were collected for three days in the middle of the period during which eggs were being broken to determine initial I. Q. This procedure was followed in order that the hen's average quality might not decrease after initial interior quality values had been obtained (Nordskog and Cotterill, 1953).

Eggs were collected hourly, identified by hen number, and placed immediately in their appropriate storage place, with one day's eggs at 30° F., one day's eggs at 60° F., and one day's eggs at 90° F. Each day after the eggs were placed in storage, one-seventh was removed between 2 and 4 p.m., and broken out immediately. Measurements and changes from original quality were computed as in the previous experiment. This gave a change in I. Q. for each day of the period at 30°, 60°, and 90° F.

The humidity of the storage places was not controlled as it was considered to have little or no effect on quality deterioration. It was checked, however, and was approximately 65 percent relative humidity in all three storage places.

RESULTS AND DISCUSSION

Experiment 1

The effect of holding and management practices on interior quality of eggs is shown in Tables I, III, and V, in which replicates are combined within each temperature. The figures represent the average change in Haugh units for all eggs in a treatment. Since all of the means were decreases from original quality, the minus signs have been omitted.

Tables which show results of statistical analysis of the data, using analysis of variance technique (Snedecor, 1946), follow the tables of Haugh unit changes for each temperature. Changes in Haugh units were averaged for the eggs in each treatment, and these means were used for the statistical analysis.

TABLE I

CHANGES* IN HAUGH UNITS AS AFFECTED BY HOLDING AND MANAGEMENT PRACTICES (40° F. ENVIRONMENTAL TEMPERATURE)

Cooling Container	Frequency of Selling per Week	Times Gathered Per Day 1	2	3	Hourly
Basket	Once	12.15	11.35	10.13	13.39
	Twice	4.36	6.62	5.87	5.74
Case	Once	10.22	10.89	13.53	12.52
	Twice	4.72	4.98	3.95	3.33

* All changes from original quality are minus, so minus (-) signs omitted.

TABLE II

ANALYSIS OF VARIANCE OF QUALITY CHANGES FOR EGGS COLLECTED AT 40° F.

Source	d.f.	M.S.	Fobs
Collection (K)	3	1.65	1.19
Cooling (C)	1	2.17	1.56
Selling (S)	1	595.87	428.68 **
K C	3	2.73	1.96
S C	1	5.29	3.81
K S	3	3.54	2.55
K S C	3	5.16	3.71 *
Error	30	1.39	
Replicates	2		
Total	47		

* Significant at .05 level.
** Significant at .001 level.

For eggs gathered at 40° F., decreases in Haugh units, due to frequency of collection, ranged from 4.36 to 12.15 for eggs gathered once daily, 4.98 to 11.35 for eggs gathered twice, 3.95 to 13.53 for eggs gathered three times, and 3.33 to 13.39 for eggs gathered hourly. Changes due to frequency of collection averaged 8.52, 9.31, 9.08, and 9.29 Haugh units, respectively. Analysis of variance indicated that frequency of collection at this temperature was not a significant factor in reducing the rate of interior quality deterioration.

Eggs cooled overnight in a basket and cased the next morning decreased from 4.36 to 13.39 Haugh units as compared to 3.33 to 13.53 for eggs cased immediately. Changes due to cooling averaged 9.26 and 8.83 Haugh units, respectively. These decreases in Haugh units were not significantly different as can be seen in Table II.

Frequency of marketing resulted in decreases of 10.13 to 13.39 Haugh units for eggs marketed once weekly, while eggs marketed twice weekly decreased only 3.33 to 6.62 Haugh units. Changes due to marketing averaged 12.57 and 5.52 Haugh units, respectively. This was an average difference of 7.05 Haugh units. Analysis of variance shows that frequency of marketing at 40° F. is highly significant. This significance is well beyond the .001 level.

TABLE III

CHANGES* IN HAUGH UNITS AS AFFECTED BY HOLDING AND MANAGEMENT PRACTICES (60° F. ENVIRONMENTAL TEMPERATURE)

Cooling Container	Frequency of Selling per Week	Times Gathered Per Day 1	2	3	Hourly
Basket	Once	9.92	8.31	10.70	10.04
	Twice	5.08	4.68	5.14	6.89
Case	Once	11.15	10.78	8.46	8.95
	Twice	5.67	5.32	5.12	6.63

* All changes from original quality are minus, so minus (-) signs omitted.

TABLE IV

ANALYSIS OF VARIANCE OF QUALITY CHANGES FOR EGGS COLLECTED AT 60° F.

Source	d.f.	M.S.	Fobs
Collection (K)	3	.73	.17
Cooling (C)	1	.02	.005
Selling (S)	1	231.83	55.07 **
K C	3	4.96	1.18
S C	1	.06	.014
K S	3	2.91	.69
K S C	3	2.21	.52
Error	30	4.31	
Replicates	2		
Total	47		

* Significant at .05 level.
** Significant at .001 level.

At an environmental temperature of 60° F., the decreases in Haugh units ranged from 5.08 to 11.15 for daily gatherings, 4.68 to 10.78 for twice daily gatherings, 5.12 to 10.70 for three times daily gatherings, and 6.63 to 10.04 for hourly gatherings. Changes due to frequency of collection averaged 7.81, 7.21, 7.46, and 7.51 Haugh units, respectively. As at 40° F., the frequency of collection was not found to be significant.

Cooling eggs overnight in a wire basket decreased Haugh units 4.68 to 10.70, while casing eggs immediately decreased Haugh units 5.12 to 11.15. Changes due to cooling averaged 7.47 and 7.51 Haugh units respectively. The differences were not significant.

Marketing eggs once weekly resulted in losses of Haugh units of 8.31 to 11.15, compared to 4.68 to 6.89 for eggs marketed twice weekly. Changes due to marketing averaged 9.69 and 5.29 Haugh units, respectively. The difference averaged 4.40 Haugh units, this difference being significant at the .001 level.

TABLE V

CHANGES* IN HAUGH UNITS AS AFFECTED BY HOLDING AND MANAGEMENT PRACTICES (90° F. ENVIRONMENTAL TEMPERATURE)

Cooling Container	Frequency of Selling per Week	Times Gathered per Day 1	2	3	Hourly
Basket	Once	16.19	14.70	20.75	17.94
	Twice	5.58	6.30	6.52	5.95
Case	Once	16.58	16.33	13.83	14.64
	Twice	7.04	8.11	4.89	4.00

* All changes from original quality are minus, so minus (-) signs omitted.

TABLE VI

ANALYSIS OF VARIANCE OF QUALITY CHANGES FOR EGGS COLLECTED AT 90° F.

Source	d.f.	M.S.	Fobs
Collection (K)	3	1.02	.27
Cooling (C)	1	10.79	2.85
Selling (S)	1	857.60	226.28 **
K C	3	16.42	4.33 *
S C	1	7.70	2.03
K S	3	4.92	1.30
K S C	3	2.88	.76
Error	15	3.79	
Replicates	1		
Total	31		

* Significant at .05 level.
** Significant at .001 level.

At 90° F., eggs gathered once daily decreased 5.58 to 16.58 Haugh units, eggs gathered twice daily decreased 6.30 to 16.33 Haugh units, eggs gathered three times daily decreased 4.89 to 20.75 Haugh units, and eggs gathered hourly decreased 4.00 to 17.94 Haugh units. Changes due to frequency of collection averaged 11.21, 11.28, 11.46, and 10.63 Haugh units, respectively. Examination of the analysis of variance table shows that frequency of collection was not a significant factor affecting interior quality.

Eggs cooled overnight in a basket decreased from 5.58 to 20.75 Haugh units, and 4.00 to 16.58 Haugh units for eggs cased immediately. Changes due to cooling averaged 11.72 and 10.50 Haugh units, respectively. The decreases were not found to be significantly different.

Frequency of marketing resulted in decreases of 13.83 to 20.75 Haugh units for eggs marketed once weekly, while eggs marketed twice weekly decreased only 4.00 to 8.11 Haugh units. Changes due to marketing averaged 16.32 and 5.34 Haugh units, respectively. This was an average difference of 10.98 Haugh units. As at 40° F. and 60° F., this difference was significant beyond the .001 level.

It should be pointed out that, while frequency of collection and type of container used for cooling were not found to be significant factors in reducing egg quality deterioration, neither were they found to be important in increasing quality deterioration. These management practices would possibly have been more important, perhaps significantly so, had the temperature of the holding room been much cooler than the temperature of the laying house. This is especially true at the 90° F. temperature, for egg room temperature could have been as much as 60° lower than environmental temperature.

Regardless of the temperature, frequency of marketing was significant at the .001 level in determining the rate of deterioration of interior egg quality. This would mean that eggs must be marketed often if high quality is to be maintained.

Experiment 2

The effect on interior quality of keeping eggs at temperatures of 30°, 60°, and 90° F. for one to seven days is shown in Figure 2. Since the eggs were in the place of storage within one hour after being laid, the changes in Haugh units would not be influenced by management practices.

It is readily apparent that the change in quality during the first 24 hours of storage is the greatest, regardless of the temperature. Analysis by a multiple comparison test adapted from a method proposed by Duncan and Bonnor (1954) showed that the change in Haugh units for the first 24 hours of storage was significantly greater

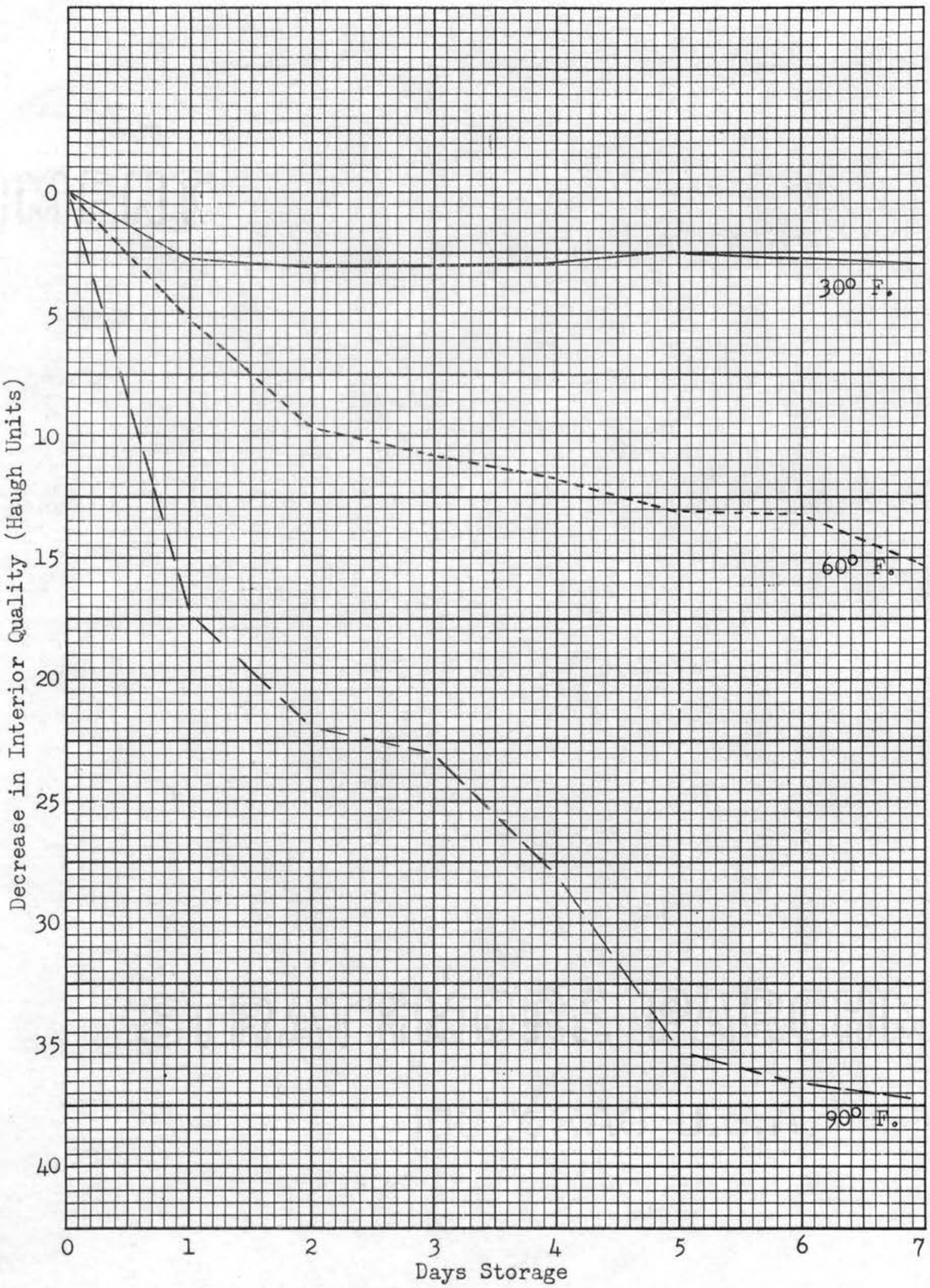


Figure 2. Change in Haugh Units per Day at Selected Temperatures Up to Seven Days

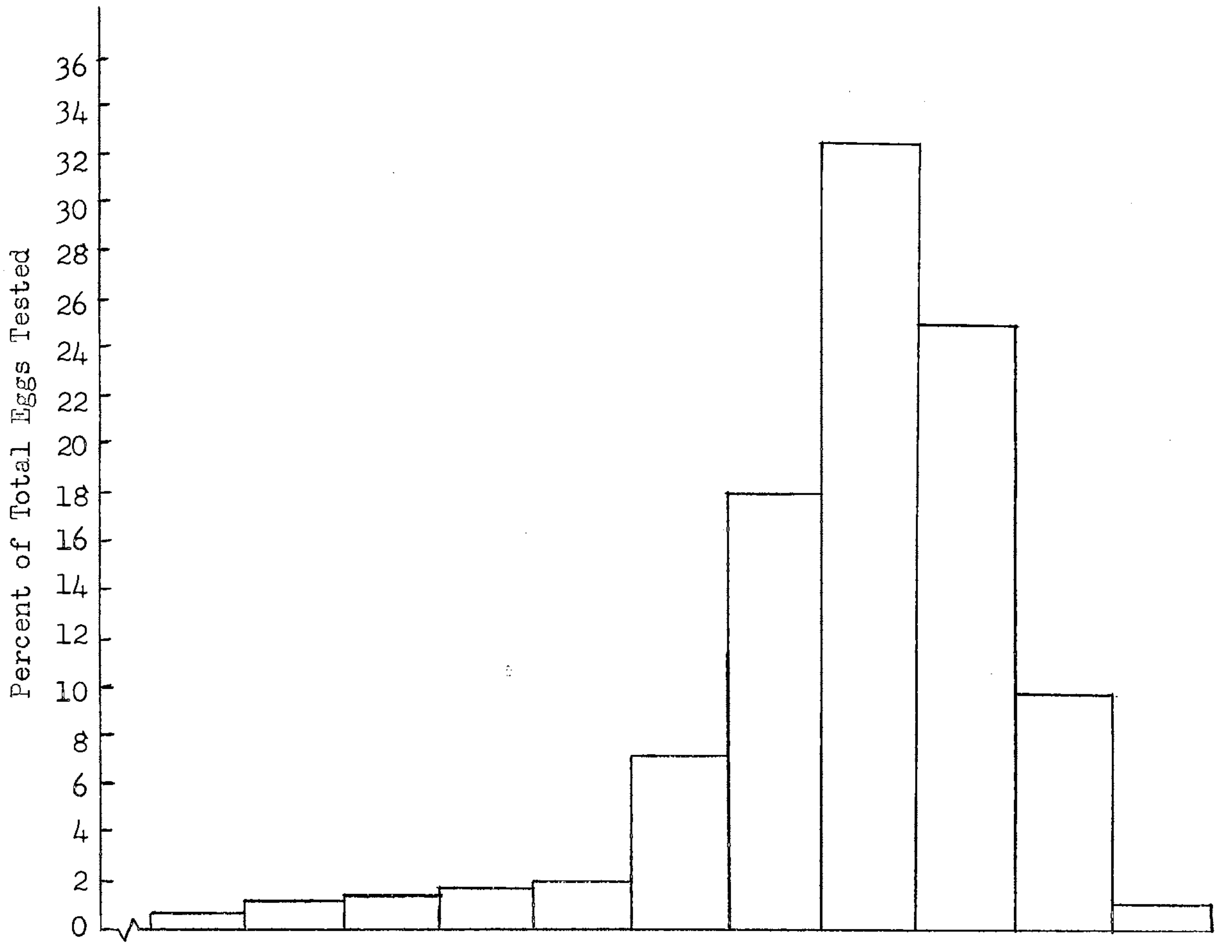
than any succeeding daily change for the eggs held at 90° F. This significance was noted only at the .05 level, and did not hold for 30° and 60° F. However, the change in Haugh units the first 48 hours after the eggs were placed in storage was significantly greater than the changes for any succeeding 48 hour period. This was true for 30°, 60°, and 90° F., and all three were significant at the .01 level.

After the initial 48 hour loss in quality, the eggs held at 30° F. maintained approximately the same quality until the end of the test. Wilhelm and Heiman (1938) found that, after an initial loss, the quality of eggs would be maintained by a temperature of 30° F. The average change in Haugh unit values of the eggs stored for four, five, and six days (Figure 2) was slightly less than for those stored for two and three days. This may have been caused by one of, or a combination of, two things. Due to chance, some of the eggs in the groups held four, five, and six days may have been higher in quality when placed in storage than the previously determined I. Q. for the hens laying these eggs. Secondly, these were all very high quality eggs, averaging approximately 90 Haugh units. With eggs of this quality the probability for error in measuring albumen height is greater than for eggs of lower quality.

Figure 2 also shows that eggs stored at 60° F. for one day were lower in quality than those stored for seven days at 30° F., and eggs stored at 90° F. for one day were lower in quality than those stored at 60° F. for seven days.

The average interior egg quality for the 290 hens used in this experiment varied a great deal. The averages ranged from 59 to 109 Haugh units, or a range of 50 Haugh units. The mean was 93.4, the mode was 93, and the median was 95 Haugh units, for the 290 hens from which eggs were tested. Percentages were determined, with each class interval including five Haugh units. The largest percentage, 32.4%, of the I. Q. averages were between 92 and 96 Haugh units. This relationship is shown graphically in Figure 3. Each column of the histogram represents five Haugh units, the one listed, plus and minus two. As an example, the column listed as 99 would contain all those eggs with a Haugh unit value between 97 and 101. The Haugh units are given for the initial averages and for the averages after storage. The averages after storage were determined by subtracting from the initial average, the appropriate figure based on the change in interior quality in Figure 2. The purpose of this type of graph is to show in what Haugh unit group eggs would be after storage for a specified time and temperature, depending upon their quality when placed in storage. It also shows percentages in the various Haugh unit groups after storage. Three and seven days have been chosen to simulate once and twice a week marketing. As an example eggs having an initial I. Q. of 104 ± 2 Haugh units, would, after three days storage at 60° F., be at 93 ± 2 Haugh units, and, after seven days storage at 90° F., be at 67 ± 2 Haugh units. Of eggs stored for seven days at 60° F., 32.4% would be in the 79 ± 2 Haugh units group.

It should be noted that the changes in interior quality as shown in Figure 2 could be applied to any group of eggs, but that the histogram of percentages given in Figure 3 would apply only to a group of hens with the same I. Q. distribution as those tested. Also, the distribution and the individual average I. Q. determined for a flock of hens should not be expected to stay the same indefinitely as disease



Initial Average	59	64	69	74	79	84	89	94	99	104	109
3 & 7 Days 30° F.	56	61	66	71	76	81	86	91	96	101	106
3 Days 60° F.	48	53	58	63	68	73	78	83	88	93	98
7 Days 60° F.	44	49	54	59	64	69	74	79	84	89	94
3 Days 90° F.	36	41	46	51	56	61	66	71	76	81	86
7 Days 90° F.	22	27	32	37	42	47	52	57	62	67	72

Haugh Units

Figure 3. Histogram of the Distribution of Haugh Units for Eggs Broken Immediately and After Selected Times and Temperatures of Storage

and age have important effects on interior quality of each individual hen.

The method used for determining Haugh unit distribution after storage (Figure 3) is valid only if high and low quality eggs deteriorate in quality at the same rate. To determine if this were the case, correlation coefficients were determined for the eggs in each storage period within each temperature, for total eggs within each temperature, and for total eggs, temperatures combined. The results are shown in Table VII. A positive correlation indicates that the higher the quality of the egg when placed in storage, the greater the loss in quality. A negative correlation indicates that the higher the quality of the egg when placed in storage, the less the decrease in quality.

TABLE VII

CORRELATION COEFFICIENTS FOR ORIGINAL QUALITY AND AMOUNT OF QUALITY DECREASE*

Days Storage	30° F.	60° F.	90° F.
1	.112	.027	-.203
2	.521	-.201	.758
3	.122	-.072	.402
4	-.133	-.351	.289
5	.144	.046	.237
6	.314	-.414	.219
7	-.071	-.146	.019
Total	.159	-.101	.275
Total of All Eggs, 30°, 60°, 90° F. Combined			.026

* Positive correlations indicate that the higher the quality of the egg, the greater the loss in quality.

For the eggs stored at 30° F., the correlation coefficients ranged from -.133 to .521 for the individual days storage, with an overall correlation of .159. At 60° F., the range was -.414 to .045, and -.101 for all eggs. At 90° F., the correlation coefficients ranged from -.203 to .758, and .275 for all eggs. The combination of all eggs stored at 30°, 60°, and 90° F. had a correlation coefficient of .026. This indicates that in the determination of Haugh unit distribution after storage, any error due to high and low quality eggs having a different rate of deterioration is insignificant.

Haugh units per se have little meaning, from the producers' point of view. Producers are interested in egg quality from an economic standpoint, more specifically, how time and temperature will affect their income. To apply the findings in such a manner, the data in Table VIII have been prepared. Grade distribution, both in percentages and dozens per 30 dozen case, value per case, and the loss from original value due to storage have been computed. These figures are based on the I. Q. distribution of the 290 hens tested (Figure 3). The values are computed with the assumed sales prices of AA @ 50¢/dozen, A @ 45¢/dozen, B @ 40¢/dozen, and C @ 35¢/dozen. Case values would vary if the price per dozen were changed, but the decrease from original price would remain the same if a 5¢ grade difference were maintained. Eggs were separated into grades according to Haugh unit values as follows: AA, 79 and above; A 56 - 78.9; B, 32-55.9; and C, 31.9 and below.

The percent of AA and A grade eggs dropped from 94.1% and 5.9%, respectively, to 0% and 62.8%, respectively, after seven days storage at 90° F. This resulted in a loss from original value of $1.992 per case. A loss of value of $1.976 per case resulted when eggs were held

TABLE VIII

EFFECT OF TEMPERATURE AND TIME ON GRADE DISTRIBUTION AND CASE VALUE*

	AA		A		B		C		Original Value Per Case	Decrease From Original Value
	%	Doz.	%	Doz.	%	Doz.	%	Doz.		
Original Quality	94.1	28.23	5.9	1.77	0	0	0	0	$14.912	
3 & 7 Days 30° F.	93.1	27.93	6.9	2.07	0	0	0	0	$14.896	$0.016
3 Days 60° F.	78.6	23.58	21.4	6.42	0	0	0	0	$14.670	$0.242
7 Days 60° F.	54.5	16.35	43.4	13.02	2.1	0.63	0	0	$14.286	$0.626
3 Days 90° F.	10.7	3.21	83.4	25.02	5.9	1.77	0	0	$13.572	$1.340
7 Days 90° F.	0	0	62.8	18.83	35.2	10.56	2.1	0.63	$12.920	$1.992

* Assuming AA @ 50¢/dozen, A @ 45¢/dozen, B @ 40¢/dozen, and C @ 35¢/dozen.

seven days at 90° F. as compared to three or seven days at 30° F. This is a more practical example as eggs are not marketed immediately after being laid. At 60° F., a temperature often used for farm refrigeration of eggs, the difference in value per case for eggs marketed at three days and for eggs marketed at seven days was $.384.

This study has not considered the cost of refrigeration. However, numerous studies have been conducted and are presently underway on this subject. The data in Table VIII show that lack of proper cooling results in a decrease in gross income to the producer. With these figures and information on cost of refrigeration, the net value of cooling, as well as the temperature, for maximization of income, could be easily determined. Regardless of the temperature selected for storage, the more frequent the marketing, the less the interior quality deteriorates and the higher the price that would be received by the producer.

SUMMARY AND CONCLUSIONS

Experiments were conducted to show the effect of management and holding conditions on interior egg quality. The time and temperature relationship and its effect on egg quality for one week at selected temperatures was also studied. Haugh units were used to measure the quality of the broken out eggs.

Of the three factors, frequency of collection, container used for cooling, and frequency of marketing, only the latter was found to be a significant factor in decreasing interior quality deterioration. Frequency of marketing was significant at the .001 level for 40°, 60°, and 90° F. environmental temperatures.

High temperature and long farm holding periods resulted in large losses in interior quality as measured in Haugh units. Eggs stored at 60° F. for one day were lower in quality than those stored for seven days at 30° F., and eggs stored at 90° F. for one day were lower in quality than those stored at 60° F. for seven days. After an initial loss of three Haugh units the first two days of storage, eggs stored at 30° F. maintained approximately the same quality throughout the test.

The initial drop in quality was the greatest, regardless of the temperature. At 30°, 60°, and 90° F., the decrease in Haugh units the first 48 hours of storage was significantly greater than the decrease for any succeeding 48 hour period.

Assuming a 5¢ per dozen difference between grades, the loss in value per case was \$1.992 for eggs stored seven days at 90° F. At 60° F., the difference in value per case for eggs marketed at three days and for eggs marketed at seven days, was \$.384.

It was concluded that a low temperature is important in retarding egg quality deterioration; but, unless the temperature for storage is near 30° F., eggs must be marketed frequently if high quality is to be maintained.

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