ABSTRACT OF THESIS

THE RELATION BETWEEN EGG QUALITY and TENDERNESS OF BAKED CUSTARDS

Submitted by

Hannah C. Yanke

In partial fulfillment of the requirements
for the Degree of Master of Science
Colorado State College
of
Agriculture and Mechanic Arts
Fort Collins, Colorado

May, 1940

ABSTRACT OF THESIS

The Problem

Investigation was made into the relationship of the physical condition of eggs and the tenderness of baked custards made therefrom.

The investigation necessitated determining the differences existing in the physical condition of the eggs studied and the determination of the degree of tenderness of the baked custards made from the eggs.

It also seemed advisable to determine whether change in pH value of the egg whites was related to variations in the degree of tenderness of custards resulting from the use of those eggs.

Under ordinary circumstances evaporation of water from eggs during storage constitutes a well-recognized physical change. A study was made of the influence on custard tenderness of the addition of an amount of water equal to the weight lost by eggs during a 30-day storage period.

Procedure

To ascertain the physical conditions that existed in fresh eggs and in eggs stored for 10, 20,

and 30 days, all eggs used in the custards were examined, and the following determinations were made:

1. The observed score according to the Wilgus standard.
2. The height of the firm white in millimeters as measured by a tripod caliper.
3. The weight of the firm white in grams.
4. The height of the yolk in millimeters as measured by a tripod caliper.
5. The diameter of the yolk in millimeters as measured by a caliper.
6. The weight of the egg (minus the shell) in grams.
7. The weight of the yolk in grams.
8. The yolk index--a calculation obtained by dividing the height of the yolk by the diameter.
9. The percentage of yolk--the weight of the yolk divided by the weight of the egg (without shell).
10. The percentage of firm white--the weight of the firm white divided by the weight of total white.
*11. The pH value of the whites--determined by use of a potentiometer.
*12. The pH value of the mixes--determined by use of a potentiometer.

The ingredients of the formula for the custards were in the proportion of 244 grams of milk (made up of equal volumes of condensed milk and water),72 grams of

---

*Used in series B only.

egg,(yolk and white mixed), and 25 grams of sugar. All custards were baked 35 minutes in 100 cc glass beakers set in a water bath in an oven with an inner temperature of 168° Centigrade. The custards were cooled for 1 hour after removal from the oven. The membrane that developed on top of the custard during baking was carefully removed before the custard was tested for tenderness.

Depth of penetration was taken to indicate comparative tenderness of custards. Measurements for the determination of the depth of penetration were made by means of a penetrometer. This instrument records to 0.1 millimeter the distance a plunger of known weight penetrates a substance in a given time. The time used in all experiments was 10 seconds.

The pH values for some egg whites were determined by a potentiometer. The pH of the mixes in which the egg whites were used was also ascertained.

In series B of the experimentation the eggs were weighed before they were placed in storage and again at the termination of a 30-day storage period. A weighed amount of water equal to the loss in weight during storage was added to the eggs before they were used in custards.

Analysis of Data

Results of the physical and chemical tests and

of the depth of penetration of custards were treated statistically.

The statistical treatment of the data is based upon the assumption that factors entering into the making of a custard were constant with the exception of the eggs used. Then a difference in the custards could be traced to a difference in the eggs used in their making.

The arithmetic mean of each test provided the basis for comparison of results of like tests on the various groups of eggs and on the custards. The standard deviation for each distribution was found by the formula: $\sigma = \sqrt{\frac{\Sigma X^2}{N} - \bar{X}^2}$

in which σ = standard deviation

ΣX^2 = summation of squares of the items

$\bar{X}^2$ = square of the arithmetic mean.

The standard error was estimated by: $\sigma_{\bar{X}} = \frac{\sigma}{\sqrt{N-1}}$

in which $\sigma_{\bar{X}}$ = standard error

N = number of items.

In order to test for significant differences between 2 means a null hypothesis, i.e., an assumption that there was no difference between the means that could not be attributed to chance, was used. The application of the null hypothesis is referred to as a critical ratio, t, and is given by t.

$$t = \frac{(\bar{X}_1 - \bar{X}_2) - 0}{\sqrt{\sigma_{\bar{X}_1}^2 + \sigma_{\bar{X}_2}^2}}$$

If t is less than 2, no conclusion can be drawn. If t is greater than or equal to 2, the difference of the values being compared is said to be significant, i.e., it is unlikely that the difference between the means was caused by chance. When t is greater than or equal to 3, the difference is said to be very significant, and there is little probability that the difference is due to chance.

Results and Discussion

Highly significant differences in physical characteristics were observed among fresh eggs and eggs stored for 10, 20, and 30 days.

Custards made with fresh eggs and with eggs stored 10, and 20 days, respectively, demonstrated significantly increasing tenderness.

The tenderness of custards made from eggs stored for 30 days appeared comparable to the tenderness of the custards made from eggs stored for 10 days. The increased percentage of egg solids is thought to be a possible factor in the tenderness of custards made with eggs stored for 30 days.

Custards made with eggs stored for 30 days, then corrected for water lost by evaporation during storage, resembled, in degree of tenderness, custards

made with eggs stored for 20 days.

It was found that alterations in the pH of the whites of the eggs proved non-effective in materially changing the pH of the custard mix.

In general it seems that the tenderness of the custards bears a relationship to the physical conditions of the eggs used in them. Custards made with eggs stored for 20 days possessed a degree of tenderness greater than for any of the other custards. Tables of results show that by the 20th day of storage at 70° Fahrenheit a greater part of the fibrous white had been broken down.

When fresh eggs were used the resulting custards were less tender than either the custards made with eggs stored for 10 days or those made with eggs stored for 20 days. The fresh eggs were found to have a greater percentage of firm white as well as firm white of greater height than did any of the other eggs tested.

Custards made with eggs of different qualities varied in degre of tenderness, but, with the exception of those made with eggs stored for 20 days, series A, all were palatable and possessed firm, smooth curds, with no development of syneresis during baking and testing.

Results of the investigation would then indicate that good custards can be made from storage eggs.

With the one exception already cited the storage eggs gave as satisfactory baked custards as did the fresh eggs.

T H E S I S

THE RELATION BETWEEN EGG QUALITY and TENDERNESS OF BAKED CUSTARDS

Submitted by
Hannah C. Yanke

In partial fulfillment of the requirements
for the Degree of Master of Science
Colorado State College
of
Agriculture and Mechanic Arts
Fort Collins, Colorado

May, 1940

COLORADO STATE COLLEGE

OF

AGRICULTURE AND MECHANIC ARTS

May 13, 1940

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY HANNAH C. YANKE

ENTITLED THE RELATION BETWEEN EGG QUALITY AND TENDERNESS OF BAKED CUSTARDS

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

MAJORING IN FOODS AND NUTRITION

CREDITS 12½

Elfriede F. Brown
In Charge of Thesis

APPROVED Augusta Allison
Head of Department

Recommendation concurred in

Committee on Final Examination

Elfriede F. Brown

Augusta Allison

W. Eybe

H. T. Guard

Committee on Graduate Work

Alvin Kezer.

Geo. F. Amy.

L. W. Durrell

ACKNOWLEDGMENTS

The author takes this opportunity to acknowledge with appreciation the assistance given by Dr. Elfriede F Brown of the Home Economics Department who thoroughly supervised the entire study; by Dr. W. E. Pyke and Mr. Gestur Johnson of the Home Economics Experiment Station who gave valuable suggestions in methods of study and made available the necessary apparatus; by Dr. H. S. Wilgus Jr. of the Poultry Department who arranged for the supply of eggs used; and by Mr. Harris Guard who aided in the statistical work.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

CHAPTER I

INTRODUCTION

For some time considerable interest in egg quality has been shown on the campus of Colorado State College of Agriculture and Mechanic Arts. Besides extensive practical and scientific work carried on in the Poultry Department, the Home Economics Section of the Colorado Experiment Station has reported progress from time to time on the project "A Study of the Factors Which Determine the Cooking Quality of Eggs." This investigation of the relation of egg quality to tenderness of baked custard is part of that Experiment Station project.

Need for the Problem

High nutritive value has been attributed to eggs by such noted authorities as McCollum (14), Sherman (24), and Saxl (17). McCollum Orent-Keiles and Day (14) in "Newer Knowledge of Nutrition" state, "Whole eggs which constitute a mixture of proteins have a higher nutritive value than any other source of protein known." Mitchell and Carmen (15) obtained data showing that 94 percent of the protein content of the whole egg is absorbed by the body and used in anabolism as

compared to 52, 83, 85, 62, and 69 percent of protein of white flour, egg albumen, milk, veal, and beef respectively.

That eggs are excellent sources of iron is also indicated by the work of Shackleton and McCance (18) who found that 100 percent of the iron of eggs is in a form available for body use.

Furthermore, eggs are included in every list of foods suggested by Saxl (17) and Sherman (24) as very good sources of the vitamins A, G, and D, and the minerals, phosphorus, iron, and iodine. Sherman (24) would include eggs with milk, fruit, and vegetables as protective foods.

A food of such excellent nutritive qualities should demand a prominent place in the average dietary. Stiebeling and Ward (24) do advocate in the prescribed "liberal diet" the use of 30 dozens of eggs per capita per year. Stewart (23), however, points out that Hawley's figures show the actual average consumption to be less than one egg per day. That this egg consumption is not commensurate with the nutritive value of eggs is due partly to ignorance of the intrinsic value of eggs. Since eggs are so important in the diet, research concerning egg quality is most important.

Statement of the Problem

In considering this problem of need for eggs and of supplying eggs in the diet the question arose: "Can acceptable custards be made from storage eggs?" or "Do the changes that occur in eggs during storage affect markedly the quality of a baked custard?" In the discussion of nutritive value of eggs, none of the authors mentioned previously in this thesis made reference to eggs as "fresh" or "storage." This omission may signify that storage has not been observed to alter materially the nutritive constituents of eggs. These and other questions allied in nature led to the interest in and desire to work out the problem: "What is the relationship, if any, between the degree of tenderness in the baked custard and the quality of the eggs used in the making of the custard?"

Delimitations

Experiments included in this study were limited to the determination of egg quality and the measurement of the tenderness of baked custards made from the eggs studied.

Since it seemed highly probable that the progressive changes in the pH of egg whites during storage

might be a factor determining "set" in the custards, pH values were observed.

Length of storage period was the only known variable in egg storage conditions.

The following considerations, although pertinent, are not included in this study:

1. Vitelline membrane strength as an indicator of egg quality.
2. Factors in the production of the eggs.

Definitions

In this discussion the term "egg quality" is used to designate the physical condition of the whole egg, the egg yolk, and the egg white as indicated by observation of score, height of the firm white, percentage of firm white, yolk index, and percentage of yolk. This is the interpretation given "egg quality" by such workers as Sharp (19) (21) and Wilhelm (31) and Wilgus (29) (30). Egg quality has commonly been merely an expression of degree of marketability, determined by the freshness of the egg or its rating or grade. Factors included in the rating or grading of eggs have been determined by candling in accordance with visibility and position of the yolk and size of the air cell.

A custard is the product resulting from the heat coagulation of a mixture of eggs, milk, and sugar.

A "desirable" custard is one that is palatable, has a fine, tender, smooth curd, and shows no indication of syneresis.

Assumptions

In undertaking a study such as the one under consideration, certain assumptions seemed warranted. It would appear logical to suppose that fresh eggs of known source from the same flock would show considerable uniformity in quality. Proof of the validity of this assumption is presented in the discussion.

Since the egg is the ingredient of custards supplying the protein responsible for the coagulation of the mix, it may be assumed that eggs of different quality would yield custards of different degrees of tenderness (eggs being the only variable). The breakdown of the firm white into watery white is, according to Balls and Swenson (4), indicative of alteration in the form of the protein. It may therefore be expected that the coagulability of the custard mix would be affected by this change in the nature of the protein.

Changes such as breakdown of the fibrous mucin of the white and increased alkalinity are commonly

recognized (3), (19), (28), (30), as occurring in the interior of the egg during storage. Therefore, the assumption was made that eggs held at 70 degrees Fahrenheit for definite periods (progressively longer) would produce custards of different quality, provided the length of storage period of the eggs was the only variable. It further seemed possible that the water content and the pH value of the eggs are determining factors in the differences in custards made with fresh and with storage eggs.

Problem Analysis

Some of the questions which presented themselves for solution in the study of "The Relation of Egg Quality to the Tenderness of Baked Custards" included the following:

1. What is the physical difference between fresh eggs and eggs stored for periods of 10, 20, and 30 days, respectively?

2. How do baked custards made with fresh eggs compare in tenderness with custards made with eggs stored at room temperature for 10, 20, and 30 days?

3. If the eggs stored for 30 days are brought up to their original weight by addition of water, what will be the degree of tenderness of the baked custard?

4. Is there a relationship between the pH value of the eggs used and the degree of tenderness of the custard?

CHAPTER II

REVIEW OF LITERATURE

Literature up to the present gives very little evidence of work on custards, and in only one instance is there any indication that experimentation is being performed on the relationship between egg quality and the quality of the custard. This is being done on soft cooked custards, not on a baked product. However, the following paragraphs show that a considerable amount of work has been done in an attempt to relate egg quality to the physical measurements; further, that some work has been carried out on the usability of eggs of varied quality in other products of cookery.

Experimental Work with Eggs in Cookery

Muse (16) of the Vermont Experiment Station is at present performing experiments to show relationship between viscosity of soft custards and egg quality.

Lowe (12) demonstrated that the alkalinity of the custard mix retarded the coagulation of egg proteins. She found salt to be an aid to the setting of the custard but beyond a certain point increased quantities would favor the tendency to curdle. She found, too, that the addition of acid gave a softer and not quite so firm a

curd as was produced by addition of salt.

Stanley and Cline (26) varied the amount of egg in custard mixes and found that the greater the proportion of egg used, the firmer the consistency of the custard. They found that the preparation procedure was also a determining factor in the resulting degree of tenderness of the custard.

Eggs with thin whites have been found to give very satisfactory results in the making of cakes, omelets, and souffles (Macleod and Nason) (13).

When Justin, Rust, and Vail (9) substituted egg yolk for the whole egg, they found that the coagulation point was raised and that, because of the increased fat content of the yolk, the curd of the custard was much smoother and the product richer in flavor.

Barmore (5) attributed the poorer quality of cakes made with eggs several days old to the proteolytic hydrolysis of egg proteins due to enzymes contained in the egg rather than to the increased proportion of thin whites.

King, Whiteman, and Rose (10) determined the amount of total solids and pH value of the eggs later used in sponge cakes. Measurements of specific volume, elasticity, and compressibility of these sponge cakes indicated there was no apparent relationship between the physical and chemical properties of the eggs used. This

work is in agreement with an earlier study by King, Morris, and Whiteman (11).

Tests for Determination of Egg Quality

At Cornell, Sharp (19) made a score sheet consisting of photographs of broken-out eggs representative of the varying degrees of the "standing up" quality of the firm white. He then used these photographic standards to designate the interior quality of eggs freshly broken out. Each egg studied would closely resemble in appearance one of the pictured standards.

Further work along this line, begun by Sharp, was done by Van Wagenen and Wilgus (30) who showed the positive relationship between the scores of quality made from the photographs taken by Sharp and the vertical height of the firm white albumen.

Sharp and Powell (21) used the tripod micrometer to determine the egg yolk index which they used as an indicator of egg quality; however, they found that small eggs consistently had a higher yolk index than did the large.

In another series of experiments on eggs, Sharp with Stewart and Gans (23) endeavored to show the relationship between interior factors and quality scores by the candlers; they used the egg yolk index as an indication of quality. As the yolk took in water from the white, it

flattened; the result was a lower index.

Other workers have used the amount of liquid and firm white of the egg as indicators of quality. Holst and Almquist (8) used a wire screen of fine mesh for separating the parts.

According to Balls and Swenson (3) the egg mucin is markedly broken down or is hydrolyzed to the extent of forming products of less hydrophylic type during storage. Therefore the bound water is released. This causes the thick white to disappear.

Wilhelm (31) developed a method of deriving the albumen index from the albumen height. He found and detected the correlation between the albumen and the albumen index of eggs of similar weight, thus simplifying and accelerating the process of determining the albumen index.

That a watery egg cannot be detected by candling and should not be discriminated against is the conviction of St. John (28) at the Washington Experiment Station. He found no consistent relationship between the moisture content of watery and firm whites.

Almquist and Lorenz (1) in their work on changes during storage of eggs show that there is a positive correlation between the keeping quality of the egg and the original amount of firm white.

Sharp (20), and later Sharp and Powell (22),

found that the pH values of egg whites increased to relatively high values as the whites became more liquid. Almquist and Lorenz (2) indicate that the change from thick white to thin white is physical, not chemical.

CHAPTER III

MATERIALS AND METHODS

Ingredients

Eggs.--Eggs used in the experimental custards were from Leghorn, White Rock, and Rhode Island Red flocks of the College Poultry Farm. Some, but not all, had been candled. Experimentation included the making of custards with fresh eggs and with eggs that had been stored at room temperature (approximately 70 degrees Fahrenheit) for 10, 20, and 30 day periods, respectively. In the first series (Series A) of custards made, all eggs used were held in refrigeration at 40 degrees Fahrenheit until the day of usage or initiation of warm storage interval. In the second series (Series B) the eggs were held at room temperature the specified time, then used. Some were made into custards immediately, others were stored for 10, 20, and 30 days.

Milk.--Condensed milk was used.

Sugar.--Beet sugar was used.

Physical Tests

Tests were made on every egg used. Each broken-out egg was examined to determine its physical

condition. The tests used to indicate the physical condition of eggs, fresh and storage, included:

1. Determination of the score according to the Wilgus standard (29).
2. Actual measurements of
   a. The weight of the interior egg.
   b. The height of the firm white.
   c. The weight of the entire white.
   d. The weight of the firm white.
   e. The height of the yolk.
   f. The diameter of the yolk.
   g. The weight of the yolk.
3. Calculations (from values obtained by actual measurements) of
   a. The yolk index.
   b. The percentage of firm white.
   c. The percentage of yolk.

The Observed Score (Wilgus Standard).--This is a value given each egg upon visual observation and comparison of the broken-out egg with a series of photographs of eggs taken by Wilgus following the method for scoring used by Sharp (19). The nine eggs photographed have been given scores from 1 to 5 at 0.5 intervals. Score 1 denotes an egg of highest quality. It occupies a small area and the firm white stands up well around the definitely centered yolk. The remaining scores indicate a progressive break-

down of the fribrous structure of the mucin. In score 5.0 a large irregular area is covered by the egg. The yolks become increasingly displaced from the center as the score goes from 1 to 5.

The observed score was more subjective than the other tests used. However, Wilgus and Van Wagenen (30) state that it provides a relatively simple and accurate measurement of the quality of firm albumen. These workers found a correlation of .934±.006 between the score for the observed condition of the firm albumen and the vertical height of the egg.

Tests on the White of the Egg.-- The height of the firm white was considered by Lowe (12) to be a good measure of quality. All heights of the broken-out egg whites were measured in millimeters by means of a tripod micrometer, an instrument used by Van Wagenen and Wilgus (30). This is so constructed that the legs (4½ inches apart) did not pierce the white. The rounded tip of the scale rod prevented piercing of the thin membrane. Measurement was taken on the plateau-like surface of the white far enough from the yolk to exclude possibility of getting the measurement of that white which rises around the yolk.

The weight of the entire white was obtained after all the white encasing the yolk had been removed.

Dr. W. E. Pyke of the Home Economics Section of the Colorado Experiment Station suggested the method for separation of the white from the yolk. This method consisted in placing the forefinger on the white near the yolk, and pressing down. Then by quick whirling motion of the finger, the white was pulled away leaving the yolk entirely free.

After the white was weighed in grams to the first decimal place, separation of the firm white from the liquid white was accomplished by a method used by Holst and Almquist (8). The white was poured onto a wire screen of nine meshes per square inch and placed over a container for the liquid white. The screen was shaken to allow the liquid white to come into contact with the surface of the screen--a precaution made necessary by the similarity in density in the firm white and liquid white.

When drops began to form slowly on the under side of the screen, the screen was tilted, allowing the firm white to run into a weighed container to be weighed.

As the ratio of firm white to the entire white is an indicator of the quality of the egg in that it shows the extent of breakdown of the fibrous mucin, (Balls and Swenson) (2), a calculation to find the percentage of the firm white was made for each egg.

Tests on the Yolk.--The tripod micrometer illustrated by Sharp (23) was used to measure the greatest height of the

yolk. Two measurements of the diameter were taken with the micrometer caliper (at approximately right angles), the average of which was used in calculation of the yolk index, the ratio of the height of the yolk to its diameter. This ratio has been used by Herrington and Sharp (7) as an index of inner egg quality. These workers state that the longer the eggs are in storage the more water from the whites enters the yolks. Therefore the percentage of yolk, by weight, in the entire egg was obtained and treated as an additional means of determining the extent of change in the egg during varied periods of storage.

After every yolk and white needed for the formula had been subjected to all the above tests, yolks and whites were put together and beaten, in preparation for use in the custard mix.

Preparation of the Custards

Careful preliminary experimentation on baked custards resulted in acceptance of the formula and method of mixing and baking herein given.

Formula for Baked Custard:

72 grams of beaten whole eggs

25 grams of beet sugar

244 grams of milk--equal proportions (by volume) of water and canned milk.

The more uniform consistency of canned milk in comparison

to that of fresh milk was the factor deciding the use of condensed milk.

After eggs were beaten 50 whirls with a rotary egg beater, the required weighed amount was placed in a mixing bowl. The sugar was added to the egg and stirred just prior to the addition of milk which had been pre-heated to 180 degrees Fahrenheit in a double boiler. This resulting mixture, (eggs, sugar, milk) was then stirred gently until all sugar had been dissolved. Then it was poured into 100 cubic centimeter glass beakers immersed about four-fifths of their height in a water bath preheated to 180 degrees Fahrenheit. The custards were immediately placed in the oven.

The thermostatically controlled electric oven used was equipped with a glass door, an inner thermometer, heat elements in both top and bottom, and an electric fan to distribute the heat more evenly throughout the area.

Previous to the entrance of the custard into the oven an inner temperature of 168 degrees Centigrade had been maintained for at least half an hour. During the baking period of 35 minutes the door was not opened but the thermometer reading was noted at intervals of 10 minutes as a check on the standardized baking temperature.

After the custards were removed from the oven, they were cooled for an hour period(first in a cold water

bath and then in air) before measurements for tenderness were made.

Tests for Tenderness of the Custard

Determinations of tenderness of the baked custards were made by means of the penetrometer, in use in the Experiment Station for measuring penetrability of fruit and other food products. The principle represented is similar to the apparatus used by King (10) to measure compressibility of cake.

The instrument measured, to 0.1 mm, the distance a plunger penetrated the test material in a given time. This plunger was constructed by Dr. Pyke. Twelve thin zinc leaves radiating from an aluminum bar provided a suitable tool for cutting the custard. Each leaf was approximately three-fourths inch across. The force exerted on the custard was 33.4 grams, the combined weight of the plunger and plunger rod with a 2.5 gram supplemental weight.

For each test the plunger was brought to rest at the center of the top of the custard from which the developed membrane had been removed. This membrane always formed during the baking interval. It was not considered representative of the consistency of the custard so it was carefully removed before a test for tenderness was attempted.

Determination of the pH Value

In the beginning it was assumed that the pH of the eggs might affect the tenderness of the custards in which they were used. Lowe (12) made reference to the fact that egg solids were rendered incapable of coagulation on heating by the addition of alkali to the custard mix. Smith (25) found that the pH of the white increased from an original value of 7.97 to 9.5 after a short time in storage. To investigate the effect on custards of changes in the pH of the eggs, the pH values of whites for each formula of several runs of custards were determined by use of a potentiometer. The pH values of the custard mixes were also determined.

Correction for Water Loss.

Since the loss of weight in eggs is due principally to evaporation of water, experimentation was carried out to determine the effects on baked custard of the addition to the eggs of that amount of water which had been lost (during the storage period) through evaporation. Eggs for this work were weighed when put into storage and on the day used. The difference between the two weights represented the weight of water needed for restoration to the original weight of the eggs.

Statistical Treatment of Data

The statistical treatment of the data is based upon the assumption that factors entering into the making of a custard were constant with the exception of the eggs used. Then a difference in the custards could be traced to a difference in the eggs used in their making.

The arithmetic mean of each test provided the basis for comparison of results of like tests on the various groups of eggs and on the custards. The standard deviation for each distribution was found by the formula: $\sigma = \sqrt{\frac{\Sigma X^2}{N} - \bar{X}^2}$

in which σ = standard deviation

ΣX^2 = summation of squares of the items

$\bar{X}^2$ = square of the arithmetic mean.

The standard error was estimated by: $\sigma_{\bar{X}} = \frac{\sigma}{\sqrt{N-1}}$

in which $\sigma_{\bar{X}}$ = standard error

N = number of items.

In order to test for significant differences between 2 means a null hypothesis, i.e., an assumption that there was no difference between the means that could not be attributed to chance, was used. The application of the null hypothesis is referred to as a critical ratio, t, and is given by

$$t = \frac{(\bar{X}_1 - \bar{X}_2) - 0}{\sqrt{\sigma_{\bar{X}_1}^2 + \sigma_{\bar{X}_2}^2}}$$

If t is less than 2, no conclusion can be drawn. If t is greater than or equal to 2, the difference of the values being compared is said to be significant, i.e., it is unlikely that the difference between the means was caused by chance. When t is greater than or equal to 3, the difference is said to be very significant, and there is little probability that the difference is due to chance.

CHAPTER IV

Results

Changes in Physical Conditions of Eggs Used

Raw data for all measurements and calculations are recorded in the appendix. Mean values of measurements of the physical characteristics of the fresh eggs and eggs stored for 10, 20, and 30 days at 70 degrees Fahrenheit are recorded in table I. The numbers of eggs, tests and custards represented by values in table I are recorded in table I-a.

It will be noted that the observed scores of eggs in the series A suggest a progressive diminution of the standing-up ability of the firm white as ageing advanced. A progressive decrease in the height of the firm white paralleled the changes indicated by the observed score.

In series B, however, a greater percentage of firm white was found to be present in the eggs stored for 30 days than in those stored for 20 days. Percentage was determined by dividing the weight of the firm white by the weight of the total white.

The decreasing values recorded for the yolk indices (table I) denote the continued absorption of water by the yolk, especially during the first 20 days of storage

A less important decrease in value of yolk index was noted during the final days of storage (series A). The yolk index for the eggs (in series B) stored for 20 days was lower than for the eggs stored for 30 days. Decreases in values of yolk indices were usually accompanied by increase in yolk percentage. As did the change in yolk index, the change in percentage of yolk became less important during the latter part of the storage period.

Table I.--MEAN VALUES FOR TESTS MADE ON EGGS AND CUSTARD MIXES

Note: The ± values recorded after each mean indicate the standard deviation of that mean

Eggs	Observed score	Height of white in mms.	% firm white	Yolk index	% yolk	pH of white	pH of custard mix
Series A							
Fresh	1.391 ± 0.499	6.083 ± 1.095	60.1 ± 1.031	0.414 ± 0.080	33.8 ± 3.949		
10-day storage	2.669 ± 0.505	3.807 ± 0.851	53.8 ± 5.941	0.371 ± 0.044	35.9 ± 3.101		
20-day storage	3.619 ± 0.612	2.489 ± 0.976	41.1 ± 1.508	0.291 ± 0.031	38.1 ± 2.798		
30-day storage	4.390 ± 0.503	1.430 ± 0.944	29.8 ± 9.829	0.237 ± 0.042	38.9 ± 4.201		
Series B							
One-day	1.171 ± 0.338	6.767 ± 0.576	61.4 ± 9.106	0.383 ± 0.019	32.4 ± 1.884	8.565 ± 0.161	6.557 ± 0.190
10-day storage	2.968 ± 0.858	3.594 ± 0.430	48.9 ±11.228	0.308 ± 0.036	35.4 ±12.271	9.400 ± 0.091	6.735 ± 0.087
20-day storage	4.100 ± 0.803	2.328 ± 0.811	27.1 ±10.242	0.230 ± .007	39.5 ± 8.248	9.375 ± 0.032	6.772 ± 0.089
30-day storage	4.357 ± 0.324	2.171 ± 0.665	38.2 ±13.954	0.232 ± .025	41.5 ± 6.293	9.368 ± 0.091	6.811 ± 0.103

TABLE Ia.--NUMBERS OF EGGS, TESTS AND CUSTARDS REPRESENTED BY VALUES IN TABLES I AND II.

Eggs	Observed Score	Height of White	% White	Yolk Index	% Yolk	Penetration	pH of Whites	pH of mix
Series A								
Fresh	38	38	18	38	38	78		
10-day storage	56	56	14	56	56	104		
20-day storage	64	64	64	64	64	104		
30-day storage	64	64	64	64	64	104		
						104		
Series B								
One day	18	18	18	18	18	31	4	4
10-day storage	16	16	16	16	16	28	4	4
20-day storage	17	17	17	17	17	28	4	4
30-day storage	36	36	36	36	36	55	6	6

The so-called t factor or critical ratio of Fisher (6) was used to indicate the significance of the changes occurring in the physical conditions of eggs during storage. A t value of 2, which roughly corresponds to the 5-percent level of significance, enables one to conclude that 95 out of 100 times there will be a significant difference between the means. It will be noted that in general the values are not merely significant but are highly significant, inasmuch as the values are considerably larger than 2 (see table II for t values and table Ia for number of eggs on which the tests were made). Usually the changes which occurred in the percentage of yolk in series B were of little significance.

TABLE II.--CRITICAL RATIOS (t FACTORS) OF DIFFERENCES OF THE MEANS

Tests	Fresh and 10-Day Storage	Fresh and 20-Day Storage	Fresh and 30-Day Storage	10- and 20-Day Storage	10- and 30-Day Storage	20- and 30-Day Storage
Series A						
Observed Score	17.90	27.85	44.38	9.25	18.41	7.72
Height of White	10.22	16.59	21.72	7.90	14.49	6.25
% White	4.62	60.63	117.87	7.75	14.50	50.13
Yolk Index	3.09	9.39	12.73	15.09	19.14	10.19
% Yolk	2.69	6.52	5.97	5.23	4.32	1.44
Penetration	18.37	22.41	8.96	6.97	1.12	5.32
Series B						
Observed Score	7.62	13.55	32.48	3.83	5.19	1.24
Height of White	18.99	18.75	27.33	5.53	9.02	0.66
% White	3.12	9.24	9.24	5.75	2.90	3.39
Yolk Index	7.35	30.60	23.59	8.67	7.76	0.49
% Yolk	0.94	3.36	7.95	1.20	1.83	0.86
Penetration	6.69	12.90	11.27*	3.26	1.97*	6.48*
pH of Whites	7.87	8.70	8.03	0.45	0.48	0.16
pH of Mixes	1.49	1.79	2.15	0.52	1.13	0.57

*30-day storage eggs were corrected for water loss.

Note--Numbers underlined in red indicate high significance.

Tenderness of Custards

Values of penetrability of the custards are recorded in Table III.

Table III.--CUSTARDS OF SERIES A AND B.

Eggs used	No. of eggs	No. of custards	No. of cups of custard tested	Mean penetration in mms. with S.D.**
Series A				
Fresh	38	6	78	66 ± 21.65
10-day storage	56	8	104	129 ± 24.28
20-day storage	64	8	104	157 ± 32.89
30-day storage	64	8	104	122 ± 58.45
Total	222	30	390	
Series B				
Fresh	18	4	31	40 ± 21.95
10-day storage	16	4	28	95 ± 28.16
20-day storage	17	4	28	118 ± 23.60
30-day storage*	36	7	55	109 ± 4.63
Total	87	19	142	
Grand total	309	49	532	

* Correction for water loss was made before using in the custards.

** Standard deviation.

Depths to which they were penetrated may be considered a good indication of the comparative tenderness of the custards because the greater the tenderness the less the resistance to penetration, and therefore the greater depth

of penetration. Then the figures giving the penetration depth record a progressive increase in the tenderness of the baked custards made from fresh eggs and from eggs stored for 10 and 20 days, respectively. A lesser degree of tenderness than that of custards made from eggs stored for 10 and 20 days was obtained in custards made from eggs stored for 30 days. Figure 1 shows the general tendency in degree of tenderness of custards made with eggs stored for periods of varying lengths.

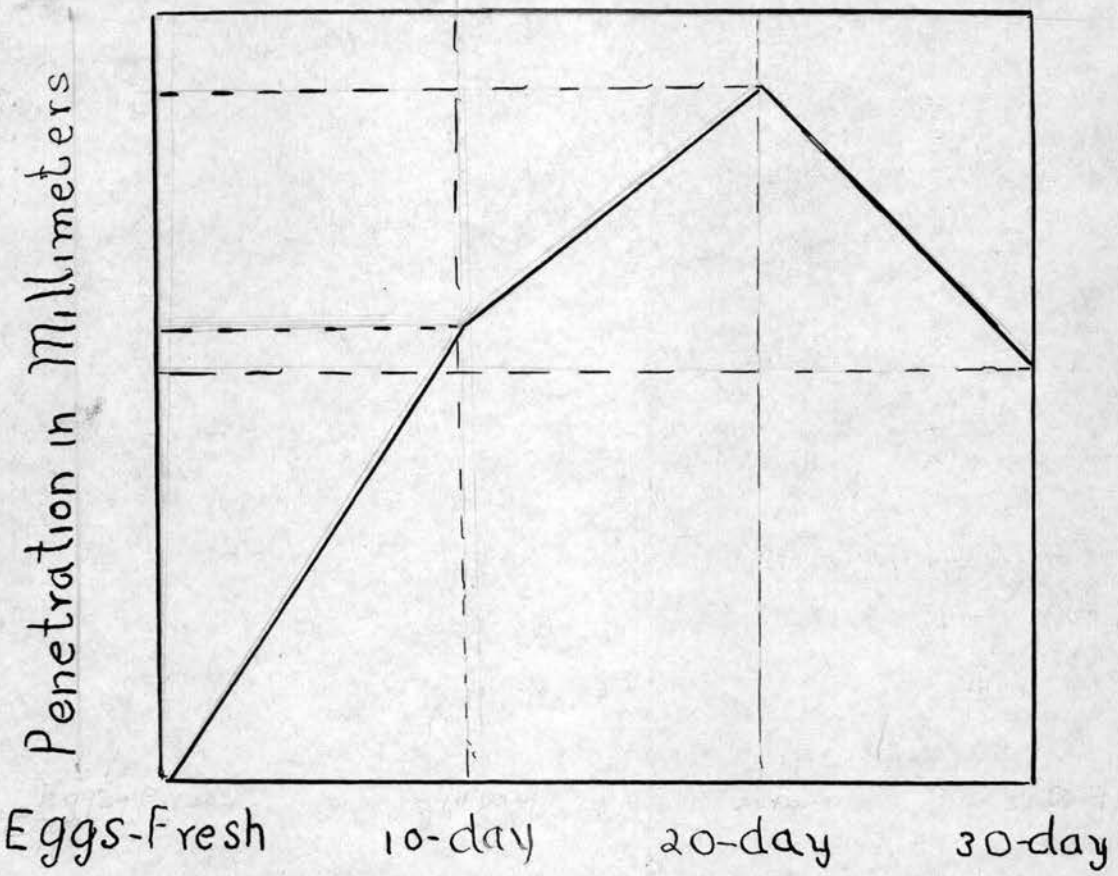

Figure 1--Relation between tenderness (depth of penetration) and age of eggs in series A. (For Series B see figure II page).

When the values for the mean depths of penetration were analyzed statistically, highly significant changes in custards made with fresh eggs and with eggs stored for 10 and 20 days were found to have occurred (table II). Comparisons of the tenderness of the custards made from eggs stored for 10 days and for 30 days show variations so slight as to be statistically non-significant.

Results of Water-Loss Correction on Custard Tenderness

Custards made with eggs corrected for the water lost (table IV) during the 30-day period of storage, were similar in tenderness to custards made with eggs s stored for only 20 days (table III series B).

TABLE IV.--WEIGHT LOSS OF EGGS HELD 30 DAYS IN STORAGE, AT 70° F.

Group of Eggs Put in Storage	Initial Wt. in Grams	Final Wt. in Grams	Loss in Grams	% Loss
1	312.2	271.6	40.6	13.0
2	306.6	271.6	35.0	11.8
3.	421.5	367.0	54.5	12.9
4	311.4	280.3	31.1	10.0
5	301.3	266.6	34.7	11.1
6	524.5	455.5	69.0	13.2
7	578.5	501.7	76.8	13.3

Similarity in tenderness of the above mentioned custards is further noted by the non-significant difference indicated by the value of the t factor (table II series B).

Influence of the pH of the Whites on Custard Tenderness

The pH values of the whites (table I) point to a sudden and significant increase in alkalinity during early storage, but a lesser change in later periods. From a study of the values of the pH of the custard mixes (table I and values of the t factor (table II) it would seem that the pH of the custard mix was not significantly affected by the pH of the eggs used.

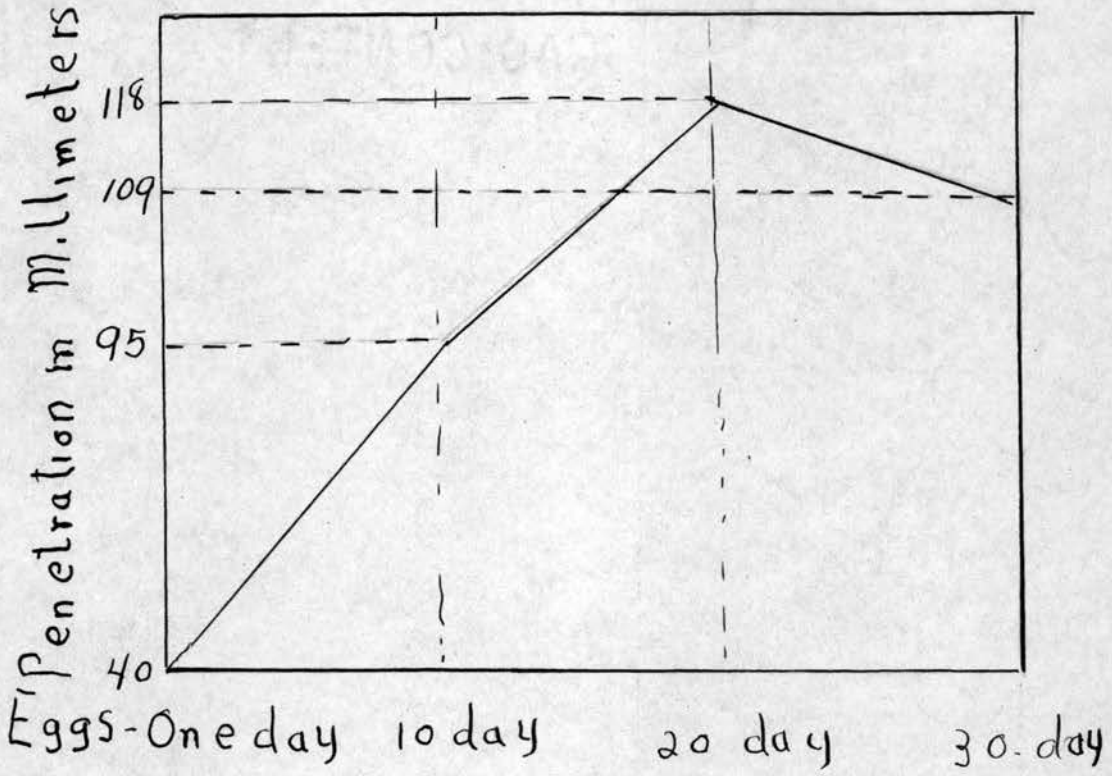

Figure II--Relation between tenderness (depth of penetration) and age of eggs in series B.

CHAPTER V

DISCUSSION

Mean values of the depths of penetration of baked custards made with fresh eggs and with eggs stored for 10 and 20 days were compared statistically. The comparisons yielded t values from 5 to 22 in series A and from 1.96 to 12 in series B (table II). A t value or critical ratio of 2 roughly approximates the 5 percent level of significance. The high values of the critical ratios in both series A and B allow the conclusion that more than 95 times out of 100 the changes in degree of tenderness observed were due to factors other than chance. Egg quality was the only known variable. Therefore the conclusion that the quality of the eggs used is a factor controlling tenderness seems warranted.

Certain relationships between physical changes in eggs during the first 20 days of storage and the tenderness of custards made from the eggs are brought out by the results recorded in tables I and III. These general relationships may be summarized as follows:

Decrease in observed score---------Increase in tenderness
Decrease in height of firm white---Increase in tenderness
Decrease in percent of firm white--Increase in tenderness
Decrease in yolk index-------------Increase in tenderness
Increase in percent of yolk--------Increase in tenderness

From the tendencies shown in the foregoing summary it seems possible that the change in the firm white (i.e., the breakdown from firm to liquid white) did contribute toward the variation in custard tenderness.

The pH of the white of eggs increased rapidly during early storage (table I). Lowe (10) states, "Alkaline hydrolysis of proteins, the breaking down of proteins into smaller units, is speeded up as the eggs become more alkaline." The possible alterations in the protein molecule in addition to the water available from the breakdown of the mucin may be effective factors in retardation of coagulation. An investigation of the specific chemical changes taking place in egg proteins as the pH increases would elucidate the problem materially.

Custards made with eggs stored for 30 days were comparable in tenderness to those made with eggs stored for 10 days, that is, less tender than the custards made with eggs stored for 20 days. Study of the critical ratios (table II) reveals the common occurrence of only slightly significant changes in eggs during the last 10 days of the 30-day storage periods. From this observation one might point to the possibility that by the 20th day of storage at 70° Fahrenheit, most of the mucin had been broken down (see "Height of White", table I). After this 20-day period very little bound water could be released. Continued evaporation of water throughout the

storage period increases the percentage of egg solids. The greater percentage of egg solids present in the custard mix may be considered a factor in the decreasing tenderness of the custards made with eggs stored for 30 days.

Custards in series B made from eggs corrected for the water lost during the 30-day storage period reached a degree of tenderness similar to that attained by custards made from eggs stored for 20 days. Study of the correlation of custard tenderness with changes in eggs during longer storage periods would be of practical interest.

At the outset it was assumed that the pH of the eggs may be a contributing factor to the degree of tenderness in the custards. However, the custard mixes proved to be of similar pH--the greatest actual variation in pH being 0.254. This was true even when there were significant differences in the pH of the egg white used. Evidently the milk acted as a buffer to minimize the effect of the alkalinity of the egg whites. All the egg whites had a higher pH than the custard mixes (table I).

Fresh eggs proved to be comparatively uniform in physical condition. Quite frequently (to be exact, 24 times out of a possible 30, table I), mean values of physical measurements on fresh eggs proved to have smaller standard deviations than did the mean values of similar

tests on other eggs.

Custards made from eggs stored for 20 days (series A) were considered inferior in that they failed to "set"sufficiently. An increased baking period might result in more desirable custards. Time did not allow investigation of this phase. An analysis of the changes in the protein of eggs during storage is another phase of the problem worthy of investigation. Such an analysis was impossible because of limitation of time.

Other limitations to the study are recognized. In the late winter and early spring the supply of eggs was curtailed. Time and oven space restricted the number of custards that could be baked.

It was stated in the introduction that desirable custards are ones that are palatable, have firm smooth curds, and show no signs of syneresis. None of the custards made had developed syneresis before tests for tenderness were made. Custards made from eggs stored for 10 and 30 days were as desirable, according to the above standards, as were those made from fresh eggs.

SUMMARY

Investigation was made to determine if the physical and chemical changes occurring in eggs during storage at 70° Fahrenheit for 10, 20, and 30 days effect changes in tenderness of the custards in which they are used. The following observations were made:

(1) Increasing lengths of storage resulted in decreases in the height and the percentage of firm white and an increase in the percentage of yolk.

(2) By the end of the 20th day period of storage much of the fibrous white had been broken down.

(3) Custards made with eggs stored for 20 days were considered inferior in that they did not "set" sufficiently during the standard baking interval.

(4) As palatable baked custards were obtained from use of eggs stored for 10 and 30 days as from use of fresh eggs. The degree of tenderness of baked custards progressively increased when fresh eggs and eggs stored for 10 and 20 days, respectively, were used.

(5) When eggs were corrected for water loss by addition of water in amounts equal to that lost during a 30-day storage period, the custards resembled in tenderness those custards made from eggs stored for 30 days.

APPENDIX

CONTENTS OF APPENDIX

APPENDIX A

DATA ON EGGS and CUSTARDS OF SERIES A

In the tables of appendix A each vertical grouping of physical measurements includes values assigned the individual eggs which together went into the making of a custard.

Likewise each vertical grouping of the penetration depths includes values assigned the individual custards made from each custard mix.

TABLE I.-FRESH EGGS

		Observed Score			
1.0	1.5	1.0	1.5	1.0	1.0
1.0	1.0	1.0	1.5	1.0	1.0
1.5	1.5	3.5	2.0	2.0	2.0
2.0	1.0	1.5	1.0	1.0	1.5
1.5	1.0	1.0	1.0	2.0	1.5
1.0	1.5	1.5	1.0	1.5	1.5
	1.5	1.0			
Means of observed scores					
1.33	1.28	1.50	1.33	1.41	1.50
			Ave. of the means		1.391
			No. of eggs		38
		Height of Firm White in Millimeters			
7.78	5.55	7.54	4.78	7.42	6.87
7.35	7.50	7.74	4.76	5.38	4.89
7.43	6.20	3.62	3.57	5.47	4.83
5.94	6.26	6.19	6.85	6.42	7.00
5.15	5.82	5.10	6.17	4.22	6.28
7.42	6.50	5.56	6.58	6.28	6.56
	6.07	6.22			
Means of heights of firm whites					
6.85	6.27	5.99	5.45	5.87	6.07
			Ave.of the means		6.083
			No. of eggs		38

Table I continued

Weight of Total White in Grams

28.2	32.2	29.1	40.9	33.5	35.1
31.0	29.3	29.7	39.0	38.3	37.1
33.0	30.3	34.3	35.8	40.9	39.6
37.2	30.4	34.3	34.5	32.1	33.5
27.3	30.9	27.0	38.3	35.8	33.5
20.6	29.8	31.8	34.2	36.0	38.2
	30.3	31.7			

Weight of Firm White in Grams*

26.7	21.1	21.3
22.6	21.2	23.3
20.2	26.2	26.1
21.2	20.6	15.9
26.3	19.4	22.2
20.1	19.7	21.7

Percentage of Firm White*

65.2	62.9	60.6
57.9	55.3	62.8
56.4	64.0	65.9
61.4	64.1	47.9
68.6	54.1	66.2
58.7	54.7	56.8
Grand Total		1083
Grand Mean		60.1
No. of Eggs		18

Height of Yolk in Millimeters

16.47	15.27	16.29	16.95	14.48	17.37
16.40	15.85	17.90	19.56	16.65	15.12
18.73	16.22	15.85	16.37	16.80	16.65
17.68	15.73	16.56	17.00	15.78	15.92
16.28	16.43	16.50	16.28	15.68	14.38
18.34	16.05	17.53	16.33	15.05	15.00
	15.19	15.88			

*Weight and percentage of the firm white were calculated for only three of the 6 mixes.

Table I continued

Average Diameter of Yolk in Millimeters

37.4	40.7	37.5	40.8	38.9	38.8
40.0	38.5	39.2	40.5	39.6	40.1
37.8	40.5	39.0	41.4	39.1	40.4
38.2	38.7	38.2	36.7	39.1	39.9
40.5	39.6	40.4	37.8	39.7	41.3
39.1	40.8	39.4	39.6	39.1	42.5
	41.2	40.4			

Yolk Index

0.440	0.375	0.434	0.415	0.372	0.447
0.410	0.411	0.456	0.482	0.420	0.377
0.495	0.400	0.406	0.395	0.429	0.412
0.462	0.406	0.433	0.463	0.408	0.399
0.401	0.414	0.408	0.430	0.394	0.348
0.469	0.393	0.444	0.412	0.384	0.350
	0.368	0.393			
Means of yolk indices					
0.446	0.395	0.425	0.433	0.400	0.388
			Ave.of the means		0.414
			No. of eggs		38

Weight of Yolk in Grams

15.6	18.1	14.8	18.9	17.0	19.7
13.5	13.5	15.8	20.6	19.1	18.0
13.5	16.1	15.4	19.6	17.6	17.3
16.0	15.4	15.5	17.1	18.1	18.3
17.2	13.4	15.9	16.1	18.1	20.0
18.0	17.7	17.5	18.5	16.2	17.5
	16.1	17.6			

Weight of Egg (Minus Shell) in Grams

43.8	50.3	43.9	59.8	50.5	54.8
44.5	42.8	45.5	59.6	57.4	55.1
46.5	46.4	49.7	55.4	58.6	56.9
53.2	45.8	49.8	51.6	50.2	51.8
44.5	44.3	42.9	54.4	53.9	53.5
38.6	47.6	49.3	52.7	52.2	55.7
	46.4	49.3			

Table I continued

Percentage of Yolk

35.6	35.9	33.7	31.6	33.6	35.9
30.3	31.5	34.7	34.5	33.2	32.6
29.0	34.6	30.9	35.3	30.0	30.4
30.0	33.6	31.1	33.1	36.0	35.3
38.6	30.2	37.0	29.5	33.5	37.3
46.6	37.1	35.4	35.1	31.0	31.4
	34.6	35.6			
Means of percentages of yolks					
35.0	33.9	34.1	33.2	32.9	33.6
			Ave. of the means		33.8
			No. of eggs		38

Penetration in 0.1 Millimeter

50	50	74	61	51	130
63	100	41	48	86	55
34	59	41	68	77	81
41	56	61	52	77	86
78	62	54	46	132	68
65	68	38	86	89	98
76	59	66	42	65	80
48	59	38	46	90	96
65	60	48	64	90	66
49	48	74	45	90	100
38	72	30	64	79	64
32	33	42	74	90	57
60	95	80	114	61	56
			Grand Total		5151
			Grand Mean		66
			No. of cups		78

TABLE II.-10-DAY STORAGE EGGS

Observed Score

2.5	3.0	2.5	2.5	3.0	2.0	3.0	3.5
2.0	3.0	2.5	2.5	3.0	3.0	2.0	3.5
2.5	3.0	3.0	3.0	2.5	2.5	2.0	3.0
2.0	2.5	2.5	2.0	3.5	3.5	2.0	3.0
2.5	2.5	2.0	3.5	2.0	2.0	2.0	2.5
3.0	2.0	3.0	3.0	3.0	3.0	3.5	2.5
3.0	2.0	2.0	2.5	2.5	2.5	3.5	3.5
				Grand Total			149.5
				Grand Mean			2.669
				No. of Eggs			56

Height of Firm White in Millimeters

3.56	2.90	3.65	3.43	3.75	4.58	3.00	2.30
4.30	3.00	4.17	3.96	3.47	3.50	5.01	2.60
3.97	3.28	4.62	3.50	3.42	4.38	4.60	3.32
5.62	4.78	3.53	5.50	3.80	2.71	3.21	3.70
4.60	4.74	3.16	3.43	4.48	5.00	6.00	4.00
2.52	3.50	2.97	4.00	2.99	2.85	2.64	3.51
3.25	3.40	5.70	4.22	4.32	3.25	2.80	2.75
				Grand Total			213.20
				Grand Mean			3.807
				No. of Eggs			56

Weight of Total White in Grams

27.3	40.1	27.7	26.6	31.3	28.5	30.4	27.5
29.3	29.5	25.5	36.0	22.7	35.5	29.8	30.0
25.8	26.3	26.5	34.8	31.7	39.5	33.5	35.2
28.5	33.3	22.5	39.0	30.2	32.4	32.1	34.5
28.8	22.3	30.5	22.5	31.6	32.0	30.8	31.5
22.8	29.5	28.2	31.7	30.5	31.5	29.8	28.9
30.8	32.5	22.8	27.5	31.7	25.5	28.5	27.5

Weight of Firm White in Grams*

16.4	10.7
16.6	12.7
17.1	17.7
17.2	16.2
11.4	15.2
12.2	15.7
11.8	14.7

Table II continued

Percentage of Firm White*

						48.2	61.0
						55.7	57.6
						51.0	49.7
						53.5	53.0
						67.9	51.7
						59.3	45.6
						58.5	46.5
				Grand total			754.2
				Grand mean			53.8
				No. of eggs			14

Height of Yolk in Millimeters

15.28	15.00	15.40	15.47	16.00	15.59	15.36	15.00
14.35	14.75	14.90	15.38	16.00	14.95	15.34	14.75
15.60	14.80	14.83	16.38	14.65	14.92	15.01	15.20
14.60	17.46	15.67	13.68	14.96	14.52	16.80	14.48
15.25	15.52	16.92	16.42	14.82	15.69	16.80	14.60
15.40	15.12	13.19	14.48	16.31	14.50	15.48	17.55
15.15	15.30	12.57	13.38	14.65	15.61	14.70	14.08

Average Diameter of Yolk

41.1	43.1	39.1	39.6	38.2	43.2	42.1	43.3
42.7	44.2	40.1	41.1	42.4	41.9	40.8	40.6
39.4	36.1	41.8	39.5	40.5	40.7	40.7	40.0
39.8	42.6	39.4	41.0	40.3	42.3	40.7	43.5
41.5	42.2	42.8	42.1	41.1	40.9	38.6	41.8
39.0	39.1	42.9	42.2	40.5	38.3	42.5	40.7
40.9	39.5	38.5	38.4	39.8	40.6	40.8	40.7

Yolk Index

0.371	0.348	0.393	0.390	0.418	0.360	0.364	0.346
0.336	0.333	0.371	0.374	0.377	0.356	0.375	0.363
0.395	0.409	0.354	0.426	0.361	0.366	0.368	0.380
0.366	0.409	0.397	0.333	0.371	0.343	0.412	0.332
0.360	0.367	0.395	0.390	0.360	0.383	0.435	0.349
0.394	0.386	0.307	0.341	0.402	0.378	0.364	0.431
0.370	0.387	0.329	0.348	0.368	0.384	0.360	0.345
				Grand total			20.827
				Grand mean			0.371
				No. of eggs			56

*Weight and percentage of the firm white were calculated for only three of the 6 mixes.

Table II continued

Weight of Yolk in Grams

16.2	19.2	18.2	16.9	14.2	21.0	17.4	19.5
17.0	18.2	16.3	18.0	18.5	18.0	17.7	16.2
16.7	13.0	18.0	16.7	16.2	16.5	17.2	18.3
15.0	20.7	14.8	16.2	16.8	16.8	18.5	17.5
15.5	19.0	19.0	18.8	16.7	18.7	15.7	17.0
15.5	15.0	15.3	18.4	17.0	15.0	18.1	18.1
16.2	17.8	10.7	15.0	15.4	16.2	17.0	17.5

Weight of Egg (Minus Shell) in Grams

43.5	59.3	45.9	43.5	45.5	49.5	47.8	47.0
46.3	47.7	41.8	48.0	51.2	53.5	47.5	46.2
42.5	39.3	44.5	51.5	47.9	56.0	50.7	53.5
43.5	54.0	37.3	55.2	47.0	49.2	50.6	52.0
44.3	51.3	49.5	51.3	48.3	50.7	46.5	48.5
38.3	44.5	43.5	50.1	47.5	46.5	47.9	47.0
47.0	50.3	33.5	42.5	47.1	41.7	45.5	45.0

Percentage of Yolk

37.2	32.3	39.6	38.8	38.2	42.4	36.4	41.4
36.7	38.1	38.9	37.5	36.1	33.6	37.2	35.0
39.2	33.0	40.0	32.4	33.8	29.4	33.9	34.2
34.4	38.3	39.6	29.3	35.7	34.1	36.5	33.6
34.9	37.0	38.3	36.6	34.5	36.8	33.7	35.0
40.4	33.7	35.1	36.7	35.7	32.2	37.7	38.5
34.4	35.3	31.9	35.2	32.6	38.8	37.3	38.8

Grand total	2010.9
Grand mean	35.9
No. of eggs	56

Penetration in 0.1 Millimeter

160	88	135	150	155	142	115	125
181	148	105	130	115	134	120	135
136	104	120	145	145	170	165	136
145	76	105	149	112	115	134	144
147	105	124	128	149	110	102	140
149	116	137	110	120	118	101	150
152	138	100	128	135	137	115	128
124	144	129	148	130	98	70	145
131	185	142	148	88	149	92	120
146	135	119	154	105	129	123	130
168	136	130	130	111	124	139	145
178	99	126	96	128	125	108	95
173	168	130	125	120	130	110	106

Grand total	13456
Grand mean	129
No. of eggs	104

TABLE III.-20-DAY STORAGE EGGS

Observed Score

3.5	4.0	4.0	3.5	4.0	3.0	3.5	3.0
4.0	3.5	4.5	3.5	3.5	4.0	3.0	4.0
3.0	4.0	3.0	4.0	4.0	3.0	3.0	4.0
4.0	3.5	3.5	3.5	4.0	4.0	3.5	3.5
3.5	3.0	3.5	3.0	3.5	4.0	3.5	4.0
4.0	4.0	4.5	4.0	4.0	4.0	3.5	3.5
4.0	4.0	4.0	3.5	3.0	3.0	3.5	3.5
3.5	3.5	4.0	4.0	4.0		3.5	3.0
	4.0						
Means of the observed scores							
3.68	3.72	3.86	3.62	3.75	3.29	3.37	3.56
				Ave. of the means			36.9
				No. of eggs			64

Height of Firm White in Millimeters

3.34	2.00	1.20	2.97	2.40	2.55	3.33	3.92
2.07	2.70	1.20	2.96	2.87	0.25	3.18	1.55
3.67	2.55	4.43	2.51	1.80	2.70	3.12	0.80
1.65	2.50	3.84	2.97	1.92	0.55	2.98	2.26
2.68	3.08	4.24	4.93	2.08	1.35	3.90	1.36
2.44	2.45	1.24	2.54	1.46	1.85	2.55	2.20
1.75	1.50	2.28	3.00	4.55	3.30	2.06	2.01
3.65	2.00	2.52	2.61	1.50		2.60	3.02
	2.51						
Means of the heights of firm whites							
2.66	2.36	2.62	3.06	2.32	1.79	2.96	2.14
				Ave. of the means			2.489
				No. of eggs			64

Weight of Total White in Grams

28.5	31.5	28.0	27.5	28.5	32.5	28.3	26.8
27.0	32.7	21.6	30.4	28.4	28.0	27.5	28.0
30.0	28.8	30.5	26.0	30.5	29.3	27.8	29.0
25.5	27.5	28.2	26.5	30.0	31.2	29.0	27.0
27.0	32.5	29.3	32.0	26.7	28.0	29.0	26.0
30.5	25.5	27.8	24.5	31.0	28.5	25.0	26.0
29.5	20.2	29.1	25.7	29.2	34.9	29.7	14.3
	16.5	25.6	28.3	28.4		25.4	27.5
	23.2						

A

9

Table III continued

Weight of Firm White in Grams

13.2	9.5	9.2	11.7	8.2	17.7	16.3	20.7
9.4	8.2	5.7	11.1	11.2	7.4	13.7	14.6
11.7	7.7	13.9	14.4	9.2	12.7	15.7	15.9
8.5	11.4	10.7	9.4	14.5	8.8	19.9	12.7
18.0	13.7	14.2	11.0	10.7	11.8	15.7	13.1
8.7	8.7	13.4	14.2	8.7	9.9	11.7	11.1
7.7	8.7	8.3	11.7	14.2	16.0	17.9	9.2
10.9	4.7	9.5	13.7	11.2		10.2	11.7
	3.7						

Percentage of Firm White

46.3	30.1	32.8	42.5	28.7	54.4	57.5	77.2
34.8	25.0	26.3	36.5	39.4	26.4	49.8	52.1
39.0	26.7	45.5	55.0	30.1	43.3	56.4	54.8
33.3	41.4	47.9	35.4	48.3	28.2	68.6	47.0
58.8	42.1	48.4	34.3	40.0	42.1	54.1	50.3
32.2	34.1	48.2	57.9	28.0	34.7	46.8	42.6
25.2	43.0	28.5	45.5	48.6	45.8	60.2	64.3
36.9	22.4	37.1	48.4	39.4		40.1	42.5
	15.9						

Means of percentages of firm whites							
34.3	31.2	34.1	44.4	37.8	39.3	54.2	53.8
				Ave. of the means			41.1
				No. of eggs			64

Height of Yolk in Millimeters

11.43	12.30	12.08	13.47	13.54	11.12	11.46	11.85
11.10	12.78	12.23	12.54	12.96	10.70	13.26	12.28
14.56	12.08	14.08	14.00	13.57	12.04	11.51	13.55
11.50	11.12	12.70	11.80	11.36	12.20	14.83	12.54
12.65	13.47	13.85	14.40	13.98	12.08	12.10	12.10
12.08	12.52	12.44	14.00	12.08	11.98	14.85	12.23
11.80	12.35	12.50	13.98	12.52	12.65	11.97	11.23
12.87	13.00	12.54	12.48	12.05		11.68	13.48
	11.51						

Table III continued

Diameter of Yolk in Millimeters

41.4	44.0	43.8	46.3	45.2	47.6	39.9	41.0
45.3	42.9	43.9	42.6	42.7	46.4	40.9	42.1
42.8	42.7	43.1	43.2	42.6	43.4	43.9	42.2
43.6	42.5	46.3	44.4	44.7	44.6	41.6	43.0
42.2	41.7	42.2	43.5	43.1	46.9	41.1	42.6
45.7	41.6	39.4	46.0	41.6	47.3	43.5	43.6
44.2	40.5	39.3	44.1	42.9	45.4	40.6	38.1
42.9	43.4	43.6	44.5	45.2		39.7	43.6
	38.4						

Yolk Index

0.276	0.279	0.275	0.290	0.299	0.283	0.287	0.289
0.245	0.297	0.278	0.294	0.303	0.230	0.324	0.291
0.340	0.282	0.326	0.324	0.318	0.277	0.262	0.321
0.263	0.261	0.274	0.265	0.254	0.273	0.356	0.291
0.299	0.323	0.328	0.331	0.324	0.257	0.294	0.284
0.264	0.300	0.315	0.304	0.290	0.253	0.341	0.280
0.266	0.304	0.318	0.317	0.291	0.278	0.294	0.294
0.300	0.299	0.287	0.280	0.266		0.294	0.309
	0.299						

Means of yolk indices							
0.282	0.0291	0.301	0.301	0.293	0.257	0.307	0.295
				Ave. of the means			0.291
				No. of eggs			64

Weight of Yolk in Grams

15.0	16.2	16.3	20.6	20.0	19.7	14.2	21.0
16.5	16.8	17.7	15.7	15.6	18.5	17.5	16.5
15.8	16.5	18.5	17.5	17.0	18.2	18.4	18.2
15.0	14.5	19.8	16.5	14.5	19.0	17.6	17.6
15.1	16.4	18.2	17.7	17.3	20.5	16.0	18.3
18.7	16.4	13.2	19.5	15.0	20.1	17.5	18.1
16.5	13.3	14.2	18.3	17.0	21.6	13.8	17.7
15.5	10.8	17.5	16.0	16.7		14.3	17.2
	11.9						

Weight of Egg (Minus Shell) in Grams

43.5	47.7	44.3	48.1	48.5	53.2	42.5	47.8
43.5	49.5	39.3	46.1	44.0	46.5	45.0	44.5
45.8	45.3	49.0	43.5	47.5	47.5	46.2	47.2
40.5	42.0	48.0	43.0	34.5	50.2	46.6	44.6
45.7	48.9	47.5	49.7	44.0	48.5	45.0	44.3
45.7	41.9	41.0	44.0	46.0	48.6	42.5	44.1
47.0	33.5	43.3	44.0	46.2	56.5	43.5	32.0
45.0	27.3	43.1	44.3	45.1		39.7	39.7
	35.1						

A

1

Table III continued

Percentage of Yolk

34.4	33.9	36.7	43.2	41.2	37.7	33.4	43.9
37.9	33.9	45.0	34.0	35.4	39.7	38.8	37.0
34.4	36.4	37.7	40.2	35.7	38.3	39.8	38.5
37.0	34.5	41.2	38.3	32.5	37.8	37.7	39.4
33.0	33.5	38.3	35.6	39.3	42.2	35.5	41.2
40.9	39.1	32.1	44.3	32.6	41.3	41.1	41.0
35.1	39.7	32.7	41.5	36.7	38.2	31.7	55.3
44.4	39.5	40.6	36.1	37.0		36.0	40.2
	33.9						
Means of the percentages of yolks							
37.1	36.0	38.0	39.2	36.3	39.3	36.8	42.1
				Ave. of the means			38.1
				No. of eggs			64

Penetration in 0.1 Millimeter

154	155	175	150	140	225	190	180
149	205	198	168	153	65	185	120
174	144	231	138	162	90	176	165
196	212	187	150	190	193	130	138
170	155	183	148	178	160	172	120
168	160	214	125	170	221	144	120
159	155	160	164	185	158	100	119
160	130	208	45	146	215	152	126
170	152	176	160	154	131	168	172
130	181	152	160	152	225	142	164
158	152	200	137	142	78	162	123
130	184	185	124	183	90	132	125
130	125	160	155	136	162	156	135
				Grand Total			16321
				Mean			157
				No. of Custards			104

TABLE IV.-30-DAY STORAGE EGGS

Observed Score

4.0	4.0	3.5	3.5	5.0	4.0	3.5	4.0
4.0	4.0	4.5	4.5	5.0	5.0	4.0	5.0
4.5	4.5	3.5	5.0	5.0	5.0	4.0	5.0
3.5	4.0	4.5	5.0	4.0	4.5	4.5	4.5
4.0	3.5	4.0	4.5	5.0	5.0	5.0	4.5
4.5	4.5	4.0	4.5	4.5	4.5	5.0	5.0
4.0	4.5	4.0	4.0	3.5	5.0	5.0	5.0
3.5	4.5	4.5	4.5	5.0	4.5	5.0	4.0
				Grand total			281.0
				Grand mean			4.390
				No. of eggs			64

Height of White in Millimeters

1.72	2.28	3.45	3.5	0.40	1.83	1.89	1.28
1.70	2.25	1.90	4.5	0.50	0.05	1.23	0.10
1.05	1.32	2.50	5.0	0.38	0.04	1.33	0.22
3.30	2.75	2.00	5.0	2.50	0.70	0.38	1.08
2.50	3.50	2.05	4.5	1.40	0.04	0.95	0.58
2.00	1.50	1.90	4.5	2.80	0.50	0.50	0.27
2.00	2.00	2.80	4.0	0.40	0.12	0.48	0.48
2.85	1.50	1.55	4.5	0.90	0.93	0.50	0.68
				Grand total			91.55
				Grand mean			1.430
				No. of eggs			64

Weight of Total White in Grams

7.8	8.7	11.7	7.6	5.8	9.2	9.7	6.7
8.2	11.7	9.2	5.7	4.6	4.7	11.7	0.0
7.7	9.7	8.0	7.9	6.2	7.7	11.0	6.7
11.6	11.7	9.7	5.8	10.5	5.7	9.0	4.9
10.3	14.7	11.8	11.5	6.7	5.8	2.7	9.2
5.7	11.2	4.7	7.3	9.2	5.9	8.0	9.7
9.7	7.7	5.7	12.9	6.4	5.1	6.2	7.7
9.5	2.2	5.7	9.2	5.7	9.8	8.8	10.8

Table IV continued

Weight of Firm White in Grams

27.2	25.5	30.3	25.3	24.8	27.8	27.1	24.5
29.0	29.5	30.5	25.1	28.5	25.0	29.2	25.2
27.5	30.0	29.0	25.1	31.5	32.7	26.3	26.3
30.9	27.0	26.5	25.5	23.5	25.2	27.5	29.2
28.0	30.7	27.5	26.0	28.5	25.1	28.0	25.4
28.5	34.0	18.5	27.5	27.5	23.5	30.0	25.7
24.5	30.0	23.3	33.5	25.5	27.6	22.7	25.5
24.0	20.5		29.5	26.8	21.5	17.5	27.1

Percentage of Firm White

28.6	34.1	38.6	36.0	23.3	33.0	35.7	27.3
28.2	39.6	30.1	22.7	16.1	18.8	40.0	00.0
28.0	32.3	27.5	31.4	19.6	23.5	41.8	25.4
37.5	43.3	36.6	22.7	44.6	22.6	32.7	16.4
36.7	47.8	42.9	44.2	23.5	23.1	9.6	36.2
20.0	32.9	25.4	26.5	33.4	25.1	26.6	37.7
39.5	25.6	15.8	39.0	25.0	18.4	27.3	30.1
39.5	10.7	20.7	31.1	21.2	45.5	50.2	39.8

Grand total	1909.0
Grand mean	29.8
No. of eggs	64

Height of Yolk in Millimeters

11.72	11.96	12.40	14.30	10.30	9.50	10.33	11.47
12.52	11.90	11.50	13.50	11.85	11.23	11.45	7.62
12.30	12.00	12.30	9.50	10.33	11.90	8.95	9.05
12.00	12.50	11.91	10.46	12.82	9.02	8.00	12.76
11.40	13.00	9.50	10.27	10.23	9.33	8.75	9.33
12.50	12.05	10.00	9.58	10.77	10.35	9.50	9.83
10.80	12.50	10.00	12.24	9.95	10.96	11.01	8.38
14.50	10.00	10.50	11.00	8.60	11.07	9.25	10.20

Average Diameter of Yolk in Millimeters

45.5	46.0	46.8	45.7	44.8	50.8	48.9	46.5
48.2	44.1	47.0	43.4	45.3	45.6	46.6	46.8
47.1	47.0	42.8	48.6	45.8	43.1	50.5	45.4
46.8	45.1	48.5	41.4	46.6	44.3	51.0	44.6
47.4	42.5	49.8	45.6	45.6	50.1	46.8	43.2
43.5	44.3	45.2	44.3	44.0	47.4	47.5	46.9
48.4	44.6	47.0	47.0	50.1	44.7	42.9	48.6
44.5	45.4	44.6	44.1	46.7	41.2	47.3	41.0

Table IV continued

Yolk Index

0.257	0.260	0.264	0.312	0.229	0.187	0.211	0.241
0.259	0.269	0.245	0.311	0.261	0.246	0.245	0.162
0.261	0.255	0.287	0.195	0.225	0.276	0.177	0.199
0.257	0.277	0.245	0.252	0.275	0.203	0.156	0.286
0.240	0.305	0.190	0.225	0.224	0.186	0.186	0.215
0.287	0.272	0.221	0.216	0.244	0.218	0.200	0.210
0.223	0.280	0.212	0.260	0.198	0.245	0.256	0.172
0.335	0.220	0.235	0.249	0.184	0.268	0.195	0.248
				Grand total			15.209
				Grand Mean			0.237
				No. of eggs			64

Weight of Yolk in Grams

16.2	17.0	19.2	20.0	16.0	19.2	20.5	19.0
20.2	15.0	19.0	17.6	18.7	17.5	17.6	15.3
16.5	18.5	17.5	16.4	16.6	16.7	20.0	15.8
15.6	17.5	20.5	17.5	17.5	13.3	18.5	16.4
16.5	16.8	17.2	14.0	16.0	19.6	17.5	14.4
16.5	15.5	14.0	15.5	15.5	18.0	14.2	16.0
18.2	18.5	17.0	19.7	20.0	21.4	15.8	16.6
19.7	16.0	14.3	16.5	14.9	15.5	16.5	15.3

Weight of Egg (Minus Shell)in Grams

43.4	42.5	49.5	45.5	40.8	47.0	47.5	43.5
49.2	44.5	49.5	42.6	47.2	42.5	46.8	40.5
44.0	48.5	46.5	41.5	48.1	49.4	46.3	42.1
46.5	44.5	47.0	43.0	41.0	38.5	46.0	45.6
44.5	46.8	44.7	40.0	44.5	44.7	45,5	34.8
45.0	49.5	32.5	43.0	43.0	41.5	44.2	41.7
42.7	48.5	40.3	52.7	45.5	49.0	38.5	42.1
43.7	36.5	41.3	46.0	41.7	37.0	34.0	42.4

Percentage of Yolk

37.3	40.0	38.7	43.9	39.2	40.8	43.0	43.6
41.0	33.7	38.3	4122	39.6	41.1	37.6	37.7
37.5	38.1	37.6	39.5	34.5	33.8	43.1	37.5
33.5	39.3	43.6	40.6	42.6	34.5	40.2	35.8
37.0	35.3	38.4	35.0	35.9	43.8	38.4	36.1
36.6	31.3	43.0	36.0	36.0	43.3	32.1	38.3
42.6	38.1	42.1	37.3	43.9	43.6	41.0	39.4
45.0	43.8	54.2	35.8	35.7	41.8	40.5	36.0
				Grand total			2493.7
				Grand mean			38.9
				No. of eggs			64

Table IV continued

Penetration in 0.1 Millimeter

10.	138	190	167	124	200	106	157
100	178	85	152	48	153	98	170
155	237	40	155	65	158	52	162
5	139	145	101	136	155	130	164
143	174	58	150	20	164	120	147
190	208	118	132	5	156	185	200
90	145	116	130	120	134	56	186
120	210	38	78	3	164	56	176
93	52	87	125	6	220	133	168
5	190	68	115	160	125	124	173
62	134	80	50	152	160	116	168
142	5	144	200	16	184	51	182
100	15	135	115	142	201	38	160
				Grand total			12723
				Grand mean			122
				No. of eggs			64

APPENDIX B

DATA ON EGGS and CUSTARDS OF SERIES B

TABLE I.-ONE DAY EGGS

Observed Score				Height of Firm White in Millimeters			
1.5	1.5	1.0	1.0	5.50	9.04	7.65	6.52
1.0	1.0	1.5	1.5	5.85	8.72	5.30	6.20
1.0	1.0	1.0	1.0	7.50	6.72	9.48	6.95
1.5	1.0	1.0	1.0	6.30	6.10	6.10	6.45
1.5				4.90			
1.5				4.60			
Means of observed scores				Means of heights of firm whites			
1.33	1.12	1.12	1.12	5.78	7.64	7.13	6.53
Ave. of the means			1.171	Ave. of the mean			6.767
No. of eggs			18	No. of eggs			18

Weight of Total White in Grams				Weight of Firm White in Grams			
34.5	34.8	33.5	31.8	20.8	19.7	20.2	25.7
33.5	27.0	34.0	38.5	25.7	15.7	20.2	19.2
37.0	29.0	33.5	33.8	23.5	16.7	21.1	22.7
34.0	28.0	37.2	33.2	21.7	15.5	21.2	22.3
31.5				16.4			
29.5				17.7			

Percentage of Firm White				Height of Yolk in Millimeters			
60.2	56.6	60.2	60.8	12.06	13.95	13.60	15.30
76.7	58.1	59.4	49.8	14.90	14.80	14.53	16.70
63.5	57.5	62.9	67.1	15.00	16.48	16.08	16.30
63.8	55.3	56.9	67.1	13.45	13.86	14.56	16.30
52.0				16.15			
60.0				13.35			
Means of percentages of firm whites							
62.7	56.9	59.9	66.2				
Ave. of the mean			61.4				
No. of eggs			18				

Table I continued

Average Diameter of Yolk in Millimeters				Yolk Index			
43.3	40.6	41.5	40.6	0.279	0.343	0.327	0.376
39.0	37.8	37.9	41.7	0.382	0.391	0.383	0.400
34.5	36.8	37.8	40.6	0.434	0.447	0.425	0.401
39.1	35.5	42.7	39.8	0.343	0.390	0.430	0.409
37.1				0.435			
37.4				0.356			
				Means of yolk indices			
				0.372	0.393	0.369	0.397
				Ave. of the mean			0.383
				No. of eggs			18

Weight of Yolk in Grams				Weight of Egg (Minus Shell) in Grams			
18.5	16.2	15.8	17.1	53.0	51.0	49.3	48.9
16.2	14.5	15.2	19.0	49.0	41.5	49.2	57.5
12.3	14.5	14.0	18.7	49.3	43.5	47.5	52.5
15.2	12.7	17.1	15.3	49.2	40.7	54.3	48.5
16.9				47.5			
14.0				43.5			

Penetration in 0.1 Millimeter			
36	18	31	62
32	56	12	62
47	60	26	48
48	6	49	56
34	32	16	70
64	16	4	82
35	10	30	84
55			
41			
30			
Means of penetration			
42.2	28.3	24.0	66.3
Ave. of the mean			40.1

Table I continued

pH of the Whites	pH of the Mixes
8.39 in custard 1	6.50 in custard 1
8.82 in custard 2	6.30 in custard 2
8.58 in custard 3	6.73 in custard 3
8.47 in custard 4	6.70 in custard 4
Mean of pH of whites	Mean of pH of mixes
8.565	6.557
Total 26.26	Total 26.23

TABLE II.-10-DAY STORAGE EGGS

Observed Score				Height of White in Millimeters			
2.0	2.0	4.0	3.5	4.75	5.04	2.50	2.20
2.0	2.0	4.5	3.0	4.87	5.03	1.48	3.51
2.5	2.0	3.5	4.0	4.20	4.65	2.45	2.53
3.5	2.0	3.5	3.5	2.10	6.30	2.40	3.50
Grand total			47.5	Grand total			57.51
Grand mean			2.968	Grand mean			3.594
No. of eggs			16	No. of eggs			16

Weight of Total White in Grams				Weight of Firm White in Grams			
28.5	29.5	27.5	28.5	17.2	16.7	15.8	12.2
28.7	26.5	28.0	28.9	15.9	13.0	6.8	13.3
31.7	30.5	25.5	29.7	15.5	17.2	18.5	10.2
28.5	30.0	23.5	27.5	11.7	15.7	9.6	12.5

Percentage of Firm White				Height of Yolk in Millimeters			
60.3	56.6	57.4	42.8	13.10	14.15	11.00	12.90
55.5	49.0	24.2	46.0	13.92	15.20	11.87	14.10
48.8	56.3	72.3	72.5	13.24	12.95	11.08	13.75
41.0	52.3	40.8	45.4	13.50	14.82	12.35	13.58
Grand total			783.2				
Grand mean			48.9				
No. of eggs			16				

Average Diameter of Yolk in Millimeters				Yolk Index			
40.2	47.7	44.4	46.7	0.325	0.296	0.247	0.276
40.1	40.3	41.7	44.1	0.347	0.377	0.284	0.319
42.9	40.7	43.9	47.0	0.308	0.318	0.252	0.292
41.0	42.9	42.9	41.0	0.329	0.345	0.287	0.331
				Grand total			4.933
				Grand mean			0.308
				No. of eggs			16

A

20

Table II continued

Weight of Yolk in Grams				Weight of Egg (Minus Shell) in Grams			
15.0	22.7	16.0	18.8	43.5	52.2	43.5	47.3
14.8	15.5	15.0	17.6	43.5	42.0	43.8	46.5
17.2	14.3	16.0	22.1	48.9	44.8	41.5	51.8
17.0	16.5	16.1	17.5	45.5	46.5	39.6	45.0

Percentage of Yolk				Penetration in 0.1 Millimeter			
34.4	43.4	36.7	39.7	138	122	116	126
34.0	35.2	34.2	37.8	81	66	110	102
35.1	33.9	38.5	42.6	54	76	100	70
37.3	35.4	40.6	38.8	124	112	51	110
				88	83	90	133
				108	40	100	128
				75	48	96	118

Grand Total	567.6	Grand total	2670
Grand mean	35.4	Grand mean	95
No. of eggs	16	No.of custards	28

pH

pH of Whites		pH of Mixes	
	9.33		6.62
	9.32		6.70
	9.55		6.76
	9.40		6.86
Total	37.60	Total	26.94
Mean	9.40	Mean	6.735
No. of mixes	4	No. of mixes	4

TABLE III.-20-DAY STORAGE EGGS

Observed Score				Height of Firm White in Grams			
3.5	3.5	4.5	4.5	2.50	3.75	1.61	2.22
4.5	3.0	4.0	4.0	1.85	4.10	2.25	2.50
4.5	3.5	4.5	4.5	.15	3.48	2.20	2.30
4.0	4.5	4.5	4.0	2.38	1.38	2.48	2.45
		5.0				1.65	
Means of observed scores				Means of heights of whites			
4.1	3.6	4.5	4.2	1.72	3.18	2.04	2.37
Ave. of the means			4.100	Ave. of the means			2.328
No. of eggs			17	No. of eggs			17

Weight of Total White in Grams				Weight of Firm White in Grams			
27.7	24.6	26.0	29.0	6.5	10.7	2.5	9.4
26.6	29.3	28.0	26.5	5.7	17.1	6.9	7.8
25.5	25.3	24.1	22.5	4.7	12.4	7.3	1.7
25.4	25.5	19.4	23.5	4.1	7.7	3.9	8.0
		21.5				4.0	

Percentage of Firm White				Height of Yolk in Millimeters			
23.4	43.6	10.0	32.4	10.00	12.60	10.10	12.30
21.4	43.8	24.6	29.4	10.08	10.83	9.99	12.50
18.4	50.1	30.2	7.5	8.98	10.60	9.30	12.03
16.1	30.1	18.1	34.0	10.40	10.55	8.33	11.20
		18.6				10.78	
Means of percentages of firm whites							
19.0	41.9	20.8	27.1				
Ave.of the means			27.1				
No. of eggs			17				

Table III continued

Average Diameter of Yolk				Yolk Index			
45.9	42.8	46.3	49.5	0.217	0.294	0.218	0.248
45.0	46.3	46.7	51.3	0.224	0.233	0.213	0.243
46.3	47.8	45.2	46.5	0.193	0.221	0.205	0.258
45.0	42.1	50.2	46.4	0.231	0.250	0.165	0.241
		46.7				0.230	
				Means of yolk indices			
				0.214	0.250	0.2068	0.248
				Ave. of the means			0.230
				No. of eggs			17

Weight of Yolk in Grams				Weight of Egg (Minus Shell) in Grams			
14.8	16.4	15.0	22.8	42.5	41.0	41.0	51.8
15.7	17.1	15.5	24,5	42.3	45.4	43.5	50.0
15.5	18.2	14.5	18.7	41.0	43.5	38.6	41.2
15.5	15.4	17.1	18.5	40.9	40.9	36.5	42.0
		14.4				35.9	

Percentage of Yolk				Penetration in 0.1 Millimeter			
34.8	40.0	36.5	44.0	109	120	94	150
37.1	37.6	35.6	49.0	131	138	110	85
37.8	41.8	37.5	45.3	150	141	151	112
37.8	37.6	46.8	44.0	105	92	137	120
		40.1		103	98	115	115
				111	104	92	152
				122	118	130	122
Means of percentages of yolks							
36.9	36.2	39.3	45.6				
Ave. of the means			39.5	Grand total			3327
No. of eggs			17	Grand mean			118
				No. of cups			28

pH of the Whites		pH of the Mix	
9.40 in custard 1		6.80 in custard 1	
9.36 in custard 2		6.71 in custard 2	
9.41 in custard 3		6.79 in custard 3	
9.33 in custard 4		6.79 in custard 4	
Mean	9.375	Mean	6.772
Total	37.50	Total	27.09

TABLE IV.-30-DAY STORAGE EGGS

(Later corrected for water loss)

Observed Score

3.5	4.0	4.5	4.5	3.5	3.5	5.0
4.0	5.0	4.5	4.5	3.5	4.0	5.0
5.0	5.0	3.0	4.0	4.0	4.5	4.5
5.0	5.0	4.5	4.0	5.0	5.0	3.5
5.0	4.5	4.5	4.0	4.5		4.0
						4.5
						4.0
Means of observed scores						
4.5	4.7	4.2	4.2	4.1	4.5	4.3
			Ave. of the means			4.333
			No. of eggs			36

Height of Firm White in Millimeters

3.45	2.50	3.01	1.35	1.98	3.37	1.00
2.52	2.33	1.51	2.23	3.00	1.90	1.05
2.00	1.70	3.60	3.06	2.00	2.00	2.50
1.80	1.53	2.52	2.20	1.70	1.50	2.25
1.00	3.01	1.62	1.65	1.90		2.07
						1.70
						3.30
Means of the heightsof whites						
2.15	2.21	2.45	2.10	2.12	2.19	1.98
			Ave. of the means			2.171
			No. of eggs			36

Weight of Firm White in Grams

4.7	10.2	15.7	11.4	13.9	14.8	9.7
8.2	3.7	8.5	11.7	13.9	9.7	15.7
2.2	4.8	17.0	15.7	9.9	9.7	12.1
1.5	0.0	11.7	9.0	5.0	11.7	12.7
5.6	9.7	12.2	0.0	4.7		10.7
						9.1
						14.2

Table IV continued

Weight of Total White in Grams

28.5	24.4	30.0	26.0	22.5	25.0	22.9
25.5	20.8	21.5	31.5	24.0	26.5	27.0
26.5	21.5	18.1	29.3	27.5	24.0	27.7
26.3	27.5	18.5	24.5	24.5	26.5	24.3
25.0	24.5	24.1	26.0	22.6		24.0
						24.9
						26.2

Percentage of Firm White

16.4	41.8	52.3	43.8	51.7	59.2	42.3
32.1	17.7	39.5	37.1	57.9	36.6	58.1
8.3	22.3	93.9	53.5	36.0	40.4	43.6
5.7	00.0	63.2	36.7	20.4	44.1	52.2
22.4	39.5	50.6	00.0	20.7		44.5
						36.5
						54.1
Means of percentages of firm whites						
17.0	24.3	59.9	34.2	39.3	45.1	47.3
			Ave. of the means			47.3
			No. of eggs			36

Height of Yolk in Millimeters

11.45	10.61	11.46	11.15	10.50	11.65	8.85
11.72	10.25	10.32	10.83	11.02	11.20	9.40
10.80	10.00	11.65	11.91	10.60	12.00	9.65
10.41	11.01	11.00	10.65	9.50	12.02	10.70
10.22	12.30	11.00	11.55	10.50		10.08
						9.00
						11.05

Average Diameter of Yolk in Millimeters

45.2	47.0	49.6	42.2	46.6	43.8	56.0
52.1	50.6	51.9	50.0	42.8	49.2	56.8
50.0	50.7	43.3	43.6	40.4	46.9	53.3
47.8	43.8	45.9	49.5	47.0	42.6	51.2
42.3	45.6	44.3	43.1	45.9		54.6
						53.2
						44.6

Table IV continued

Yolk Index

0.253	0.225	0.231	0.264	0.225	0.265	0.158
0.224	0.202	0.198	0.216	0.257	0.227	0.165
0.216	0.197	0.269	0.273	0.262	0.255	0.181
0.217	0.251	0.239	0.215	0.202	0.282	0.208
0.241	0.269	0.248	0.267	0.228		0.184
						0.169
						0.247
Means of the yolk indices						
0.230	0.229	0.237	0.247	0.235	0.257	0.187
			Ave. of the means			0.228
			No. of eggs			36

Weight of Yolk in Grams

15.5	17.1	18.7	15.5	18.2	16.0	16.0
22.0	18.2	20.7	19.1	14.0	20.5	23.0
20.8	17.0	25.9	15.2	13.5	21.0	20.3
16.4	15.5	20.0	16.0	16.2	17.0	20.2
13.3	16.0	15.1	16.0	15.7		23.5
						20.1
						15.8

Percentage of Yolk

35.2	41.2	38.3	37.3	44.7	39.0	41.1
46.3	46.6	49.0	37.7	36.8	43.6	46.0
43.9	44.1	58.8	34.1	32.9	46.6	42.2
38.4	36.0	51.9	39.5	39.8	39.0	45.3
34.7	38.5	38.5	38.0	40.9		49.4
						44.6
						37.6
Means of percentage of yolks						
39.7	41.5	47.3	37.3	39.0	42.1	43.7
			Ave.of the means			41.5
			No. of eggs			36

Weight of Egg (Minus Shell) in Grams

44.0	41.5	48.7	41.5	40.7	41.0	38.9
47.5	39.0	42.2	50.6	38.0	47.0	50.0
47.3	38.5	44.0	44.5	41.0	45.0	46.0
42.7	43.0	38.5	40.5	40.7	43.5	44.5
38.3	40.5	39.2	42.0	38.3		47.5
						45.0
						42.0

A

26.

Table IV continued

Penetration in 0.1 Millimeter						
164	131	95	98	98	110	29
86	170	92	84	118	125	86
146	128	120	106	88	33	47
138	97	145	80	110	114	135
92	102	92	160	106	86	58
120	150	85	137	112	102	100
112	169	140	90	82	5	157
						130
						68
						120
						144
						135
						164
Means of penetration						
122.5	135.0	109.7	107.9	102.0	82.1	105.6
			Ave. of the means			109
			No. of cups			55

Appendix C

Table I.--SUMMARY OF MEANS (M.), STANDARD DEVIATIONS, (S.D.) and STANDARD ERRORS (S.E.) OF MEASUREMENTS TREATED STATISTICALLY IN SERIES A

	Fresh Eggs	10-Day Eggs	20-Day Eggs	30-Day Eggs
Observed Score				
M.	1.391	2.669	3.619	4.390
S.D.	0.499	0.505	0.612	0.530
S.E.	0.022	0.068	0.077	0.064
Height of Firm White				
M.	6.083	3.807	2.489	1.430
S.D.	1.095	0.851	0.976	0.944
S.E.	0.179	0.114	0.122	0.118
Percentage of Firm White				
M.	60.1	53.8	41.1	29.8
S.D.	1.031	5.941	1.508	9.829
S.E.	0.250	1.650	0.189	0.123
Yolk Index				
M.	0.414	0.371	0.291	0.237
S.D.	0.080	0.044	0.031	0.042
S.E.	0.013	0.005	0.002	0.005
Percentage of Yolk				
M.	33.8	35.9	38.1	38.9
S.D.	3.949	3.101	2.798	4.201
S.E.	0.659	0.419	0.035	0.545
Penetration				
M.	66.	129	157	122
S.D.	21.65	24.28	32.89	58.45
S.E.	2.46	2.39	3.23	5.75

Appendix D

Table I.--SUMMARY OF MEANS (M.), STANDARD DEVIATIONS, (S.D.) and STANDARD ERRORS (S.E.) OF MEASUREMENTS TREATED STATISTICALLY IN SERIES B

	Fresh Eggs	10-Day Eggs	20-Day Eggs	30-Day Eggs
Observed Score				
M.	1.171	2.968	4.100	4.357
S.D.	0.338	0.858	0.803	0.324
S.E.	0.082	0.221	0.200	0.054
Height of Firm White				
M.	6.767	3.594	2.328	2.171
S.D.	0.576	0.430	0.811	0.665
S.E.	0.125	0.111	0.201	0.112
Percentage of Firm White				
M.	61.4	48.9	27.1	38.2
S.D.	9.106	11.228	10.242	13.954
S.E.	2.796	2.905	2.560	2.358
Yolk Index				
M.	0.383	0.308	0.230	0.232
S.D.	0.012	0.036	0.007	0.025
S.E.	0.005	0.009	0.001	0.004
Percentage of Yolk				
M.	32.4	35.4	39.5	41.5
S.D.	1.884	12.271	8.248	6.293
S.E.	0.456	3.168	2.062	1.063
Penetration				
M.	40	95	118	109
S.D.	21.95	28.16	23.60	34.07
S.E.	4.00	5.41	4.54	4.63

Table 1 continued

	pH of the White			
M.	8.565	9.400	9.375	9.368
S.D.	0.161	0.091	0.032	0.091
S.E.	0.092	0.052	0.018	0.040
	pH of the Mix			
M.	6.557	6.735	6.772	6.811
S.D.	0.190	0.087	0.089	0.103
S.E.	0.109	0.050	0.051	0.046

Bibliography

(1)*Almquist, H. J., and Lorenz, F. W. Firm white of fresh and storage eggs. Poultry science, 14: 340-1, November 1935.

(1)*Almquist, H. J., and Lorenz, F. W. Liquefaction of egg white. U. S. egg and poultry magazine, 38:20-3, March 1932.

(3) Balls, A. K., and Swenson, T. L. Formation of thin white. U. S. egg and poultry magazine, 20:22-27, August 1934.

(4)*Balls, A. K., and Swenson, T. L. Proteolysis in stored eggs. Industrial and engineering chemistry, 26:570-572, May 1934.

(5)*Barmore, Mark A. The influence of various factors, including altitude, in the production of angel food cake. Fort Collins Colo.,Colorado. Agricultural experiment station, 1936. (Technical bulletin, No. 15)

(6) Fisher, R. A. The design of experiments. London, Oliver and Boyd, 1935. 252 p.

(7)*Herrington, B. L., and Sharp, Paul F. The effect of holding on the appearance of the opened egg. U. S. egg and poultry magazine, 40:37-39, November 1934.

(8)

A
31
(8)*Holst, W. F., and Almquist, H. J. Measurement of deterioration in the stored hen's egg. Hilgardia, 6:49-60, August 1931.

(9)*Justin, Margaret M. and others. Foods. New York, Houghton-Mifflin co., 1933. 569 p.

(10)*King, F. B., and others. Some methods and apparatus used in measuring the quality of eggs for cake making. Cereal chemistry, 13:37-49, January 1936.

(11)*King, F. B., and others. Cake-making qualities of eggs as related to some factors in egg production. Cereal chemistry, 13:703-711, November 1936.

(12)*Lowe, Belle. Experimental cookery from the chemical and physical standpoint. New York, Wiley and sons, 1937. 583 p.

(13)*Macleod, Annie Louise, and Nason, Edith H. Chemistry and cookery. New York, McGraw-Hill, 1937. 568 p.

(14) McCollum, E. V., and others. The newer knowledge of nutrition. 5th ed. New York, Macmillan company, 1939. 701 p.

(15) Mitchell, H. H., and Carmen, G. G. The biological value of the nitrogen of mixtures of patent flour and other foods. Journal of biological chemistry, 68:183-191, April 1926.

(16)*Muse, M. A. A study of the viscosity of soft custards as affected by egg quality. Burlington,

Vt., Vermont. Agricultural experiment station, 1939. (Research study) (Work in progress) (Abstract in Association of land-grant colleges and universities. Home economic section. Research committee, and American home economic association. Research department. Notes on graduate studies and research in home economics and home economics education, 1937-38, Washington, U. S. Office of education, 1938. p. 30. Misc. 2086)

(17) Saxl, Joseph. Pediatric dietetics. Philadelphia, Lea and Febiger, 1937. 565 p.

(18) Shackleton, Leslie, and McCance, Robt. The ionizable iron in foods. Biochemical journal, 30:591, April 1936.

(19)*Sharp, Paul F. The condition of the apparent thick white as an important factor in studying the quality of eggs. U. S. egg and poultry magazine, 40:33-37, November 1934.

(20)*Sharp, Paul F. The pH of the white as an important factor influencing the keeping quality of hen's egg. Science, 69:278, March 1929.

(21) Sharp, Paul F., and Powell, C. K. Decrease in interior quality of hen's egg during storage as indicated by the yolk. Industrial and engineering chemistry, 22:908-910, August 1930.

(22)*Sharp, Paul F., and Powell, C. K. Increase in the pH of the white and yolk of hen's eggs. Industrial and engineering chemistry, 23:196-9, February 1931.

(23)*Stewart, G. F., Sharp, P. F. and Gans, A. R. The relation of yolk index to the interior quality by candling and from the opened egg. U. S. egg and poultry magazine, 38:1-5, November 1932.

(24) Sherman, Henry C. Chemistry of food and nutrition. New York, The Macmillan company, 1938. 640 p.

(25) Smith, E. C. The pH of the white of egg. Gt. Britain. Department of scientific and industrial research. Food investigation board. Report, 1934, p. 50-2. (Abstract in Chemical abstracts 30:175, January 1936.).

(26)*Stanley, Louise, and Cline, Jessie. Foods: their selection and preparation. Boston, Ginn and co., 1935. 458 p.

(27) Stewart, Jean J. Foods: production, marketing, consumption. New York, Prentice-Hall, Inc., 1938. 737 p.

(28)*St.John, J. L., and Castor, A. B. Nature of watery eggs. (In Washington.(State) Agricultural experiment station, Pullman. Forty-fourth annual report, 1934. p. 27-28. Its Bulletin, no. 305)

(29) Van Wagenan, A., and Wilgus, H. S., Jr. The determination and importance of the condition of the

firm albumen in studies of egg quality. Journal of agricultural research, 5:1129-1147. December 1935.

(30)*Wilgus, H. J., Jr., and Van Wagenan, A. The height of the firm albumen as a measure of its condition. Poultry science, 40:319-322, July 1936.

(31)*Wilhelm, L. A. Egg quality, a literature review. U. S. poultry magazine, 589-594, October,1939.