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Cooking Quality and Flavor of EGGS

As related to candled quality, storage conditions, and other factors

U. S. DEPARTMENT OF AGRICULTURE

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Martha E. Hollinger, Louisiana State University
Baton Rouge, Louisiana

Ruth Jordan, Purdue University
Lafayette, Indiana

Barbara A. McLaren and W. J. Stadelman, State College
of Washington, Pullman, Washington

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Cooking Quality and Flavor of EGGS

As Related to Candled Quality, Storage Conditions, and Other Factors

Prepared by Elsie H. Dawson, Cora Miller, and Ruth A. Redstrom,
Human Nutrition Research Branch, Agricultural Research Service

INTRODUCTION

Quality, price, and size are factors that housewives consider most important when they buy eggs, according to an analysis of 31 consumer egg-preference studies made in 18 States and Canada.[1] Many of the studies revealed that housewives are willing to pay a premium for high-quality eggs. Most housewives had a number of ways to evaluate egg quality. Many said that a firm, upstanding yolk was what they looked for in quality; others listed such things as firm whites, odor, color of yolk, and absence of blood spots. Most consumer complaints about eggs referred to undesirable conditions of the whites and yolks, blood or meat spots, and bad flavor, taste, or odor.

In selecting eggs, consumers today are guided by the grade. Grade is usually assigned after the eggs have been examined before a candling light. Candling is a practical method of estimating several aspects of quality of raw eggs in the shell. Mobility, visibility, and shape of the yolk shadow in candling tend to be associated with the firmness of the thick white; the thicker the white and the less mobile and visible the yolk, the higher the quality assigned to the egg. The United States grading standards are based primarily on these characteristics, although condition of the shell and size of the air cell are also taken into consideration. Shell eggs are classified in order of decreasing candled quality into four market grades, AA, A, B, and C; usually the higher the grade, the higher the price per unit in the same size eggs.

PURPOSE OF THE RESEARCH

Eggs graded by candling have been on the market for over 30 years, but little has been known about the relationship between functional characteristics in cooking of eggs and candled grade. A coordinated research project was therefore

[1] A. W. JASPER. SOME HIGHLIGHTS FROM CONSUMER EGG STUDIES. U. S. Dept. Agr., Agr. Inform. Bul. 110, 25 pp., illus. June 1953.

designed for the purpose of providing new information regarding the following:

(1) The reliability of the candled quality of eggs as a guide to their performance in food preparation and palatability when served alone or in combination with other ingredients;

(2) The suitability of shell eggs of different candled qualities (resulting from storage conditions) for different purposes in the home preparation of foods;

(3) The retention of cooking quality and palatability of eggs during storage for varying periods of time and under storage conditions commonly used; and

(4) The relation of climate or season of production to the quality of eggs.

In this report are presented only the highlights of these studies for use in educational programs. Details of the experiments may be obtained by reference to other publications of this research cited on the inside of the back cover.

There has been considerable previous work on several phases of this problem, such as the effect of ration on yolk color, the effect of season, breed, and storage temperature on albumen index and Haugh units, the relative merits of various methods of measuring opened egg quality, the relation of internal characteristics of the raw egg to candled quality, and the effects of oil dipping.

References to other publications on the subject are given on page 43.

PLAN AND PROCEDURES

Collaboration of the agricultural experiment stations of three States—Washington, Louisiana, and Indiana (designated in this report as Stations I, II, and III, respectively)—made it possible to include in the study eggs produced in different parts of the country—the Far West, the Far South, and the North Central States. Each station worked independently but with uniform procedures and during approximately the same period of time. Some phases of the experiment were carried out by all three stations and others by only one or two stations, so that all stations are not represented in each experiment.

Infertile eggs from healthy hens were used throughout. At two stations the eggs were obtained from hens fed standardized balanced rations and at one station, from hens of two breeds on two rations. One flock each of Single Comb White Leghorns, and of New Hampshires were fed a ration rich in the pigment-containing ingredients—yellow corn and alfalfa meal—and another flock of each breed was fed a similar ration but with wheat, barley, and oats in place of yellow corn and alfalfa meal.

The different candled qualities of eggs were obtained by holding newly laid eggs of A or AA quality in cold storage, in the refrigerator, and at room temperatures; samples were taken out of storage at regular intervals of time to determine the rate of deterioration in quality. The term "stored" and "storage" are used for convenience in this report to describe eggs held under all conditions, although the industry prefers to reserve use of these terms for cold-storage eggs only.

Some eggs were oil-dipped before they were stored along with untreated eggs, so that the effectiveness of the oil dip as compared with no treatment could be evaluated.

In the grading of eggs for this research the candled quality of each individual egg was determined and only eggs that candled into a specific quality were used for further testing, whereas in the market grading of eggs a tolerance of 20 percent of the eggs from the major quality is permitted in the labeled grade. The term "candled quality" is therefore used here instead of the term "grade." For cooking tests

eggs of the predominating candled quality at each sampling period were used in most cases; occasionally eggs of one lower quality were used. At each period data were compiled according to the candled quality of the eggs sampled and also according to the time and the temperature of storage.

The length of the storage periods at the different temperatures and humidities varied somewhat among stations, but each station included the first and one or more of the remaining conditions listed below:

(1) From 6 to 10 months (24 to 40 weeks) in cold storage at 30° to 32° F., with a relative humidity of 85 percent or more.

(2) Up to 7 months (28 weeks) at refrigerator temperature, 40° to 45° F., with a relative humidity of 72 to 74 percent.

(3) From 1 to 9 weeks at room temperature in various seasons. Two stations used air-conditioned constant-temperature rooms, 70° to 80° F. and 72° ±2°, as well as uncontrolled temperature rooms. The lowest temperature recorded was 68° and the highest 95°, with relative humidities ranging from 26 to 90 percent.

(4) After eggs had been kept 6 months in cold storage, they were stored at higher temperatures, some up to 8 weeks longer at 40° to 45° F., with a relative humidity of 72 to 74 percent, and some 2 weeks longer at 70° to 88°, with a relative humidity of 26 to 48 percent.

Newly laid eggs candling A or AA quality were obtained at each test period from the same flocks that produced the eggs for storage and used as reference standards for all tests on quality and functional properties of stored eggs.

Some eggs from each sampling were used for soft-cooking in the shell and evaluated for flavor only. The remainder were broken out for use.

For representative samples the appearance of the raw egg was evaluated by four common laboratory methods:

(1) Albumen index: Height of thick albumen divided by width;

(2) Haugh unit: Logarithm of height of thick albumen multiplied by 100 adjusted according to egg weight to the equivalent value of a standard 2-ounce egg;

(3) Van Wagenen score: Appearance of the egg as compared with a set of numbered pictures of eggs with different degrees for albumen firmness; and

(4) Yolk index: Height of yolk divided by average width, usually multiplied by 100 to give whole numbers.

In the Van Wagenen evaluation, a score of 1 is highest, 5 is lowest; in all others, the higher the number, the higher the quality of the egg.

The broken-out eggs were used for cooking tests in poaching, as thickening agents in baked custards, and as leavening agents in angelfood cakes. The firmness of custards and the volumes of cakes made with stored eggs as compared with those made with newly laid eggs were used as the criteria for retention of thickening and leavening power of the eggs during storage.

The relative palatability of each product rated by trained tasting panels was used as a measure of the retention of the palatability of the eggs during storage. All mixing, baking, and other procedures were standardized and all tasting panels used the same rating system.

The internal quality of the stored eggs and the quality and palatability of products made from them were compared with the qualities of the newly laid eggs. The results are expressed as percent of the values obtained for newly laid eggs.

FINDINGS

The findings from the three stations taking part in the study are presented in the following charts. Charts are numbered in the upper right-hand corner.

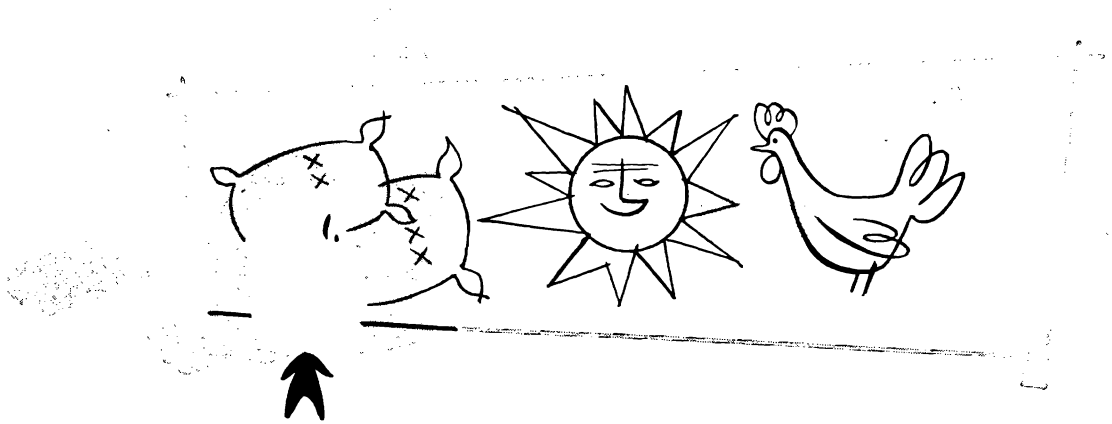
Winter eggs had slightly higher albumen index than summer eggs. Ration or breed made no appreciable difference in albumen index, although ration caused eggs to vary in yolk color.

In the laboratory the albumen index, which numerically expresses the comparative firmness of thick albumen in egg whites, is a common method of measuring egg quality.

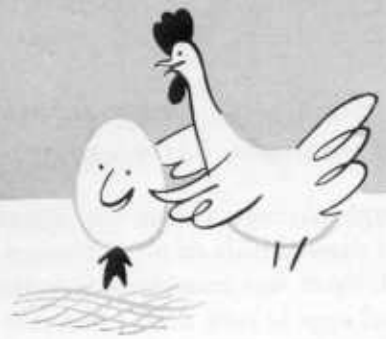
Even in newly laid eggs the firmness of thick albumen varies. Among the sources of variation mentioned in the literature are season, climate, and breed of hen. To study such factors, Station I separated New Hampshire and White Leghorn hens into two flocks for each breed and during both winter and summer seasons fed a high-pigment-containing ration (described on p. 2) to one flock of each breed and a low-pigment-containing ration to the other. They then were able to compare newly laid eggs three ways—between seasons, between rations, and between breeds.

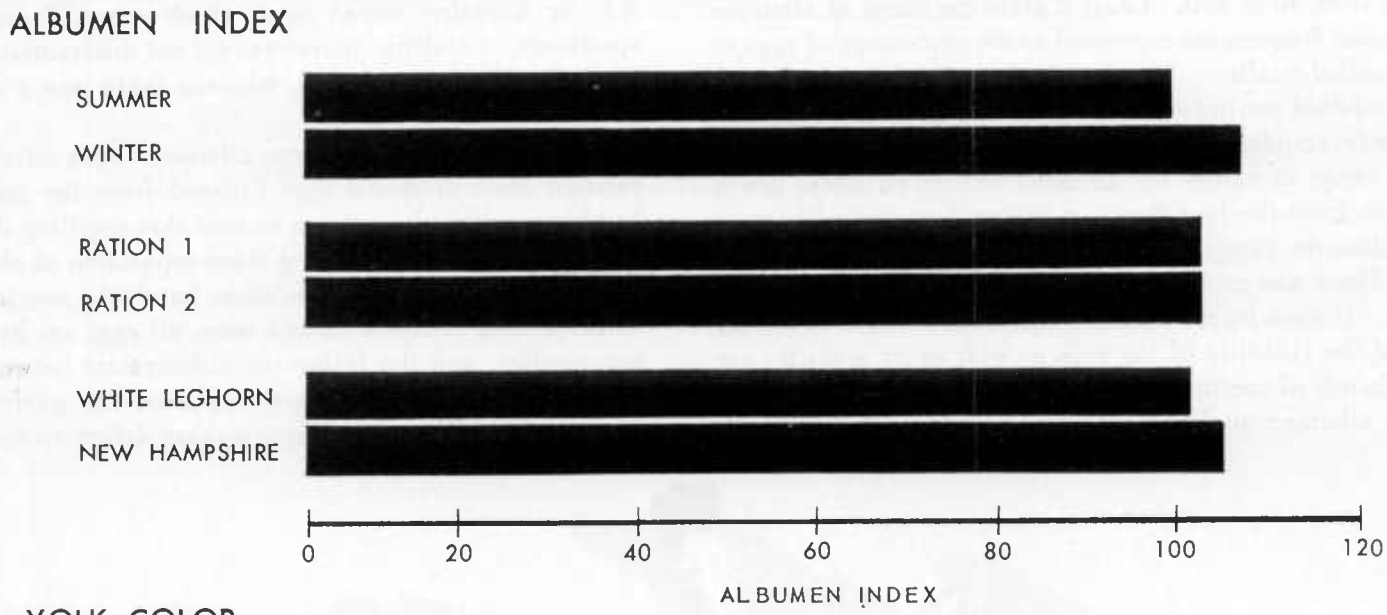
In average albumen index values, newly laid winter eggs were slightly higher than summer eggs in both breeds. There was no difference in albumen index due to the rations. A slightly higher albumen index of New Hampshire eggs as compared with that for White Leghorn eggs did not reach statistical significance. These comparisons are shown in chart 1.

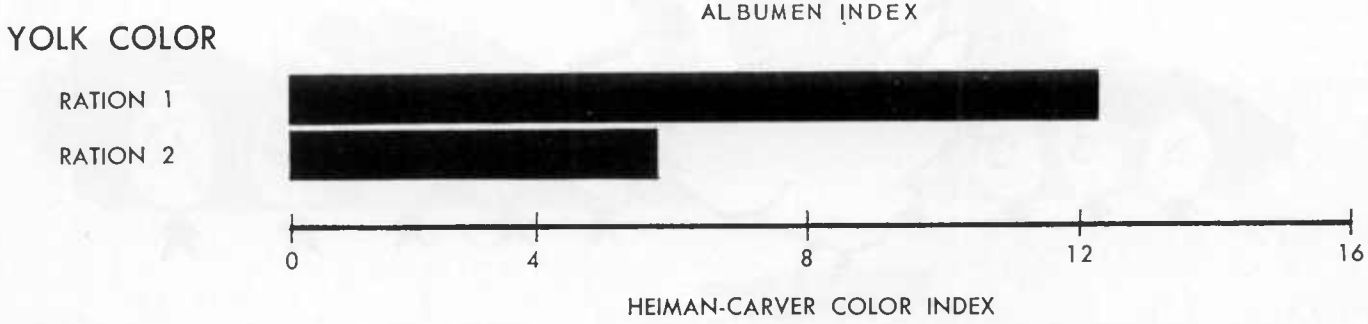
When diet sources for both breeds of hens were compared, yolk color was found to be the only measurement that indicated any appreciable difference attributable to the diet. This color difference probably influenced the candled quality of the eggs, because the dark-colored yolks from hens fed the high-pigment-containing diet were more visible in candling than were the light yolks from hens of either breed on the other diet. The light shells of the eggs from the Leghorn hens permitted greater visibility than the dark shells of the eggs from the New Hampshire hens. Consequently, the light-shelled, dark-yolked eggs were predominately A quality by candling, whereas the dark-shelled, dark-yolked New Hampshire eggs were predominately AA quality.



ALBUMEN INDEX VALUES OF NEWLY LAID EGGS ARE LITTLE AFFECTED BY SEASON, RATION, AND BREED; YOLK COLOR IS AFFECTED BY RATION







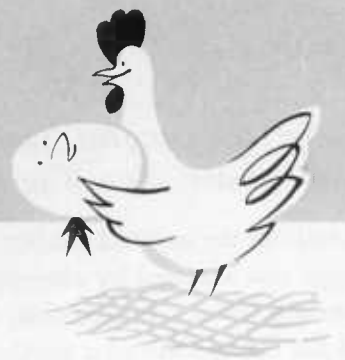
There was a wide range in albumen index values for newly laid eggs and for stored eggs of different candled qualities, but average values decreased with decrease in candled quality.

Although average values for albumen indices of newly laid eggs showed little or no difference due to season, ration, or breed, there was considerable variation in values among individual eggs in each flock. Extreme values for a few eggs ranged from 40 to 200. Chart 2 gives the range of albumen indices and frequencies expressed as the percentage of eggs of each candled quality. The distribution of the eggs in the different candled quality classes represents one candler's evaluation under standardized conditions.

The range of values for albumen indices of 2,600 newly laid eggs from the four flocks at Station I was as wide as or wider than the range for any one candled quality of stored eggs. There was an overlapping of values among all quality classes. It must be remembered that both the size of the air cell and the visibility of the yolk as well as its mobility are determinants of candled-quality classification, so that eggs of similar albumen quality might conceivably vary sufficiently in other characteristics to fall into different categories in candling.

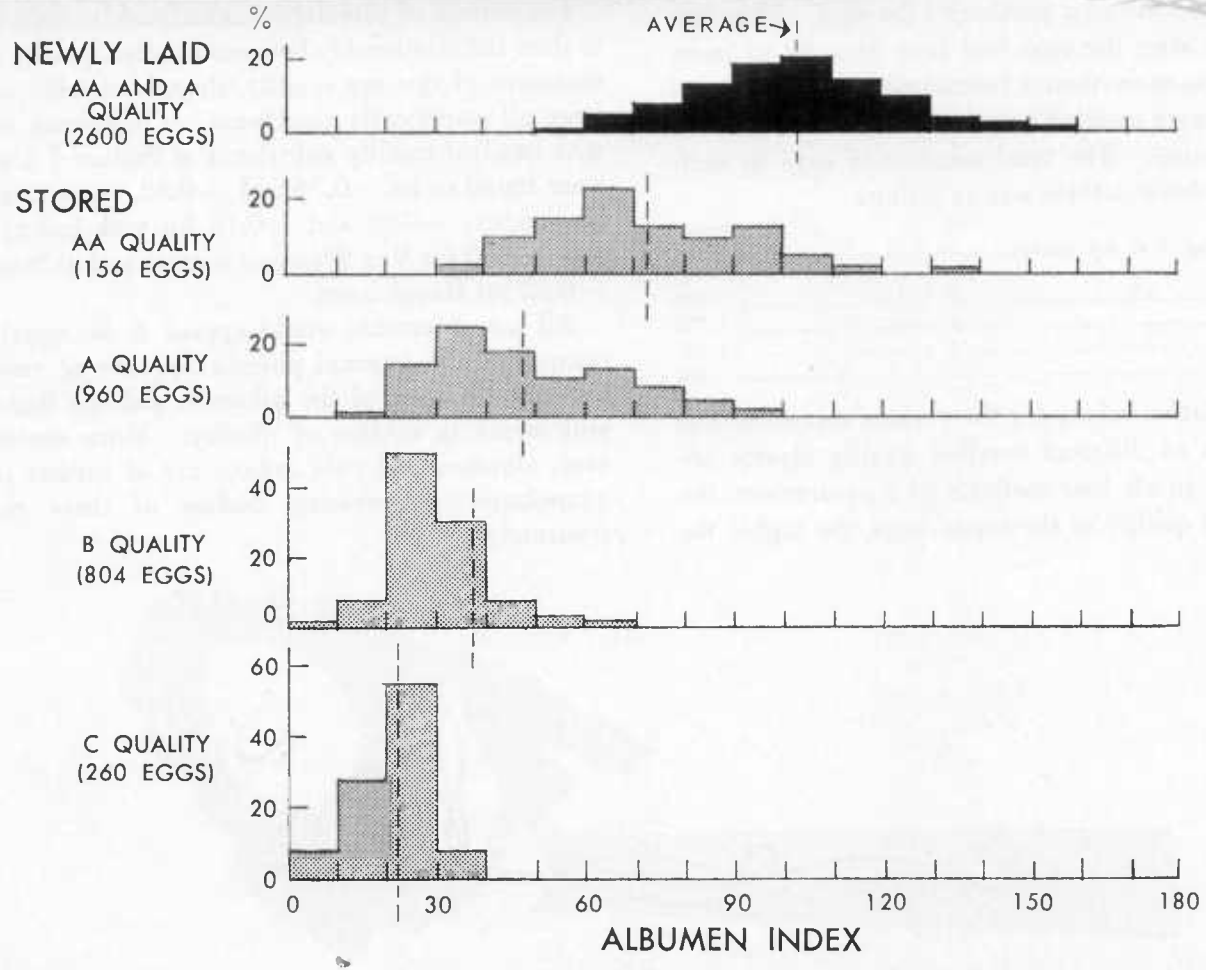
The average albumen index of 102 for newly laid eggs of AA and A quality was higher than the averages for either AA- or A-quality stored eggs, which were 72 and 47, respectively. Candling, therefore, did not differentiate between newly laid and stored eggs, whereas there was a difference in albumen index.

However, since the average albumen index values of one candled class of stored eggs differed from the majority of another candled class, it can be said that candling does serve a useful purpose in obtaining some separation of stored eggs into quality classes. On the other hand, the overlapping of values among different classes when all eggs are handled by one candler, and the failure to differentiate between newly laid and stored eggs, suggest the need for perfecting the method of candling or devising a more definitive method.



ALBUMEN INDEX VARIES WITH CANDLED QUALITY OF NEWLY LAID AND STORED EGGS

Values for eggs of different candled qualities overlap



The higher the candled quality of stored eggs, the higher the internal quality as shown by albumen index, yolk index, Van Wagenen score, and Haugh unit.

At all stations the internal quality of representative samples of raw eggs was assessed by albumen index, yolk index, and Van Wagenen score. In addition, some of the stations determined the Haugh unit of a portion of the eggs. Measurements were made after the eggs had been brought to room temperature and no more than 4 hours had elapsed between the time the eggs were candled and the time their broken-out quality was measured. The total number of eggs in each category from all three stations was as follows:

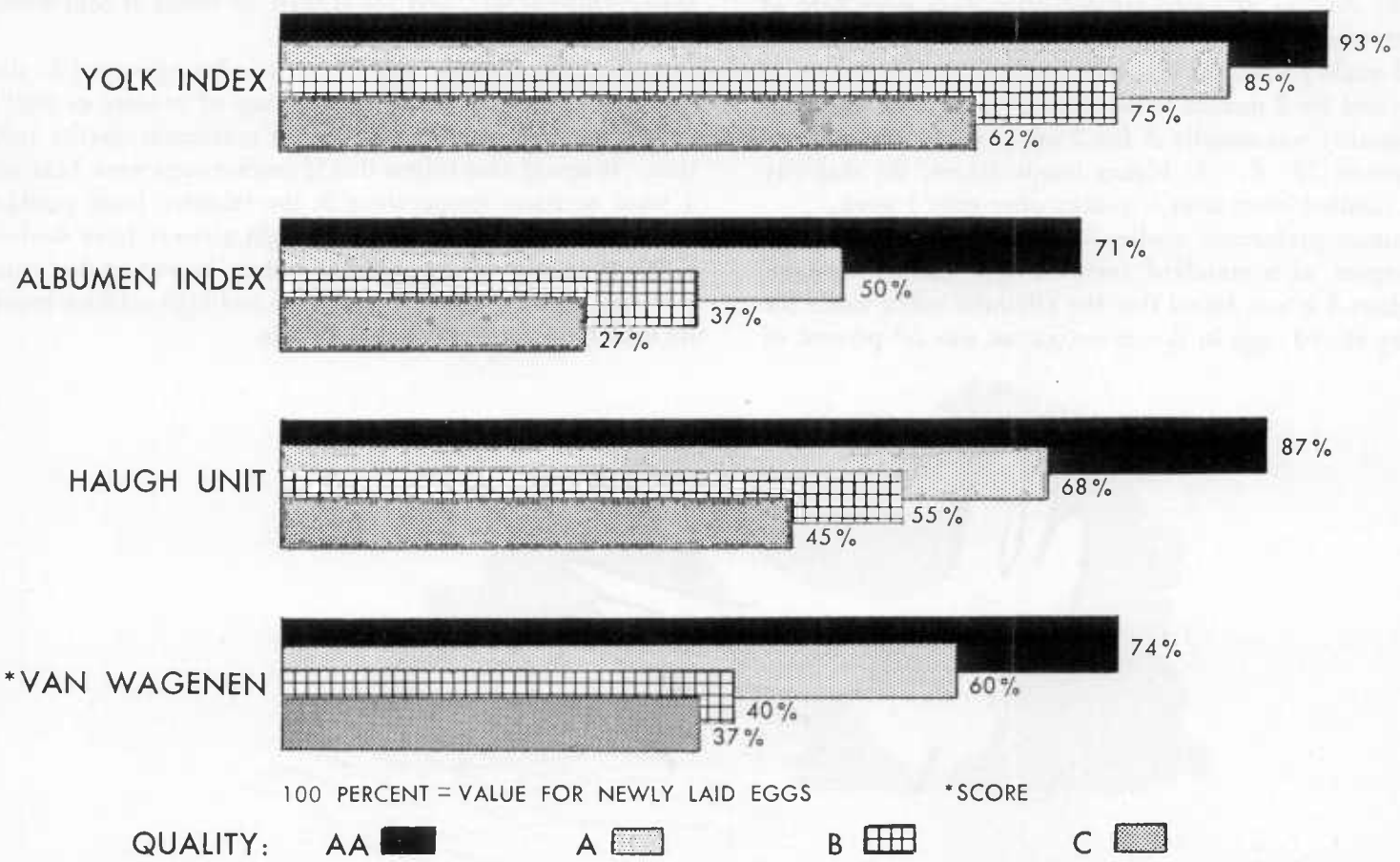
	Number
Newly laid eggs candling A or AA quality	2,828
Stored eggs candling:	
AA quality	156
A quality	1,772
B quality	1,436
C quality	860

The average relative values for the various measurements of the stored eggs of different candled quality classes are given in chart 3. In all four methods of measurement, the higher the candled quality of the stored eggs, the higher the internal physical values of the raw eggs. However, values for stored eggs of AA and A quality were from 7 to 50 percent lower than those for newly laid eggs of AA and A quality.

Coefficients of correlation calculated by individual stations to show the relationship between candled quality and the other measures of raw egg quality, though variable in magnitude, were all statistically significant. Coefficients of correlation with candled quality calculated at Station I and Station III were found to be −0.74 and −0.38, respectively, for albumen index; −0.81 and −0.16 for yolk index; and +0.76 and −0.40 for Van Wagenen scores; and at Station III only, −0.52 for Haugh units.

All measurements would appear to be equally useful in comparing the internal physical quality of raw eggs, since both the thinning of the albumen and the flattening of the yolk occur in decline of quality. More specifically, however, albumen and yolk indices are of further usefulness in quantitatively expressing decline of these characteristics separately.

INTERNAL CHARACTERISTICS OF STORED EGGS ARE RELATED TO CANDLED QUALITY BUT VALUES ARE LOWER THAN FOR NEWLY LAID EGGS



Albumen thinned so rapidly in eggs stored at 72° F. that in 2 weeks they were below standard quality; eggs kept at 45° retained albumen quality for 18 weeks; at 32° for at least 40 weeks.

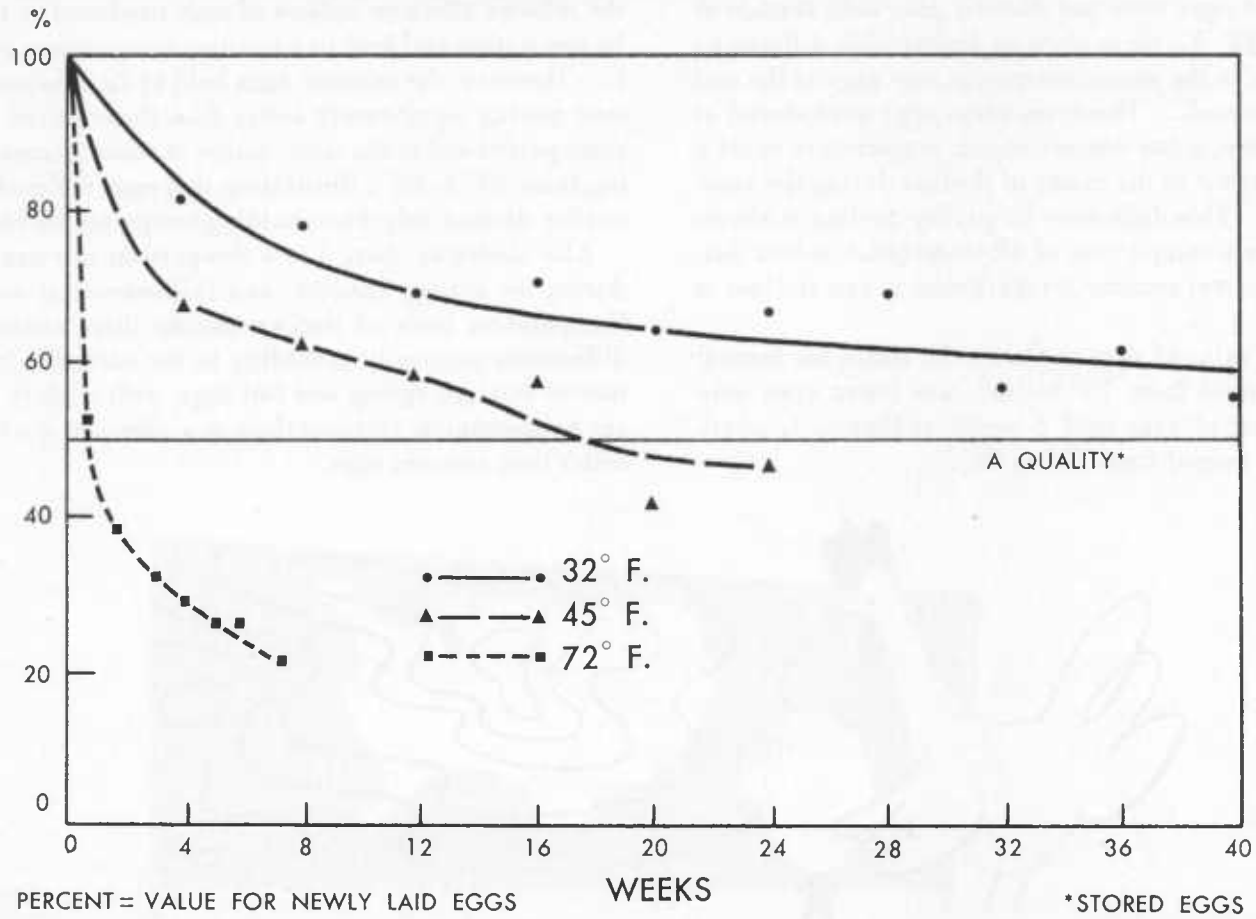
Eggs that were stored at room temperatures were sampled each week; those kept at lower temperatures were usually sampled at monthly or biweekly intervals. In chart 4 is given a comparison of the rate of thinning of the egg albumen as shown by relative albumen indices when eggs were held at different temperatures. At all stations the predominating candled quality was A or higher for at least 6 months in cold storage, and for 2 months in the refrigerator. The predominating quality was usually A for 2 weeks when temperatures were around 72° F. At higher temperatures, the majority of eggs candled lower than A quality after only 1 week.

Consumer preference studies indicate that grade A eggs are accepted as a standard for desirable quality in eggs. From chart 3 it was found that the albumen index value for A-quality stored eggs in this investigation was 50 percent of the value for newly laid eggs. When eggs were stored at 72° F., the albumen thinned so rapidly that eggs were below this standard of quality in 2 weeks. Eggs stored promptly kept A quality for approximately 18 weeks at refrigerator temperature of 45°, and for at least 40 weeks at cold storage temperature of 32°.

At all temperatures the albumen index appeared to drop rapidly, which stresses the importance of prompt as well as continuous refrigeration of eggs for maximum quality retention. It would also follow that if market eggs were held only 1 week at room temperature in the transfer from producer to cold-storage warehouse, they might already have declined to low A or to B quality. It is therefore important that newly laid eggs be held at low temperature and high relative humidity until they are put into cold storage.

ALBUMEN INDEX IS AFFECTED BY STORAGE TEMPERATURE

At room temperature raw albumen quality declined rapidly



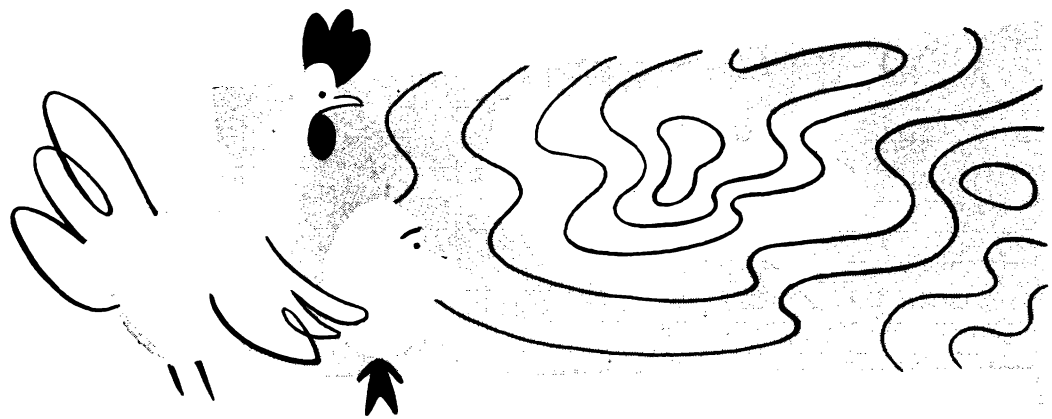
Eggs stored in different localities or in different seasons varied in rate of decline of albumen quality only when temperatures of holding varied.

The comparative rates of decline in quality of eggs during storage as measured by the albumen index of raw broken-out eggs were remarkably similar from station to station when storage conditions were comparable. For example, when newly laid eggs were put directly into cold storage at approximately 32° F., there were no appreciable differences between stations in the measurements on raw eggs at the end of the storage periods. However, when eggs were stored at room temperatures, a few degrees higher temperature made a noticeable difference in the extent of decline during the same period of time. This difference in quality decline is shown in chart 5, where a comparison of albumen index values during storage at normal summer temperatures at two stations is given.

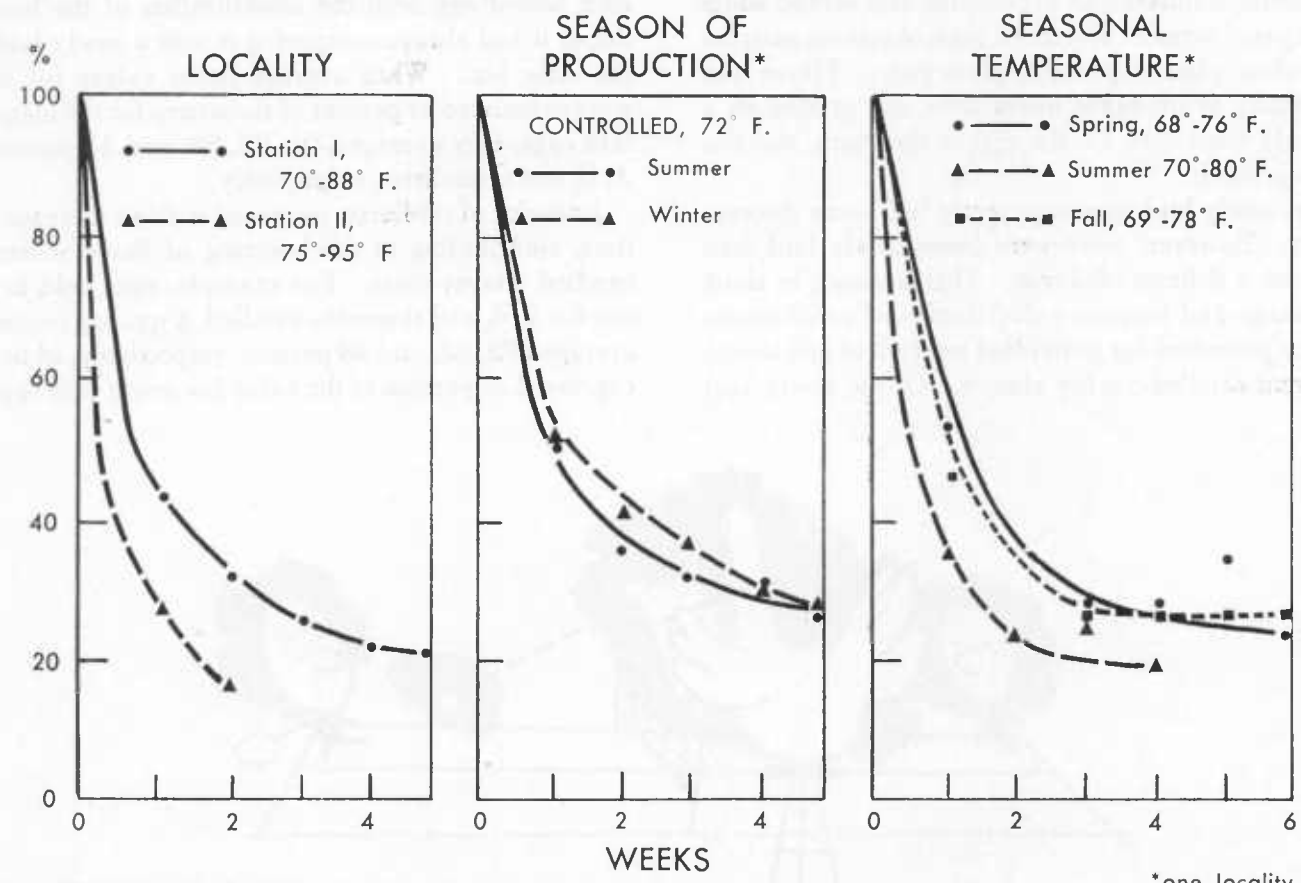
The albumen value of eggs at Station II, where the normal temperatures ranged from 75° to 95°, was lower after only 2 weeks than that of eggs held 5 weeks at Station I, where the temperature ranged from 70° to 88°.

Although the albumen indices of newly laid eggs averaged somewhat higher in winter than in summer, the season of production had no apparent effect on the rate of quality decline during storage. This is best seen in chart 5 by comparing the relative albumen indices of eggs produced in two seasons by one station and kept in a constant-temperature room at 72° F. However, the summer eggs held at 72° maintained albumen quality significantly better than those stored during the same period and at the same station at room temperature varying from 70° to 88°, illustrating that eggs differed in rate of quality decline only when holding temperatures varied.

Also shown in chart 5 is a comparison of rates of decline during the spring, summer, and fall seasons at one location. Comparative rates of decline during three seasons showed differences primarily according to the variation in temperature of storage; spring and fall eggs, with slightly lower storage temperatures, retained their raw albumen quality slightly better than summer eggs.



ALBUMEN INDEX IS AFFECTED BY TEMPERATURE VARIATIONS IN DIFFERENT LOCALITIES AND SEASONS



100 PERCENT = VALUE FOR NEWLY LAID EGGS

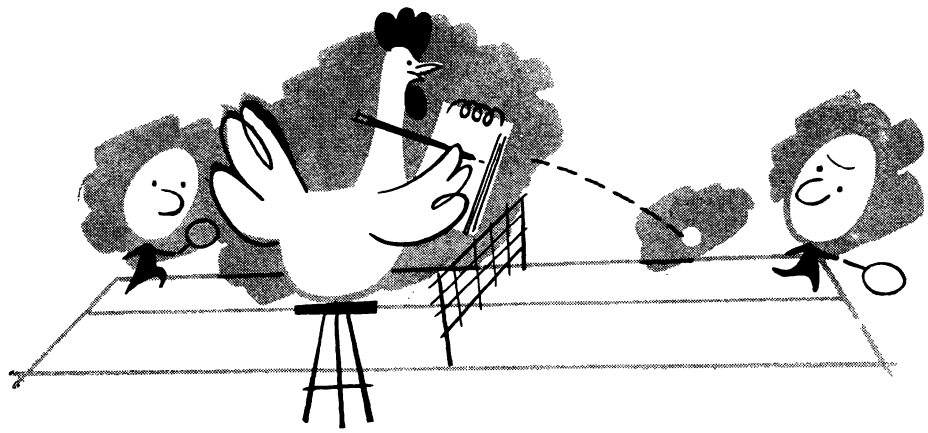
There was a wide range in flavor scores for newly laid and stored eggs of different candled quality, but the average flavor values decreased with decrease in candled quality.

Flavor is considered by many people to be a most important aspect of egg quality. To evaluate the flavor of eggs, taste panels scored soft-cooked eggs to which no seasonings were added to influence flavor. Newly laid and stored eggs were soft-cooked under standardized procedures and served while warm. Each panel member scored all eggs, obtaining samples of yolk with clean plastic spoons or glass rods. Flavor was rated on intensity of off-flavor discernible and graded on a numerical scale from 5 to 1—the higher the score, the less off-flavor was present.

Frequently, newly laid eggs apparently had some discernible off-flavor. However, there were fewer newly laid than stored eggs with a definite off-flavor. This is shown in chart 6, where the range and frequency distribution of panel scores at Station I are presented for individual newly laid and stored eggs of different candled-quality classes. Of the newly laid eggs 54 percent had some discernible off-flavor, while 93, 97, 99, and 100 percent of the stored eggs of AA, A, B, and C qualities, respectively, had some off-flavor.

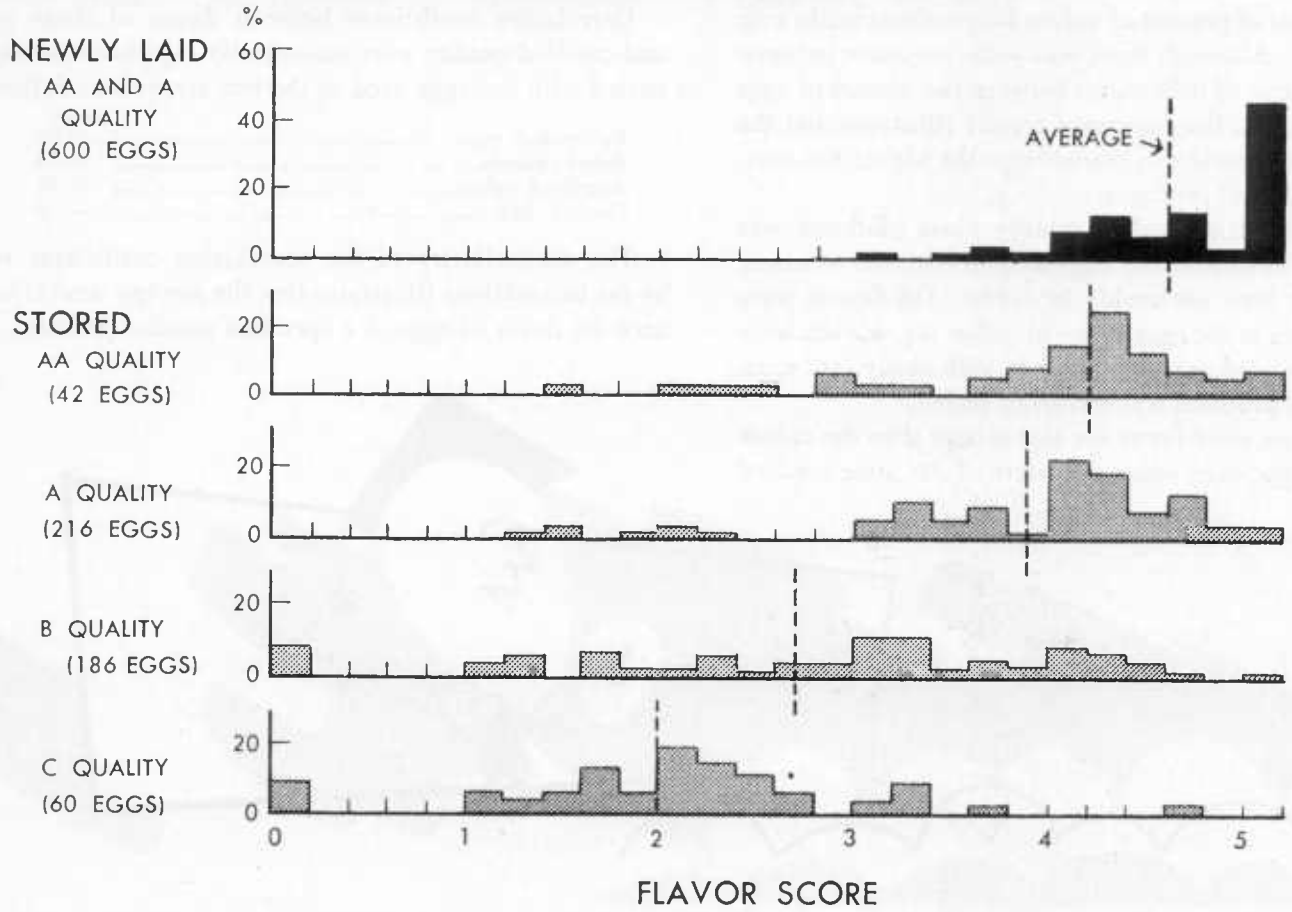
Hen-to-hen differences were avoided at Station I by marking each stored egg with the identification of the hen that produced it and always comparing it with a newly laid egg from the same hen. When average flavor values for stored eggs were calculated as percent of the scores for the matched newly laid eggs, they averaged 91, 85, 59, and 43 percent for AA, A, B, and C qualities, respectively.

Intensity of off-flavor increased with an increase in storage time, contributing to the lowering of flavor scores within a candled quality class. For example, eggs held in cold storage for 2, 4, and 6 months candled A quality consistently but averaged 93, 82, and 48 percent, respectively, in flavor scores expressed as percent of the value for newly laid eggs.



FLAVOR SCORES FOR SOFT-COOKED EGGS RANGED WIDELY WITHIN A CANDLED QUALITY

Newly laid eggs had highest flavor scores



The higher the candled quality of stored eggs, the higher the flavor score of cooked products—soft-cooked eggs, baked custard, and angelfood cake.

Flavor was evaluated not only for soft-cooked eggs but also for eggs used in baked custards and angelfood cakes.

In chart 7 are shown flavor scores for soft-cooked eggs, custards, and cakes according to the candled quality of the eggs, expressed in terms of percent of values for products made with newly laid eggs. Although there was some variation between stations in the extent of differences between two classes of eggs for any one product, the combined results illustrate that the higher the candled quality of stored eggs, the higher the average flavor scores for all products.

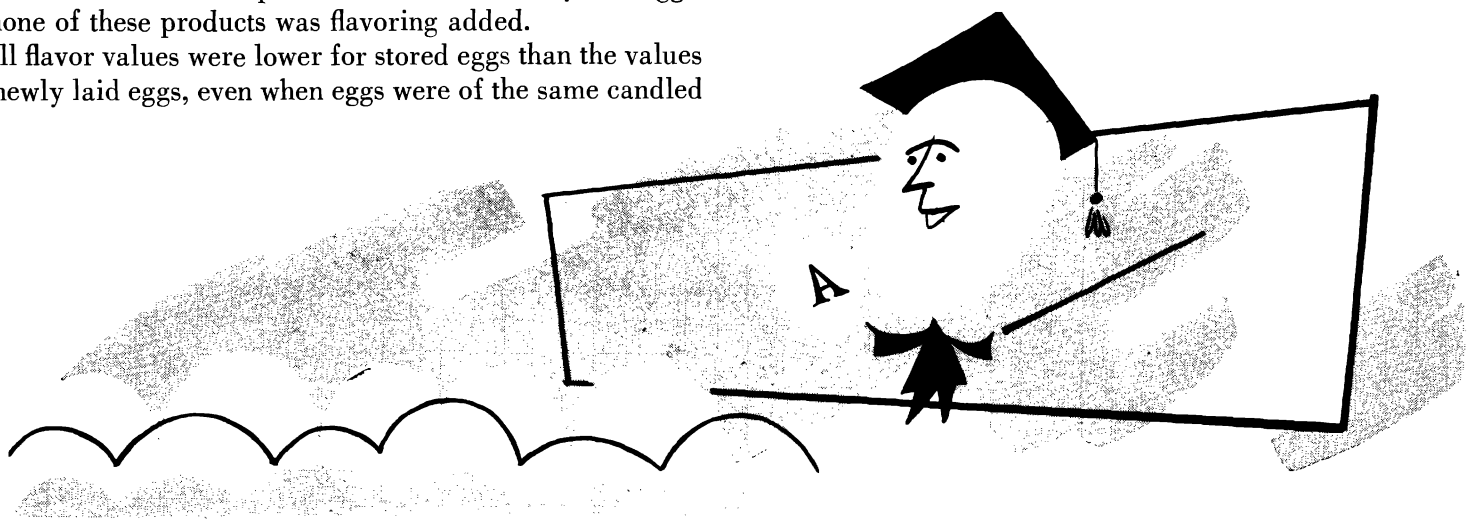
In general, within a candled quality class off-flavor was more noticeable in soft-cooked eggs than in custards or cakes, and was usually least noticeable in cakes. Off-flavors were assumed to be due to the eggs, since all other ingredients were the same as those used in products made with newly laid eggs. To none of these products was flavoring added.

All flavor values were lower for stored eggs than the values for newly laid eggs, even when eggs were of the same candled quality. For soft-cooked eggs, average flavor scores for AA- and A-quality stored eggs were 88 to 91 percent as high as those for newly laid eggs. Stored eggs of B and C quality had lower flavor scores than those of AA and A quality.

Correlation coefficients between flavor of these products and candled quality were statistically significant, though they varied with the eggs used at the two stations as follows:

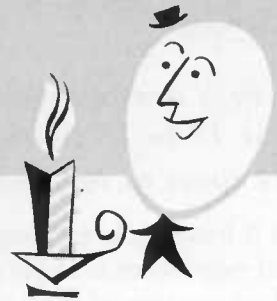
	Station I	*Station III*
Soft-cooked eggs	—0.66	—0.56
Baked custards	—.78	—.34
Angelfood cakes	—.76	—.45
Poached eggs	—.73	------

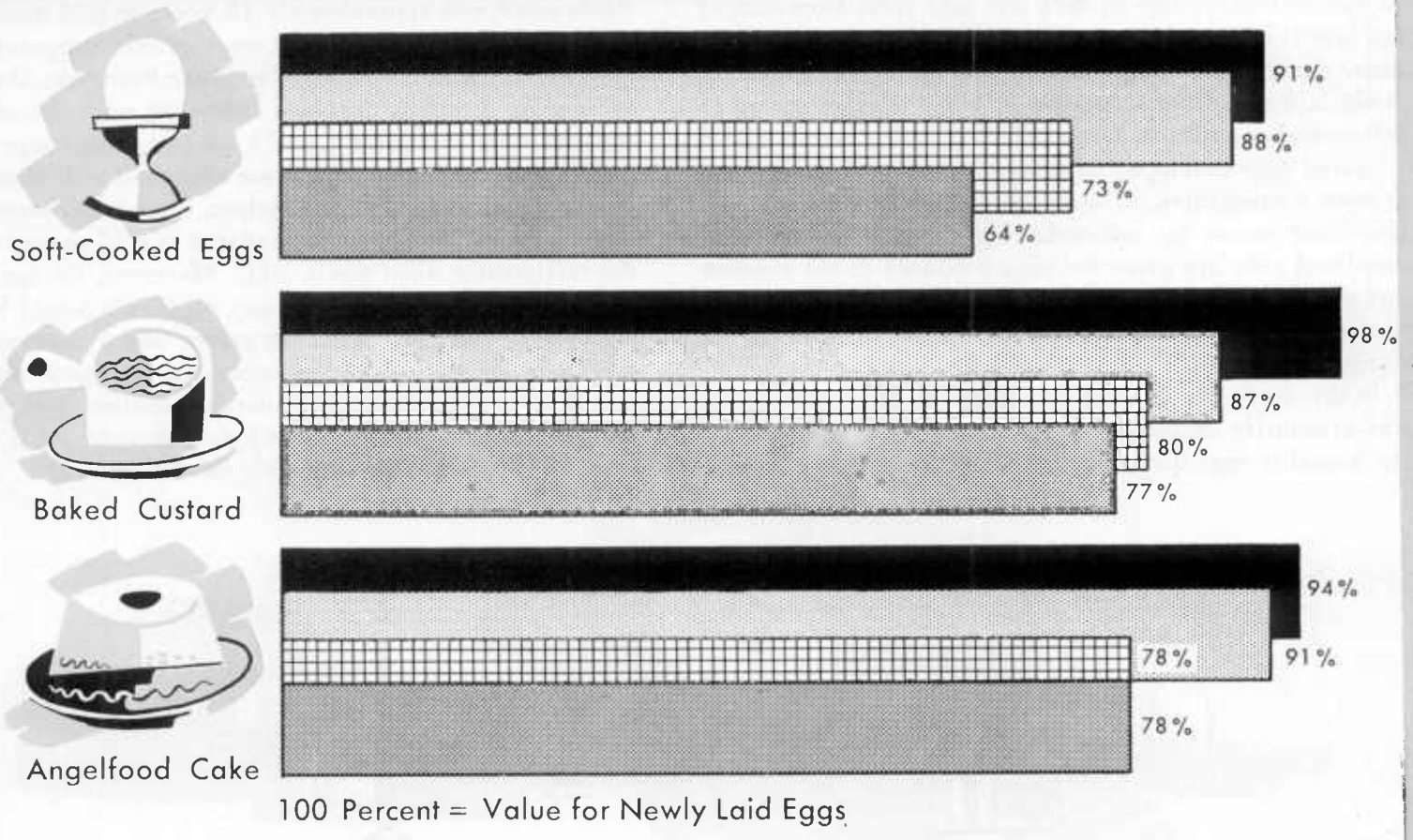
The dissimilarity of the correlation coefficients reported by the two stations illustrates that the storage conditions influence the flavor of eggs of a specified candled quality.



FLAVOR OF STORED EGGS IS RELATED TO CANDLED QUALITY

Eggs of Higher Candled Quality are Better Flavored





In flavor, eggs were scored the equivalent of A quality after being held in cold-storage or in a household refrigerator 13 to 15 times as long as eggs held at room temperature when used as soft-cooked eggs, and at least 24 times as long when used in baked custards or angelfood cake.

Although it has long been recognized that off-flavors occur in newly laid eggs, there is as yet no satisfactory explanation. At Station I where eggs of dark and light yolks from each of two breeds of hens were produced by feeding them different diets, there was no difference in average flavor scores for newly laid eggs from either diet or breed whether scored as soft-cooked or as poached eggs.

Stored eggs developed off-flavors most rapidly when kept at room temperatures. This is shown in chart 8, where relative flavor scores for soft-cooked eggs, baked custard, and angelfood cake are given for eggs produced in the summer and stored at room temperature of 72° F., together with relative scores for eggs kept in cold storage at 32°, and in the refrigerator at 45°.

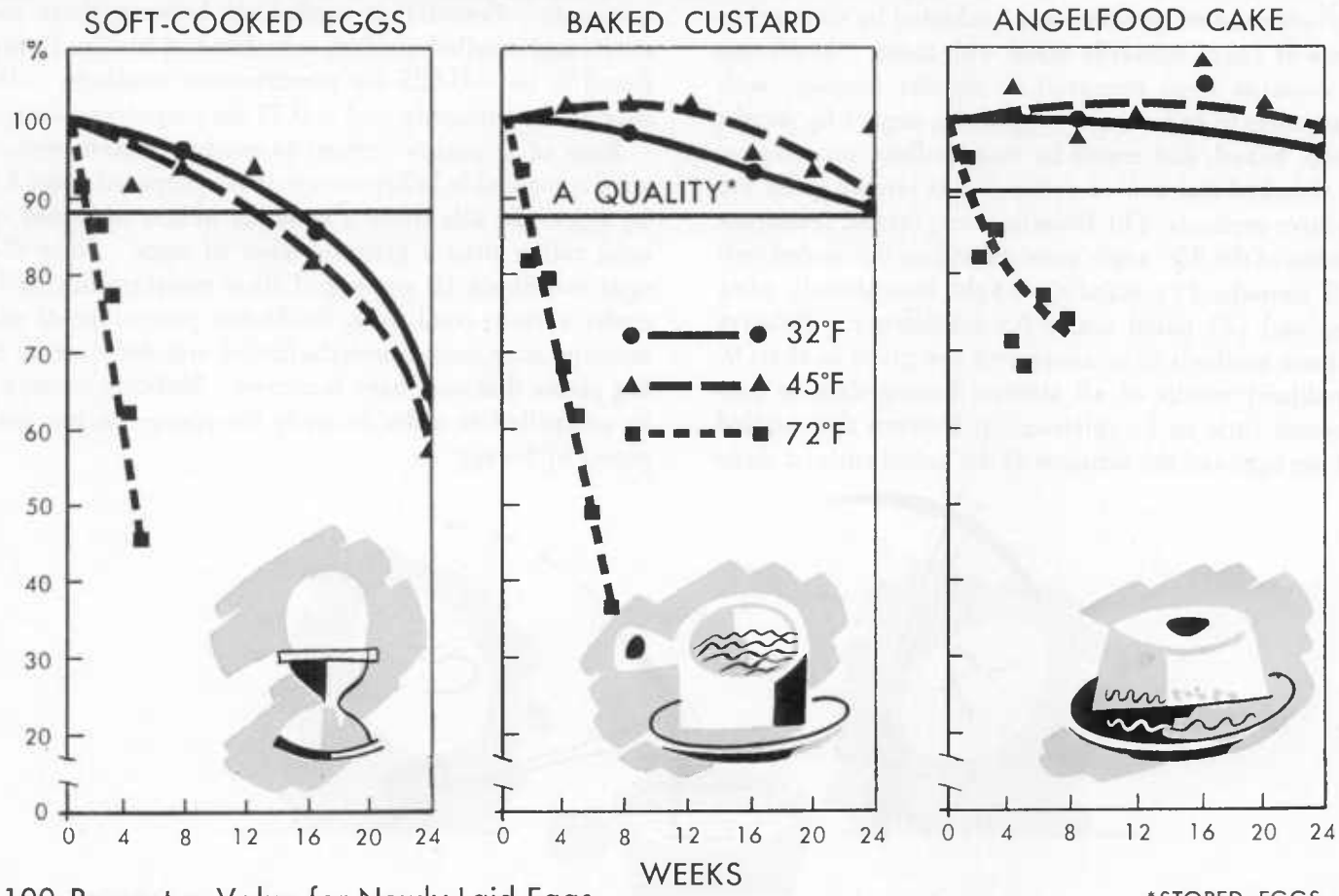
In this study the standard for flavor of eggs for table use was arbitrarily designated as the average flavor score for the A-quality eggs shown in chart 7. Chart 8 shows that the maximum storage time for the retention of flavor of eggs used as soft-cooked eggs, comparable to the average A-quality flavor score, was approximately 15 weeks in cold storage, 13 weeks in the refrigerator, and 1 week at room temperature.

In baked custards and angelfood cake flavor was above the average for A-quality eggs held at least 24 weeks in cold storage and in the refrigerator, and 1 week at room temperature.

When the results found here are compared with what might be expected in an ordinary situation, it must be remembered that the eggs in this study were placed in cold storage and in the refrigerator when newly laid. Moreover, the eggs were stored in such a manner that any off-flavors would be due solely to changes within the egg rather than to absorption of flavors. The storage life as measured by flavor retention would be expected to be considerably shorter if eggs were kept unrefrigerated for a time before storage, or if stored together with flavor-contaminating substances.

FLAVOR IS AFFECTED BY STORAGE TEMPERATURE

Off-Flavors Developed in Cold Storage are Most Noticeable in Soft-Cooked Eggs



100 Percent = Value for Newly Laid Eggs

*STORED EGGS

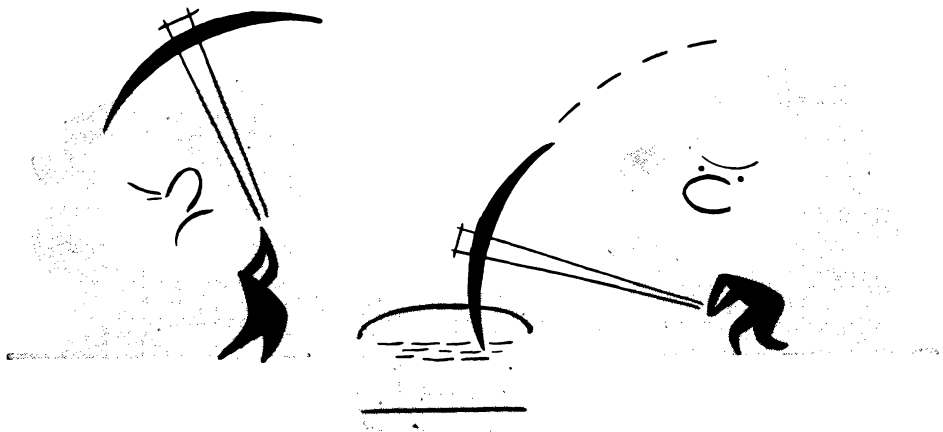
Differences in firmness of custard made with eggs of different candled qualities were small as shown by instrument measurements and by tasting panels.

The change in egg proteins from liquid to gel or solid when eggs are heated makes them useful in food preparation for such purposes as thickening, binding, and coating.

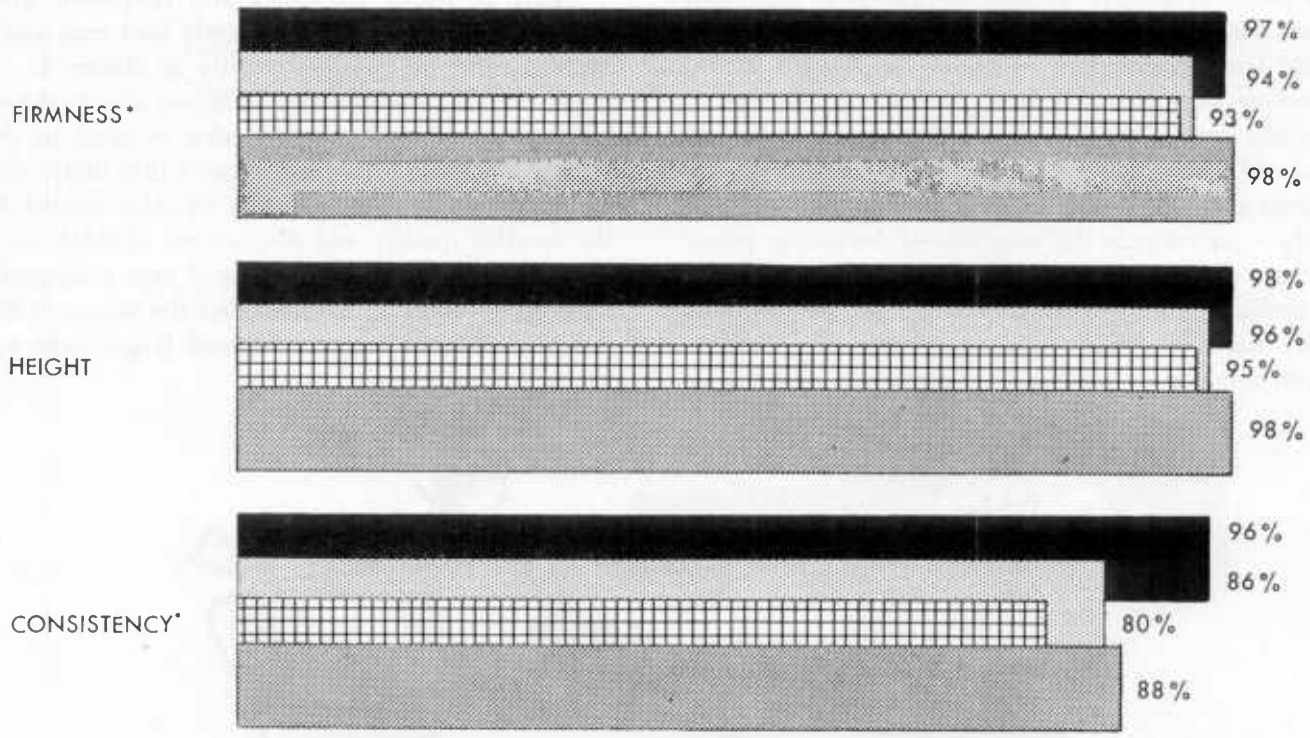
In this study the comparative thickening power of stored eggs of various candled qualities was evaluated by comparing the firmness of baked custards made with them. At all stations the custards were prepared in similar manner, with the same amounts of ingredients (egg, milk, sugar) by weight being mixed, baked, and tested by standardized procedures. Firmness of baked and cooled custards was measured by the following three methods: (1) Penetrometer, that is, resistance to penetration of the 45° angle cone resting on the cooled custard for 5 seconds, (2) standing height immediately after unmolding, and (3) panel scores for consistency. Relative value for these methods of measurement are given in chart 9.

The combined results of all stations having data to contribute showed little or no relationship between the candled quality of the eggs and the firmness of the baked custard made from them, as measured by penetrometer readings or height of the baked custard. The panel scores for consistency showed greater differences in the four candled-quality classes than were shown by objective penetrometer or custard-height measurements. Correlation coefficients between these measurements and candled quality, calculated at Station I only, were found to be +0.625 for penetrometer readings, −0.44 for height measurements, and −0.77 for consistency scores.

Eggs of C quality seemed to produce baked custards that were comparable in firmness to those prepared from AA-quality eggs. In this study a constant weight of liquid egg was used rather than a given number of eggs. Since C-quality eggs lost about 10 percent of their moisture during holding under various conditions, the higher percentage of solids remaining may have counterbalanced any decrease in thickening power that may have occurred. Moisture content should be controlled in order to study the change in the thickening power of the egg.



CUSTARD FIRMNESS IS NOT RELATED TO CANDLED QUALITY OF STORED EGGS



100 PERCENT = VALUE FOR NEWLY LAID EGGS

*BY PENETROMETER

*Score

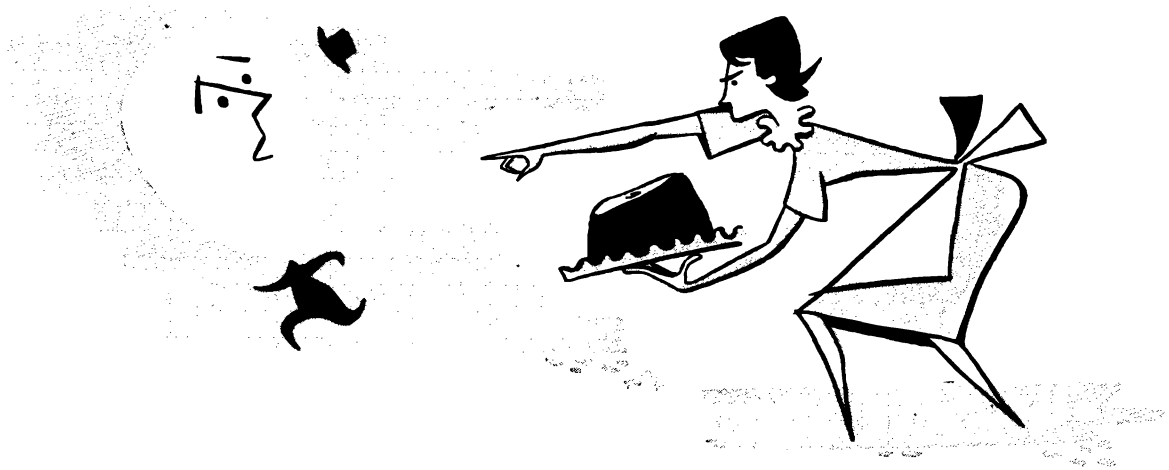
QUALITY: AA A B C

There was a wide range in volumes of cakes made from newly laid eggs as well as from stored eggs of different candled qualities, but average values decreased with decrease in candled quality.

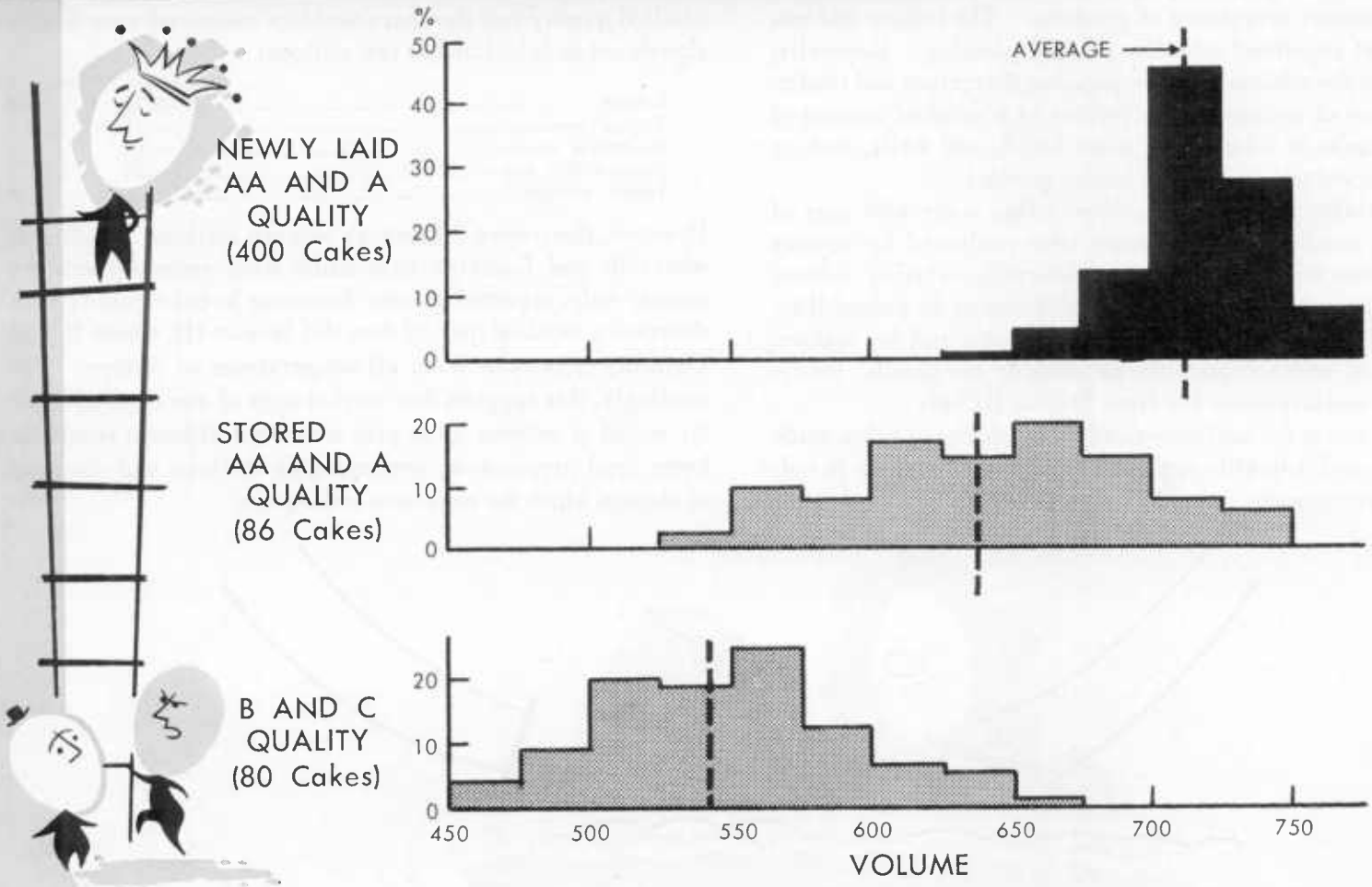
The foaming quality of eggs, as well as their thickening power, makes them useful in food preparation. Fairly stable foams are necessary in order to obtain the light spongy texture of meringues, souffles, sponge-type cakes, and the like. The foaming quality of eggs is related to leavening power, since the air in the pockets formed during foaming provides the leavening action. Increase in volume during baking, however, depends not only on the amount and type of leavening gases present but also on the elasticity and strength of the structural materials.

The volume and palatability of angelfood cakes were used in this study to investigate the retention of leavening power of egg whites. A standardized procedure was used throughout. The amount of air incorporated was regulated by beating the meringue to a definite specific gravity; and the temperature and amount of ingredients, amount of mixing of batter, and baking procedures were standardized. Cake volume was measured by the rape seed test: the volume of seeds required to fill the pan containing the cake was subtracted from the amount required to fill the empty pan.

Chart 10 shows the range and frequency distribution of volumes of cakes made with newly laid eggs and with stored eggs of different candled quality at Station I. Although it is known that atmospheric conditions affect cake volumes, the similarity in distribution of cake volumes in chart 10 and albumen indices in chart 2 suggest that under the conditions of this experiment the volumes of cakes varied directly with the candled quality and the amount of thick albumen in the eggs. Both newly laid and stored eggs produced cakes overlapping in range of volumes, but the averages show that the AA- and A-quality eggs produced larger cake volumes than B- and C-quality eggs.



ANGELFOOD CAKE VOLUME DECREASED WITH LOWERED CANDLED QUALITY OF EGGS



There was a direct relation between the candled quality of the eggs and the volume, texture, tenderness, and acceptability of cakes made from them.

Volume measurement of angelfood cake provides a simple objective means of comparing the leavening performance of eggs of various qualities, but is insufficient in itself to determine consumer acceptance of products. The texture and tenderness of angelfood cake also must be pleasing. Generally, the larger the volume the more pleasing the texture and tenderness, since an increase in the volume of a weighed amount of batter results in thinner and more fragile cell walls, making for a finer texture and a more tender product.

Palatability factors of angelfood cakes made with eggs of different candled quality classes were evaluated by sensory testing panels at all stations to determine whether volume differences were accompanied by differences in palatability. In chart 11 are given the values for volume and for texture, tenderness, and acceptability as rated by the panels; tensile strength measurements are from Station III only.

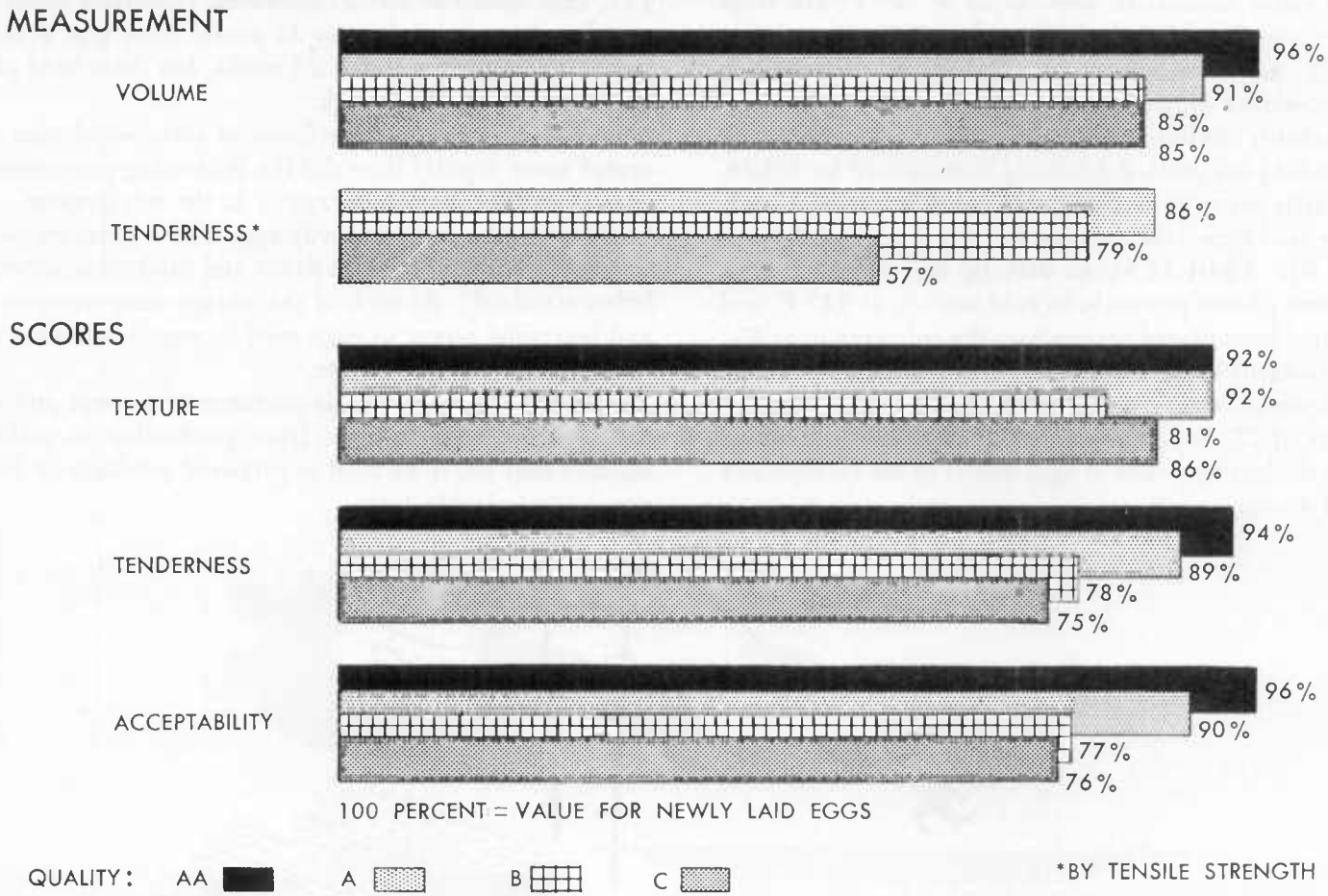
Panel scores for tenderness and acceptability of cakes made with AA- and A-quality eggs paralleled the differences in volume measurements.

In all measurements, B- and C-quality eggs produced cakes with lower values than did those of A or AA quality. Relationships as shown by correlation coefficients between candled quality and the characteristics measured were highly significant as calculated at two stations:

	Station I	*Station III*
Volume	−0.79	−0.62
Texture scores	−.74	------
Tenderness scores	−.80	------
Acceptability scores	−.79	------
Tensile strength	------	.36

However, there were differences between stations. Station I, where B- and C-quality eggs came from room-temperature storage only, reported greater decreases in cake quality with decreasing candled quality than did Station III, where B- and C-quality eggs came from all temperatures of storage. Accordingly, this suggests that market eggs of one candled quality would at various times give somewhat different results in home food preparation, depending on the type and duration of storage which the eggs have undergone.

ANGELFOOD CAKE QUALITY IS RELATED TO CANDLED QUALITY OF STORED EGGS



Reducing storage temperature from 72° to 45° or 32° F. increased the "useful life" of eggs for thickening and leavening purposes from 22 to 28 times at 45° and from 33 to 35 times at 32°.

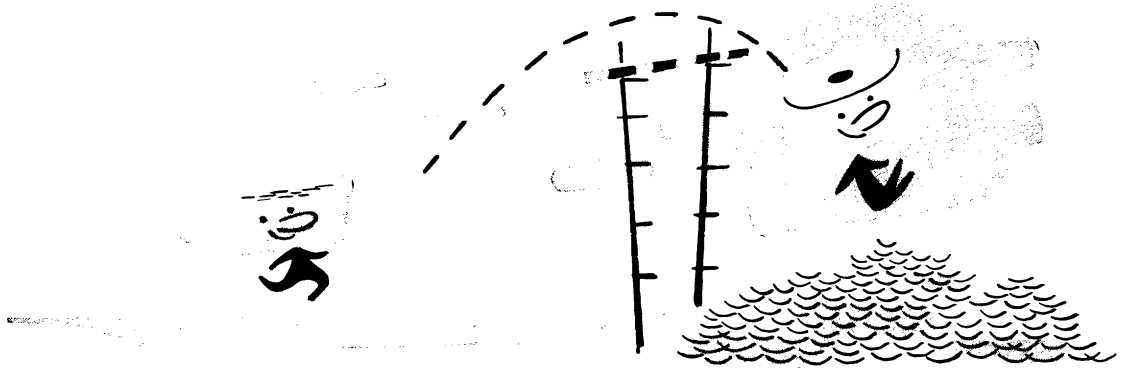
A comparison of the retention of thickening and leavening properties of eggs stored at three temperatures is shown in chart 12. The relative values for height of custards and volume of cakes made with eggs stored at 72° F. are from Station I; those for these products made with eggs stored at 45° and 32° are from Station III. Values for the retention of these functional properties during holding in cold storage were remarkably similar at the two stations.

The standard for custard firmness, as measured by height, was arbitrarily set at 96 percent of the value for custard made with newly laid eggs—the average for stored eggs of A quality (chart 9). Chart 12 shows that, by this standard, eggs that had been placed promptly in cold storage at 32° F. and those that had been placed promptly in the refrigerator at 45° produced custards of desirable firmness after being held for 33 and 28 weeks, respectively, and also those kept at room temperature of 72° for only 1 week. There was little difference in the thickening power of eggs stored in the refrigerator and in cold storage.

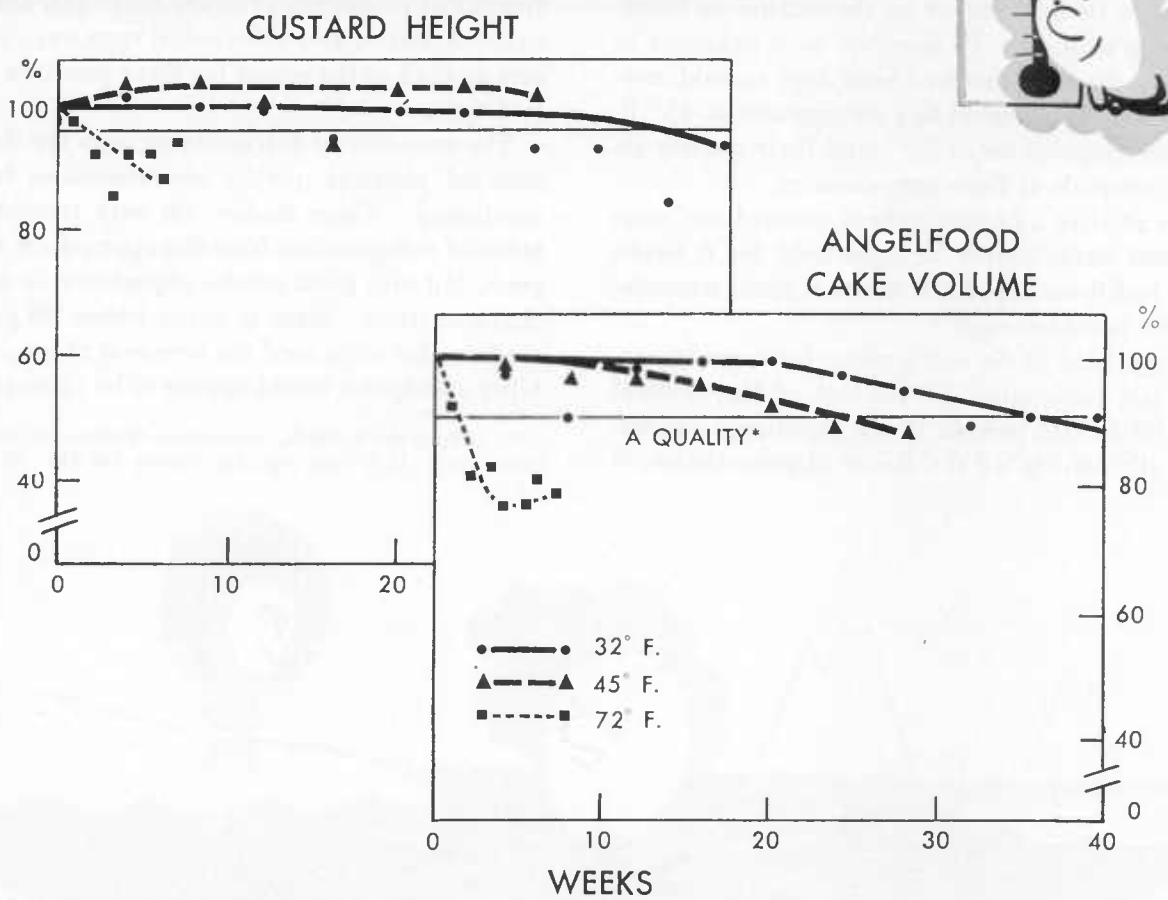
Similarly, when the standard for cake volume was set at 91 percent of the value for cake made with newly laid eggs (the average of stored eggs of A quality as shown in chart 11), eggs stored at 32° F. produced angelfood cakes of desirable volume for as long as 35 weeks, those kept at refrigerator temperature for about 22 weeks, but those held at room temperature for only 1 week.

As shown in chart 8, the flavor of soft-cooked eggs deteriorated more rapidly than did the thickening properties when eggs were held in cold storage or in the refrigerator. When baked custards were made with eggs held at room temperature for more than 1 week, both flavor and thickening power were below standard. At each of the storage temperatures, flavor and leavening power of eggs used in angelfood cakes deteriorated at about the same rate.

These results stress the importance of prompt and continuous refrigeration of eggs from production to utilization, whether they are to be used in prepared products or for table use as recognizable eggs.



THICKENING AND LEAVENING PROPERTIES ARE RETAINED BY STORAGE OF EGGS AT 45° F. OR LOWER



100 PERCENT = VALUE FOR NEWLY LAID EGGS

*STORED EGGS

After being held in cold storage for 6 months, eggs maintained more desirable quality during 6 weeks' holding in a refrigerator at 45° F. than during 2 weeks' holding at 72°.

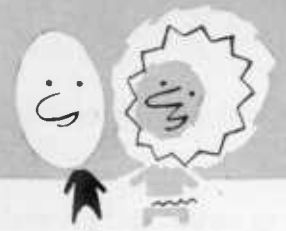
Eggs put into cold storage during seasons of high production may be expected to be moved out for distribution within 6 months. After being removed from cold storage, it would be usual for them to be held longer by the retailer or homemaker before being utilized. To simulate such practices in this study, some of the eggs that had been kept in cold storage for 6 months were transferred to a refrigerator at 45° F. and some to room temperature of 72°, and their quality assessed at 2-week intervals at these temperatures.

Chart 13 gives relative albumen indices, custard and cake measurements, and flavor scores for eggs held for 6 weeks in a refrigerator and those kept for 2 weeks at room temperature after 6 months in cold storage.

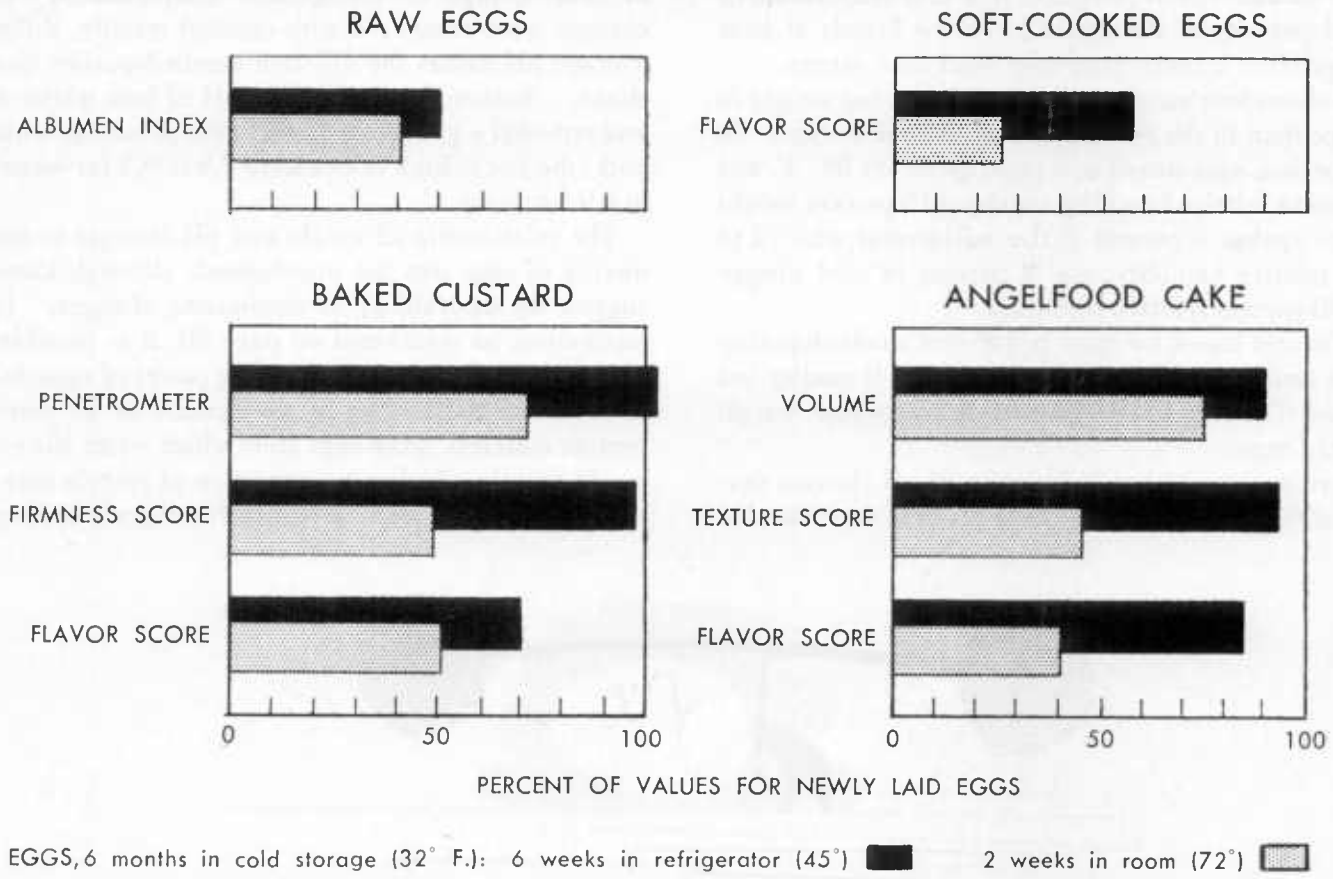
Cold-storage eggs held in the refrigerator for 6 weeks candled B quality and maintained 50 percent of the original albumen value, 90 to 102 percent of the functional properties, and 57 to 85 percent of the flavor characteristics of newly laid eggs. Unrefrigerated cold-storage eggs, on the other hand, candled B quality in 2 weeks, maintained 41 percent of the albumen quality and 71 to 76 percent of the functional properties of newly laid eggs, but flavor scores for custards, cakes, and soft-cooked eggs were only 26 to 51 percent as high as the scores for these products made with newly laid eggs.

The necessity of refrigerating eggs for the maintenance of internal physical quality characteristics has already been mentioned. These studies not only reemphasize the importance of refrigeration from the appearance and functional aspects, but also point out its importance in maintaining flavor characteristics. Since in many homes 80 percent of the eggs used are for table use,[2] the retention of quality from a palatability standpoint would appear to be of major importance.

[2] C. LeBovit and F. Clark. HOUSEHOLD PRACTICES IN THE USE OF FOODS, THREE CITIES, 1953. U. S. Dept. Agr., Agr. Inform. Bul. 146. 90 pp., illus. April 1956.



QUALITY IS BETTER WHEN EGGS ARE HELD AT REFRIGERATOR RATHER THAN ROOM TEMPERATURE AFTER COLD STORAGE



Eggs lost weight and increased in pH more rapidly in room storage than in cold storage or in the refrigerator.

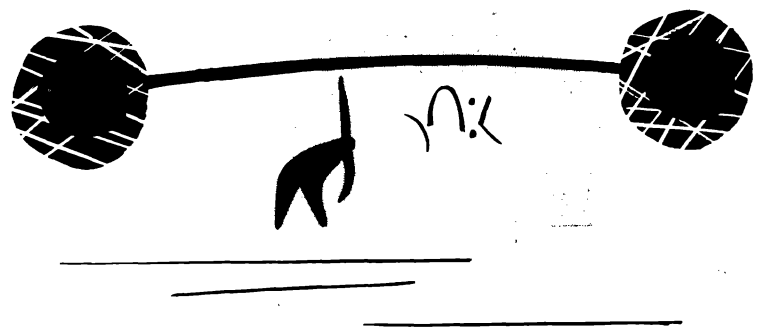
Observations on weight and pH changes of eggs were made in this study. It has been known that these changes occur during storage, the extent of change depending mainly on the humidity of the atmosphere, length of time and temperature of storage, and porosity of the eggshell. Some breeds of hens reportedly produce a more protective shell than others.

Chart 14 shows how much more rapidly eggs lost weight in room storage than in the refrigerator or in cold storage. In an 8-week period, eggs stored in a room at 70° to 88° F. and 26 to 73 percent relative humidity averaged 15 percent weight reduction, as against 5 percent in the refrigerator with 72 to 74 percent relative humidity, and 2 percent in cold storage with 85 to 90 percent relative humidity.

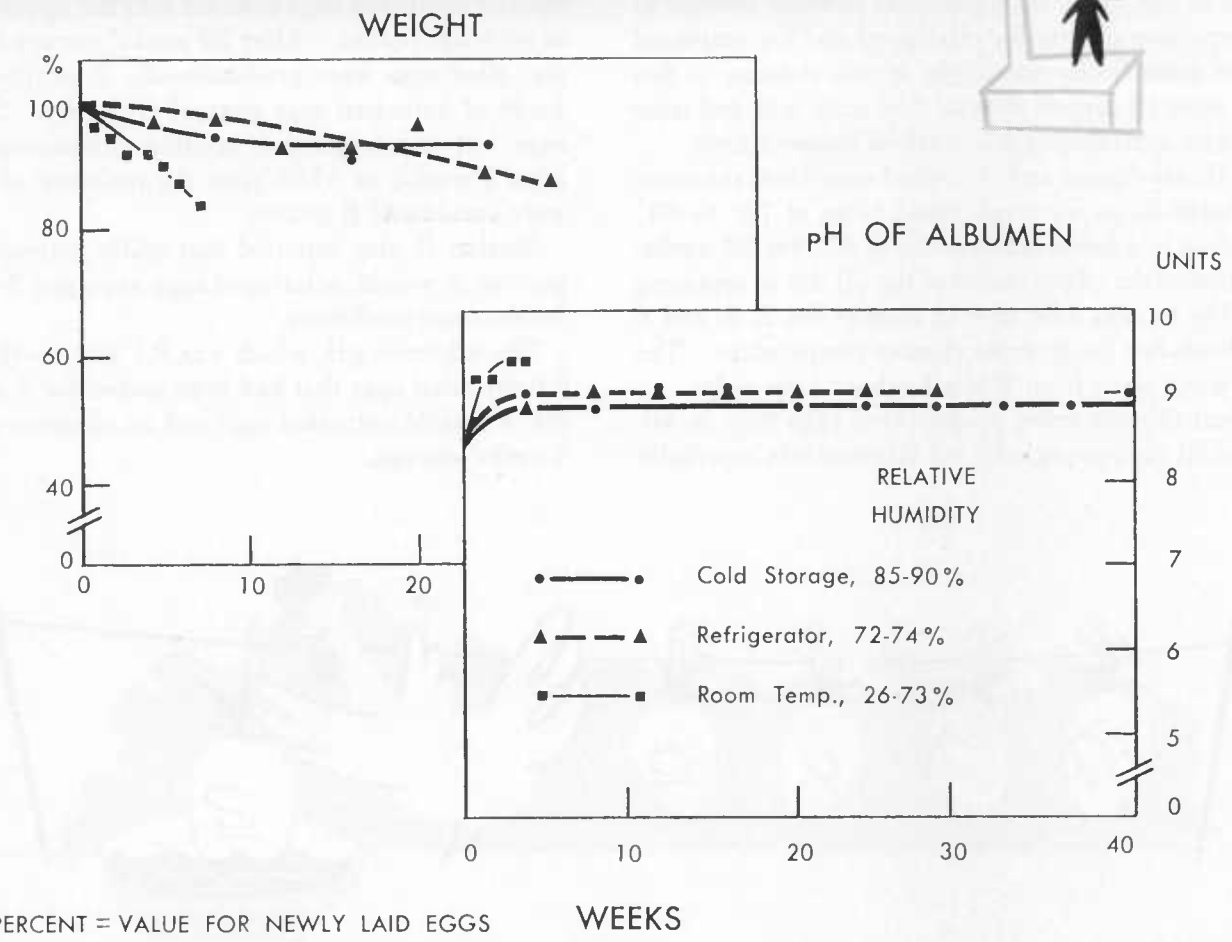
Average weight losses for eggs in different candled-quality classes were similar. All stored eggs of A and B quality lost 8 percent and C quality lost 10 percent of the average weight for newly laid eggs.

Also shown in chart 14 is a comparison of pH changes during storage at three temperatures. The pH of albumen tended to reach a maximum in 4 weeks at all temperatures of storage and thereafter to remain comparatively constant, although the extent of increase at room temperature was greater than at cold storage or refrigerator temperatures. When pH changes were compared with candled quality, differences in average pH values for different candled-quality classes were slight. Station II measured the pH of both whites and yolks and reported a greater increase in the pH of egg white than of yolk; the low to high values were 7.9 to 9.5 for whites and 5.9 to 6.9 for yolks.

The relationship of weight and pH changes to the cooking quality of eggs was not investigated, although known effects suggest the desirability of minimizing changes. In this investigation, as mentioned on page 20, it is possible that decreases in thickening and leavening power of eggs during storage were partially offset by an increase in the percentage of protein material, since eggs from which water has evaporated would contain a higher concentration of protein than an equal weight of egg magma or albumen from newly laid eggs.



WEIGHT AND pH OF EGGS CHANGE DURING STORAGE



100 PERCENT = VALUE FOR NEWLY LAID EGGS

Oil dipping retarded change in candled quality and thinning of albumen.

Various methods of retarding quality decline of eggs by closing the pores of the shell have been practiced for some time. An oil dip in clear, odorless, tasteless mineral oil has been accepted as one of the most practical methods devised to date. A comparison of data for oil-dipped and for untreated eggs from the same flocks was made at two stations in this study. Eggs were oil dipped the day they were laid and were stored along with untreated eggs at various temperatures.

At Station II, oil-dipped and untreated eggs from the same flocks were stored in an air-conditioned room at 70° to 80° F. for 4 weeks or in a home refrigerator at 45° for 24 weeks.

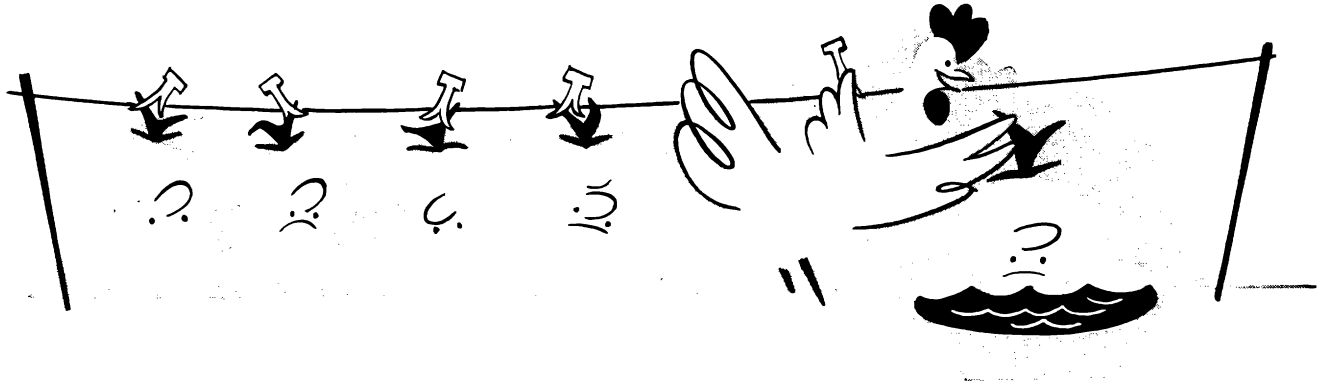
Station I studied the effectiveness of the oil dip in retaining albumen quality in eggs held in cold storage for 2, 4, and 6 months and thereafter for 2 weeks at room temperature. The eggs for this study were from White Leghorn hens only.

Albumen had thinned more in untreated eggs than in oil-dipped eggs at all storage periods, but thinning was especially noticeable after the eggs had been held at room temperature, as shown in chart 15.

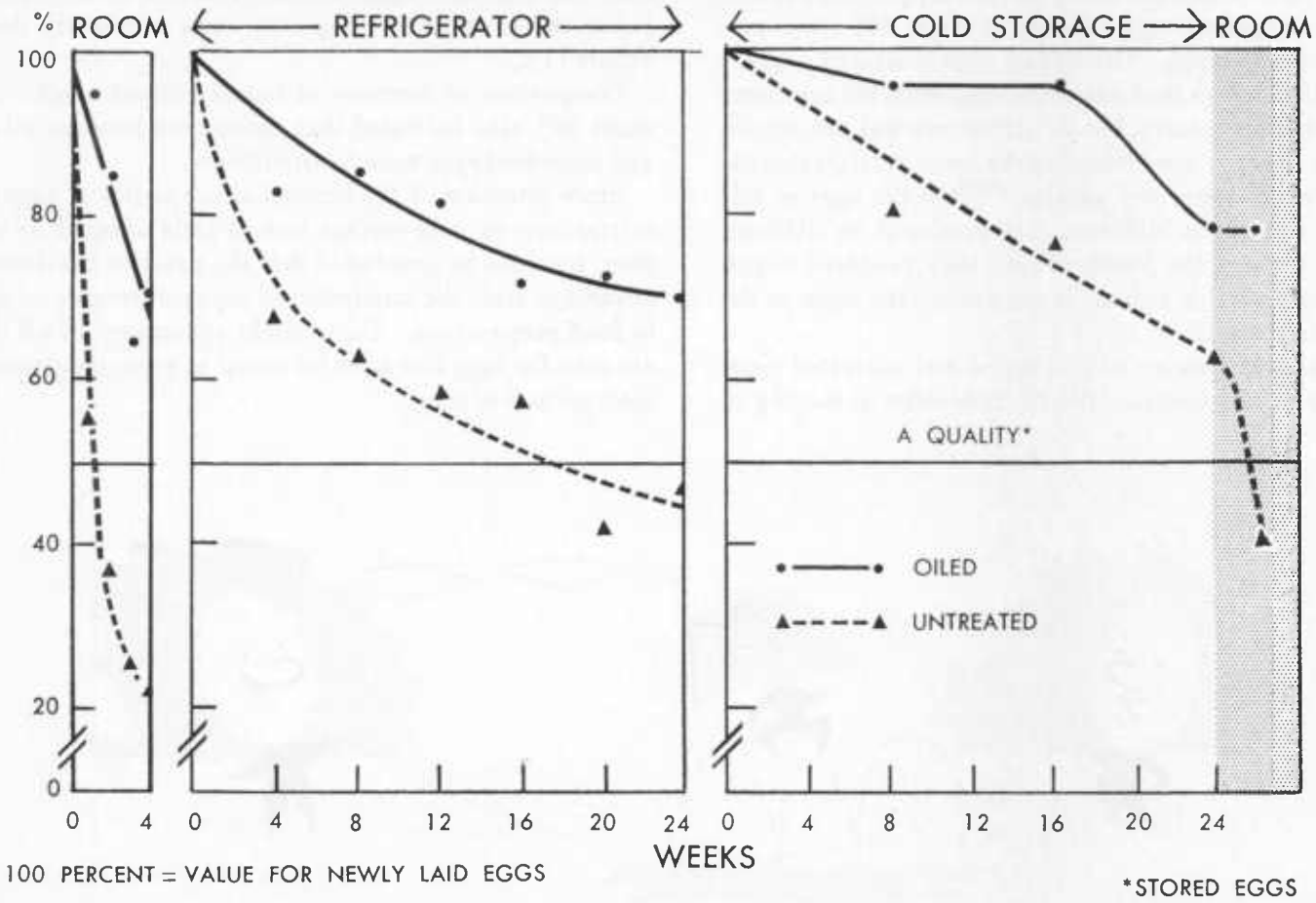
In addition, it was found that a higher percentage of oiled than of untreated eggs candled into the upper quality classes at each test period. After 20 weeks' storage in the refrigerator, oiled eggs were predominantly B quality while the majority of untreated eggs were of C quality. Similarly, oiled eggs left unrefrigerated candled predominately A quality after 3 weeks, at which time the majority of untreated eggs were considered B quality.

Station II also reported that while untreated eggs lost 19 percent in weight, oil-dipped eggs averaged 2 percent loss under the same conditions.

The albumen pH, which was 8.1 for newly laid eggs, was 8.6 for oiled eggs that had been stored for 4 weeks at 70° to 80° F., while untreated eggs had an albumen pH of 9.4 after 4 weeks' storage.



RAW ALBUMEN QUALITY IS RETAINED BETTER IN OIL-DIPPED THAN IN UNTREATED EGGS



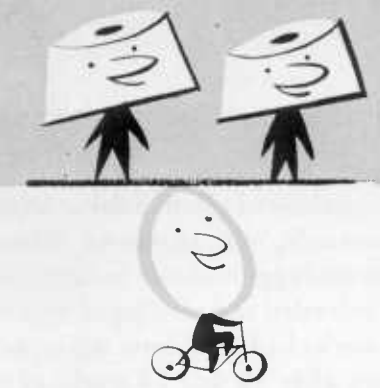
Oil dipping eggs did not appreciably affect their functional properties as shown by the volume of angelfood cakes.

The comparative functional performance of untreated and oil-dipped eggs was also investigated. The volumes of angelfood cakes made from untreated and oil-dipped eggs stored at different temperatures, as shown in chart 16, are representative of the findings. Oil-dipped eggs produced slightly larger angelfood cakes than untreated eggs when the eggs were kept at room temperatures, but the difference was not significant. When the eggs were stored in the home refrigerator the volumes of cakes were very similar. Since the eggs in this experiment were from different lots produced in different parts of the country, the length of time they produced angelfood cakes of desirable volume is not exactly the same as the time shown in chart 12.

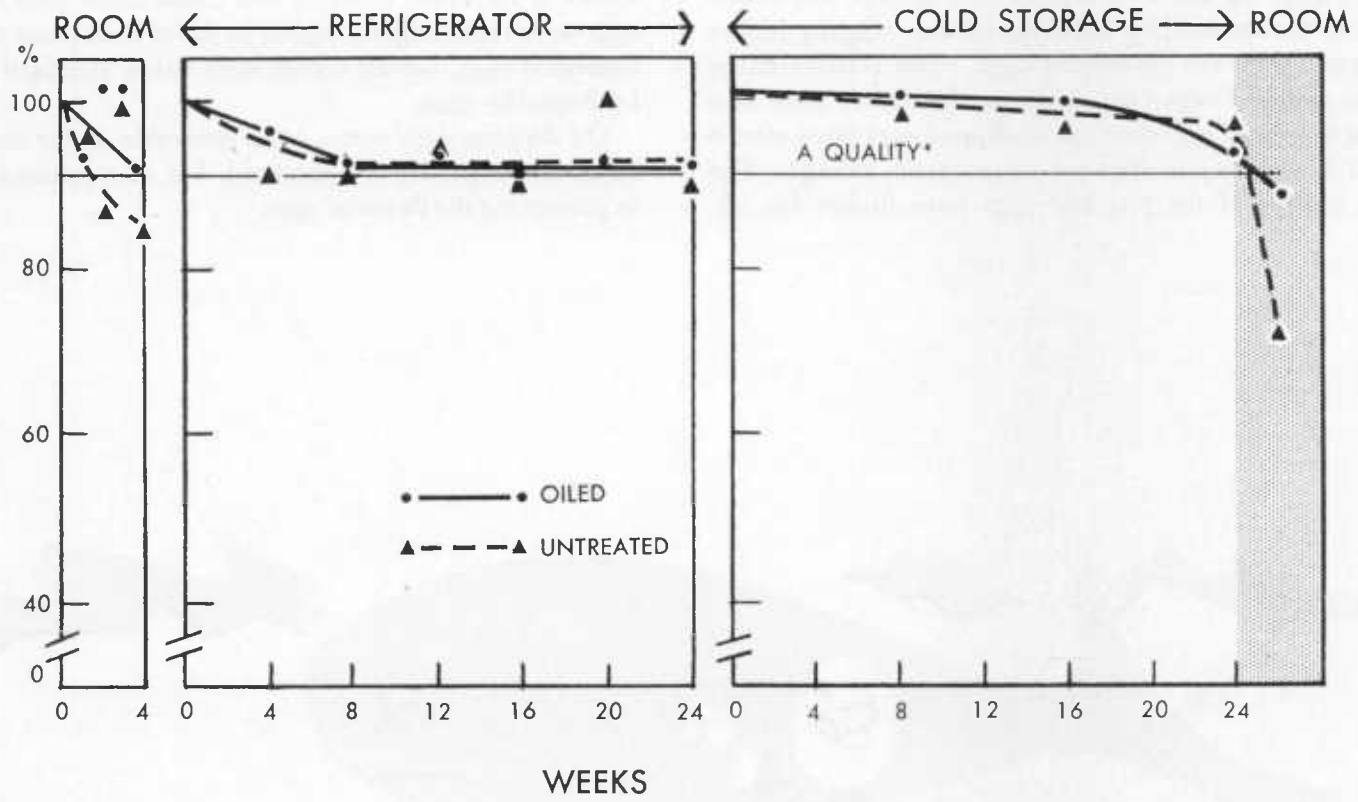
Functional performance of oil-dipped and untreated eggs, as shown by cake volumes, differed little after 6 months in cold storage. After a subsequent 2-week period at room temperature, however, oil-dipped eggs produced larger cakes than did untreated eggs, but the volumes of the cakes were below the average for A-quality eggs previously described (chart 11).

Comparison of firmness of baked custards (not shown in chart 16) also indicated that differences between oil-dipped and untreated eggs were nonsignificant.

Since retention of the functional properties of eggs during refrigerator or cold storage was so little affected by oil dipping, it would be concluded that the practice has little or no advantage from the standpoint of the performance of the eggs in food preparation. Some slight advantages of oil dipping are seen for eggs that must be stored at room temperature for short periods of time.



ANGELFOOD CAKE VOLUMES ARE SIMILAR WHEN CAKES ARE MADE WITH OIL-DIPPED OR UNTREATED STORED EGGS



100 PERCENT = VALUE FOR NEWLY LAID EGGS

*STORED EGGS

Oil dipping eggs before putting them in cold storage cannot be depended upon to maintain flavor.

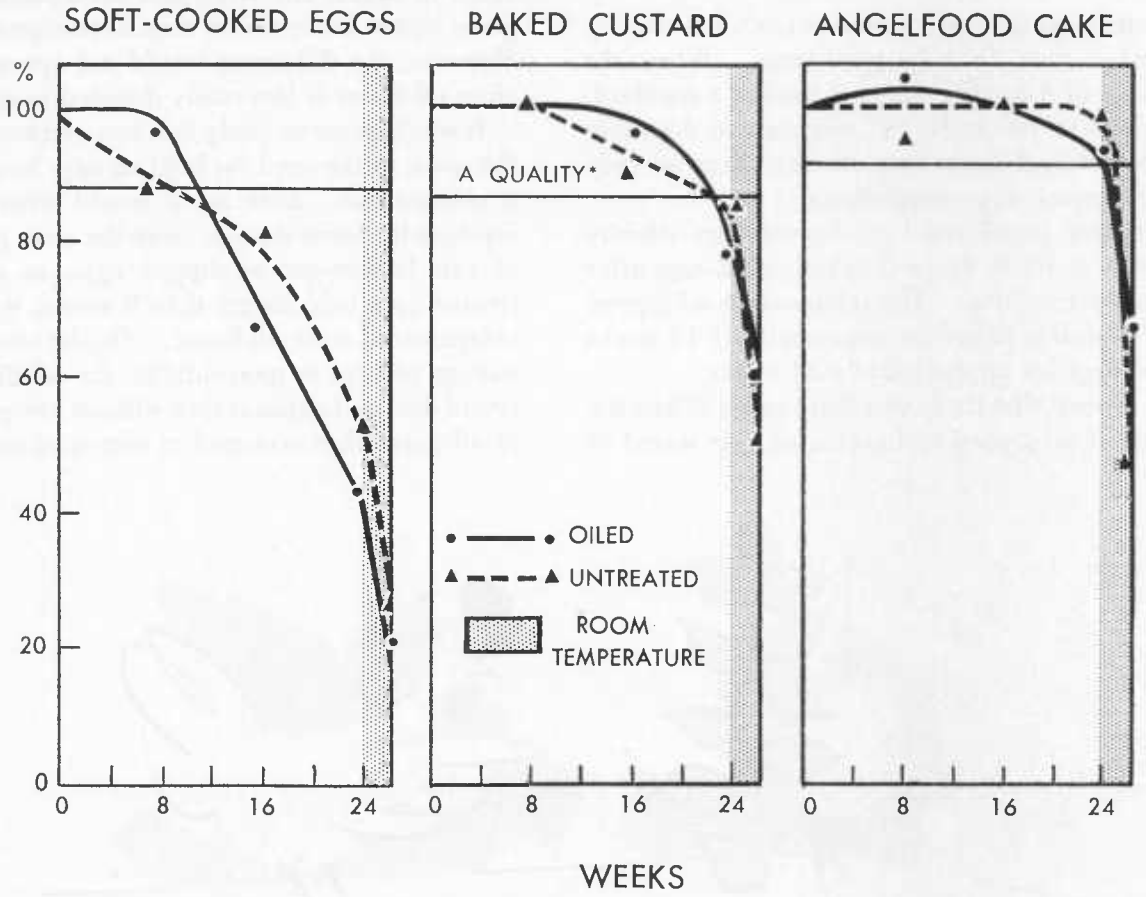
A comparison of relative flavor scores for soft-cooked eggs, baked custards, and angelfood cakes made with oil-dipped and untreated eggs is shown in chart 17.

Both untreated and oil-dipped eggs stored at 32° F. for only 8 to 12 weeks had off-flavors when tasted soft-cooked. Average scores after 16 and 24 weeks of cold storage and subsequent room-storage holding for 2 weeks were slightly higher for untreated than for oil-dipped eggs. The relative flavor scores for poached eggs (not shown in the chart) were also higher for untreated eggs than for oil-dipped eggs rated after 6 months at 32° and again after subsequent room storage. The albumen indices of the poached eggs were higher for oil-dipped than for untreated eggs, but the lower flavor scores for oil-dipped eggs offset this advantage.

Little off-flavor was discernible in custards or cakes made with oil-dipped or untreated eggs during 6 months' storage at 32° F. After the eggs had been stored an additional 2 weeks at 72°, both custards and cakes made with oil-dipped eggs were rated slightly higher in flavor than those made with untreated eggs, but all scores were below standard as set up by A-quality eggs.

Oil dipping eggs seems to be desirable as far as retention of albumen quality is concerned, but of questionable value in preserving the flavor of eggs.

FLAVOR CHANGE DURING COLD STORAGE IS SIMILAR FOR OIL-DIPPED OR UNTREATED EGGS



100 PERCENT = VALUE FOR NEWLY LAID EGGS

*STORED EGGS

There was no advantage in the oil dipping of eggs for home storage with respect to the development of off-flavor in eggs.

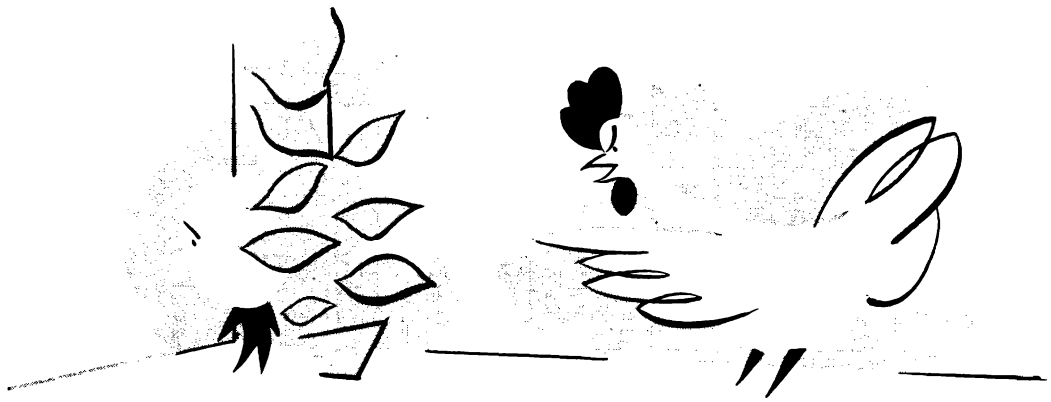
In chart 18 is shown a comparison of flavor scores for oil-dipped and untreated eggs soft-cooked after being stored in an air-conditioned room at 70° to 80° F. and in a home refrigerator at 45°.

In unrefrigerated eggs off-flavor seemed to develop slightly faster in untreated than in oil-dipped eggs. When the average flavor value of A-quality eggs was used as a standard, oil-dipped eggs kept at 70° to 80° F., maintained desirable flavor for approximately 2 weeks and untreated eggs for only 1 week, but the difference was not significant.

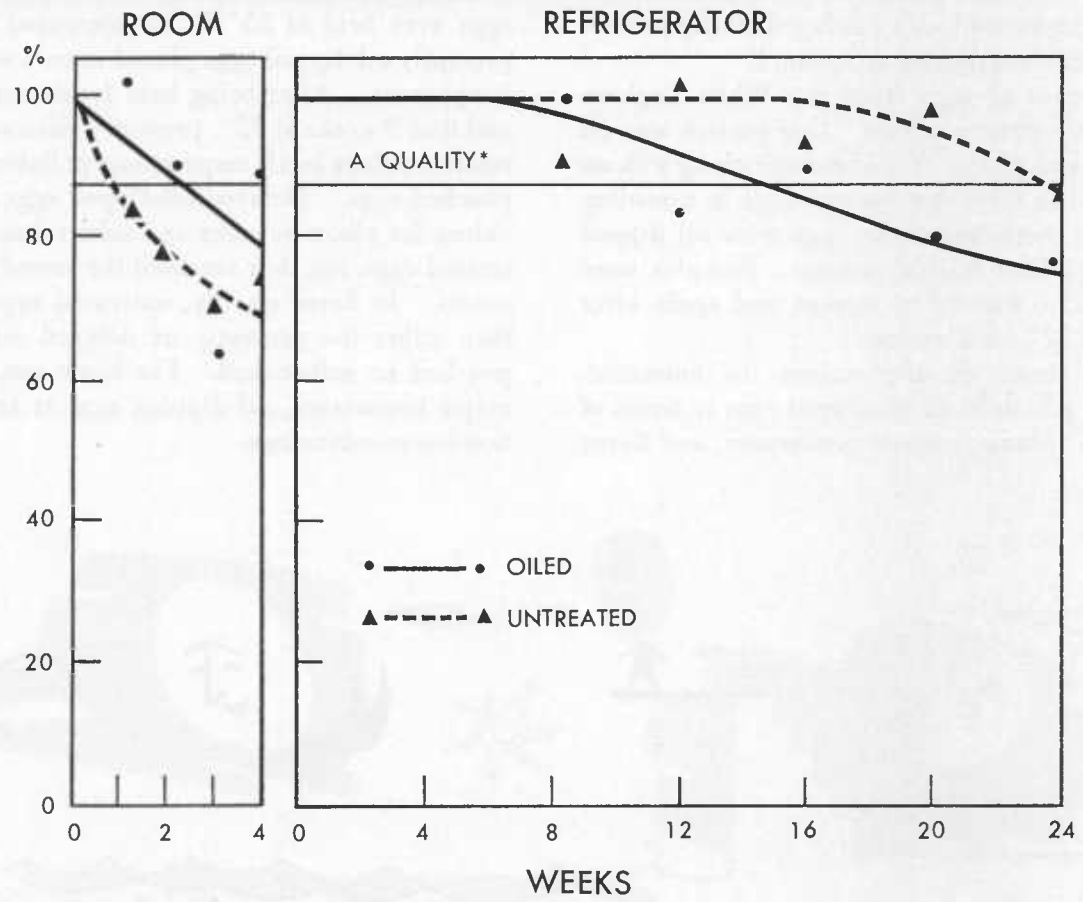
The sensory testing panel rated oil-dipped eggs slightly but not significantly lower in flavor than untreated eggs after storage in a home refrigerator. The refrigerated oil-dipped eggs maintained desirable flavor for approximately 14 weeks and the untreated eggs for approximately 24 weeks.

Other studies showed that there was little or no difference between the flavor of oil-dipped and untreated eggs stored in the refrigerator when scored in baked custard or in cakes, and there was no difference between the flavor of unrefrigerated oiled or untreated eggs scored in custards. When rated in cakes, unrefrigerated oil-dipped eggs usually were given higher flavor scores than unrefrigerated untreated eggs. However, the difference would not appear to be significant, since off-flavor is less easily detected in cake than in custard.

It would seem unlikely that homemakers would have either the space or the need for holding eggs longer than 8 weeks in a refrigerator. Even so, it would seem undesirable to oil dip eggs for home storage, since the more pleasing appearance of raw broken-out oil-dipped eggs, as compared with untreated eggs held longer than 8 weeks, was offset by the development of more off-flavor. On the other hand, when room storage of eggs is unavoidable, the oil dip would appear to retard decline in appearance without any greater development of off-flavor than occurred in untreated eggs.



DEVELOPMENT OF OFF-FLAVOR AT ROOM OR REFRIGERATOR TEMPERATURE IS NOT RETARDED BY THE OIL DIPPING OF EGGS



100 PERCENT = VALUE FOR NEWLY LAID EGGS

*STORED EGGS

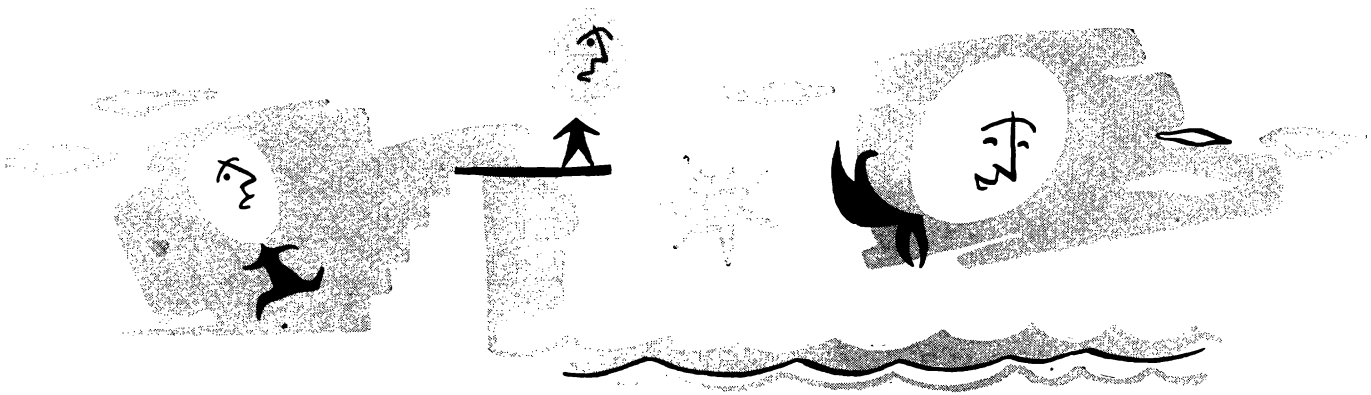
Prompt and delayed oil dipping retarded thinning of albumen and loss of leavening power but did not retard development of off-flavors in eggs during 6 months in cold storage plus 2 weeks at 72° F.

A delayed oil-dip treatment might be practiced where a producer allowed eggs to accumulate for a time before dipping them or where they were treated at some point in distribution. The effectiveness of such a delayed oil-dip process in retarding quality loss was studied at Station I.

One day's production of eggs from two White Leghorn flocks was divided into three portions. One portion was oil dipped immediately and placed in cold storage along with an untreated portion. The third portion was kept in a cooling room at 55° F. for a week before the eggs were oil dipped and placed with the others in cold storage. Samples were tested after 2, 4, and 6 months of storage and again after they had been kept at 72° for 2 weeks.

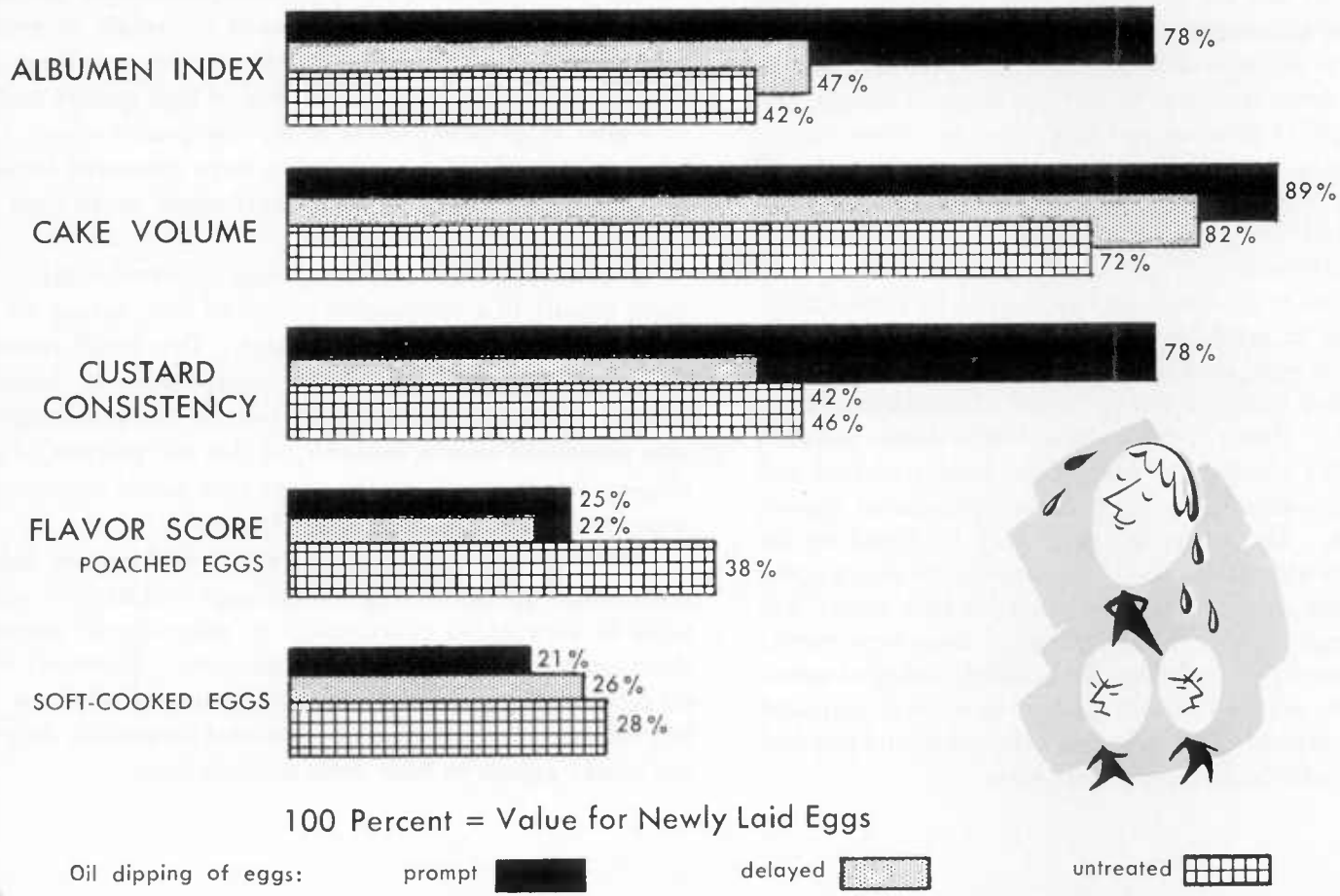
In chart 19 are shown relative values for untreated, promptly oil-dipped, and delayed oil-dipped eggs in terms of albumen index, cake volume, custard consistency, and flavor of cooked eggs after 6 months in storage at 32° F. plus 2 weeks at room temperature.

The loss of quality during the week the delayed oil-dipped eggs were held at 55° F., as compared with untreated and promptly oil-dipped eggs placed in cold storage immediately, is apparent. After being held for 6 months in cold storage and then 2 weeks at 72°, promptly oiled eggs retained highest relative values in all respects except flavor of soft-cooked and poached eggs. Delayed oil-dipped eggs had higher average values for albumen index and cake volume than those for untreated eggs, but they received the lowest custard consistency scores. In flavor quality, untreated eggs were rated higher than either the promptly or delayed oil-dipped eggs when poached or soft-cooked. For home use, where flavor is of major importance, oil dipping eggs at any point in distribution has no advantage.



QUALITY OF STORED EGGS IS BETTER AFTER PROMPT THAN AFTER DELAYED OIL DIPPING

Treated and Untreated Eggs Held for 2 Weeks at Room Temperature After 6 Months in Cold Storage



SUMMARY

Eggs of different candled qualities resulted from holding newly laid eggs for definite periods of time under temperature and humidity conditions which previously had been found to be common practice. The higher the holding temperature, the more rapid was the decline in candled quality. It was observed that deterioration from one candled quality to a lower one was accompanied by thinning of albumen, flattening of yolk, development of off-flavors, losses in weight, and increases in pH of albumen and yolk; also, to a lesser extent, by decreases in thickening and leavening powers. At all temperatures of storage noticeable thinning of albumen and development of off-flavors occurred earlier than decline of functional performance.

Candled quality of stored eggs appears to be a reasonably reliable guide in predicting the comparative appearance of broken-out raw eggs, cooking qualities, and palatability, provided the lower qualities are the result of time-temperature deterioration. Direct relationships were shown between candled quality classes and the various factors studied and reported independently by three State agricultural experiment stations. That some variation may be found in the quality of eggs within one class is indicated by the overlapping range of values reported by one station for both newly laid and stored eggs. Under the conditions of these experiments it has been shown that the higher the candled quality of stored eggs, the better are the products made from them as indicated by objective tests and panel ratings of soft-cooked and poached eggs, baked custards, and angelfood cakes.

No difference was found in the keeping qualities of eggs that was due to season or locality of production when relative albumen indices were compared after storage under comparable conditions.

The loss of weight *per se* by evaporation of water during storage would seem to be of little importance to the homemaker if prepared dishes were made by weight or volume. However, to make a cupful of egg white for angelfood cake would require more eggs of low than of high quality because of higher evaporation losses in the low-quality eggs. Likewise, in custards, if egg quantities were measured by count rather than by weight, a softer custard might result from low-quality eggs.

At all temperatures, changes in eggs appeared to take place more rapidly in a comparable period of time during the first part of the storage period than later. This result reemphasizes the importance of prompt refrigeration to minimize changes. Changes in eggs during holding in a home refrigerator proceeded slowly, however, so that the practice of purchasing 1 or 2 weeks' supply at one time would appear to be sound from the homemaker's standpoint.

The practice of oil dipping of newly laid eggs to aid the retention of quality during storage appeared to have advantages in view of its effectiveness in reducing the extent of thinning of albumen at all temperatures. However, since oil dipping did not retard the development of off-flavor and had little effect on retention of functional properties, the practice would appear to have definite limitations.

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