SHELL TREATMENT FOR PRESERVATION OF HEN EGGS

by

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INTRODUCTION AND LITERATURE CITATION

For ages man has been faced with the problem of saving excess food produced in time of plenty until it might be used. Since his adoption of an agricultural life, this problem has developed into the preservation of the fruits of the harvest for use throughout the ensuing year. Although the production of eggs is not of the same exclusively seasonal nature as that of vegetable crops, nevertheless their production is, to a large extent, seasonal. According to Dvoracheck and Stout (1918), 50 per cent of the egg production occurs during the months of March, April, May and June. Although this figure of 50 per cent may no longer be correct, it is still true that a peak in production comes in the spring, and that some eggs produced at this time must be stored for use during the fall and winter.

It is difficult to say when practices in preservation were begun but according to Jones and DuBois (1920), perhaps the earliest expedient was to bury or pack eggs in an air-tight substance. In England a first prize was given in the year 1884 for eggs which had been dipped in gum arabic. Second prize went for eggs rubbed with lard and packed in salt (Barrows 1890). Other common practices existing at this date were: packing in lard barrels, saw dust, ashes, baked earth, molasses or powdered charcoal. Coating with vaseline, varnish or shellac was also used. Still another method was stated in motto form, "boil one minute, keep one year". This method was to coagulate a layer of albumen on the interior of the egg next to the shell. Eggs which had been pickled in lime water were on the market at several cents per dozen less than fresh eggs. Spamer (1931) stated that Holland began preserving eggs in linseed oil as early as 1807 and that pickling in lime water began in 1875. Sodium silicate has been, and to some extent, is still a common home method of preserving eggs.

The use of inert gases followed and paralleled many of the methods used. Many modifications of the basic methods used for preserving eggs have been tried. Most of the methods are reported in the form of patents from the United States, Britain, Germany, France and a few other countries. All the workers have realized that keeping the eggs cool is an important factor.

In general, storage of eggs can be divided into four classes: (1) at low temperature without preliminary treatment, (2) by packing in comparatively air-tight substances (3) in the dry state after coating with various impervious agents or (4) in solutions with or without preliminary treatment. A preservative coating is preferred to a preservative solution for practical commercial handling reasons and appearance of the egg. It is with this method that the work to be reported is concerned.

Some of the methods of coating eggs have already been mentioned. Jones and DuBois (1920) applied aluminum soap from a gasoline bath and reported that eggs thus treated were superior to other methods at that time. In further experimenting they applied their soap from pentane and in this way prevented off flavors and odors.

Sharp (1937) set the requirements of a shell treatment as follows: the coating should prevent evaporation and escape of carbon dioxide and should be odorless, tasteless and invisible. It will be quickly noticed that these requirements would eliminate all of the early shell treatments because no doubt they were very noticeable; many would impart a taste, an odor, or a greasy or shining appearance.

Probably to date the use of mineral oils has more nearly filled these requirements than any other shell treatment. This process was originated in Indianapolis, Indiana about the year 1913 by a baker (Triller, 1933). Most commercial oiling processes are carried out at a temperature of 100° F. to 180° F. (Swenson, Slocum and James, 1936). A modification of the oiling process has been practiced to some extent in which the oil is applied under partial vacuum and this vacuum released by introducing carbon dioxide (Swenson, Slocum, James and Kirkpatrick, 1933; Knight, 1938). These workers reported a definite advantage in using a carbon dioxide vacuum dip over an ordinary oil dip. Swenson and his co-workers (1933) reported 25 per cent more efficiency as shown by candling.

Oiling of eggs possesses some objectional features. Among the most serious of these are the excess oil left on the shells (Triller, 1933), the great losses of oil in flats and fillers (Swenson and James, 1933) and the length of time necessary for excess oil to drain from the shell. Other disadvantages encountered include its complication when used on a farm and its inability to be used on eggs still wet from washing. Some objection has been raised in regard to oiled eggs being more brittle than fresh eggs. Swenson and James (1932) performed a rather conclusive experiment to disprove this notion.

Oils with different physical properties have been used with different degrees of success. Swenson, Slocum and James (1932) showed that paraffin and asphalt base oils were equally effective in preserving eggs when both oils have the same pour point. These workers showed that oils with low viscosity and pour points of 35° F. to 38° F. gave best results when eggs are to be stored at temperatures in the range of 31° F. to 34° F.

It has been the common concept that rendering the shell impervious to gases was the means of reducing weight and carbon dioxide losses (Almy, Macomber and Hepburn, 1922). Swenson and Mattern (1930) considered that shrinkage due to the loss of carbon dioxide and moisture is the greatest economic factor encountered in the cold storage of shell eggs. Almquist and Holst (1931) state that weight loss in stored eggs is undoubtedly controlled by the shell porosity. These workers showed a parallel trend of weight loss and porosity.

The work to be presented in this report was undertaken with hope of developing a method of sealing the pores of the egg shell which could be practiced on the farm as well as in a produce house and be applicable to washed eggs which were still wet. It was felt that a method which could be applied to washed eggs would be of definite advantage, as Funk (1938) reported that 25 per cent of eggs produced are dirty and can be effectively cleaned by using dilute solutions of sodium hydroxide. The eggs cleaned in this manner are reported to keep as well in cold storage as clean eggs which were not washed. Sharp (1937) has found that the hydrogen ion concentration of the white has a very decided influence on the standing up qualities of the white, as well as influencing the rate of passage of water into the yolk during storage. He also showed that very little deterioration of the thick white took place when eggs were held one week at 86° in an atmosphere of 25 per cent carbon dioxide, whereas eggs held under similar conditions, except that a carbon dioxide equilibrium between the contents of the egg and the atmosphere was not maintained, lost their "standing up" quality and the yolk index was also markedly reduced. In view of Sharp's work and the general knowledge that retaining the carbon dioxide is very fundamental in preserving quality in eggs, it was reasoned that to treat eggs on the farm soon after being layed (before the pH became high) would be a decided advantage in preserving quality.

Oiling eggs on a farm for commercial use has never been practiced primarily because facilities for such a practice on a small scale have never been developed. The fact that eggs which have been washed cannot be oiled until dry, and the problem of properly heating the oil are two major obstacles. It was, therefore, thought that water soluble materials could be used to seal the pores of the shell and would retard the carbon dioxide and water losses if these losses occurred as vapor diffusion through the shell pores. Treating eggs by dipping them in water soluble materials would also eliminate many of the disadvantages encountered in oil dipping.

MATERIALS AND METHODS

Sealing Against Water and Carbon Dioxide Losses

Attempts were made to seal eggs by coating them with water soluble materials. It was found that the porosity could be markedly decreased but under the conditions of the accelerated tests used, the eggs thus treated lost water and carbon dioxide to about the same extent as untreated eggs. The water loss was determined by weight change during the test and the carbon dioxide loss was determined by change in pH of the egg white.

The eggs were treated by dipping them in different concentrations of aqueous solutions of soluble materials for different lengths of time. The eggs were then allowed to drain on a wire rack, weighed on a balance to 0.01 g, placed in combination egg case filler-flats and held at 98° F. and 60 per cent relative humidity for seven days, at which time they were reweighed and opened to determine the pH of the white. The difference in weight was recorded and a drop of phenophthalein indicator was added to the white; if the indicator turned pink (pH greater than nine) the pH was not determined, however, if it remained colorless the pH was determined by means of a quinhydrone electrode. Where the pH was determined a portion of both the thick and thin white was taken by slicing off a sample by means of a spatula.

In all, 18 water soluble materials were tried and only one merits mention. Aqualube (Glyco Products Co.), a commercial product, yielded gratifying results in checking water and carbon dioxide losses. It was found, however, that aqualube was not a suitable product for the commercial preservation of eggs as it left a sticky, undesirable surface on the shell. Attempts to prevent this stickiness and shine of the shell by mixing with resins and also flatteners such as calcium carbonate, magnesium oxide, etc., failed to give the desired results. Two lines of attack were employed in the use of flatteners: application from a suspension and dusting with the dry powder.

Aqualube exhibited properties which distinguished it from the other materials used. After being applied to the shell of the egg, it lost its characteristic solubility in water. It appeared to be chemically combined to the shell as a precipitate, whereas the other water soluble materials used could be easily removed from the shell by dipping in water for a short time. When the aqualube treated eggs were dipped into a suspension of calcium carbonate, the aqualube was apparently removed from the shell, at least both the stickiness and the sealing property were destroyed.

With the failure of all the water soluble materials except the one producing a water repellant surface to give the desired results, it was considered advisable to investigate the possibility of producing films of oil around the egg from a water dispersion.

Oil in water emulsions were made by the use of various emulsifying agents. In all, 25 different emulsions were made. The main criteria for eliminating these emulsions and retaining the best one for further use were: (1) stability of the emulsion, (2) the type of surface left on the egg after treatment and (3) its effectiveness in reducing water and carbon dioxide losses. The emulsifying agents were all commercial products and varied in composition.

The emulsion chosen for further consideration after favorable results were obtained under the accelerated testing conditions was one having the composition of one part of triethanolamine oleate (Glyco Products Co.) and five parts of oil to 25 parts of water, and a modification of this having the composition of one part of triethanolamine oleate and seven and one-half parts of oil to 25 parts of water. These emulsions were made by dissolving the triethanolamine oleate in the warmed mineral oil. This mixture was allowed to cool, at which time the water was added slowly with constant stirring to a smooth consistency. In early experiments the emulsion was run through an homogenizer but this was later found to be unnecessary. These two stock solutions were found to remain stable over a period of several months when stored in glass containers. A slight separating of the emulsion was observed but it redispersed immediately upon shaking. There was no apparent breaking down of these emulsions.

Further dilutions with water were made from the stock solutions for the treating of eggs. Hereafter a one to eight dilution of the first mentioned emulsion will be referred to as "Emulsion No. 1", a one to ten dilution of the other emulsion will be referred to as "Emulsion No. 2".

The method of treatment was essentially the same as that used in testing the water soluble materials. The eggs were dipped into various concentrations of the emulsions and for different lengths of time depending upon the individual experiment.

Experiments to determine the applicability of the emulsion to washed eggs were made. It was found that eggs still wet from washing could be treated in the same manner as dry eggs, but it was found advisable to rinse the eggs after washing in basic solutions, as excessive amounts of the base caused the emulsion to break down, and left a soapy film on the egg.

In the storage experiments where the apparent quality of the eggs were measured, the determination was made by breaking the eggs out and determining the Haugh Units (Haugh, 1937).

Porosity

Porosity measures were made on eggs receiving no treatment, eggs treated with a water soluble wax like product, and eggs treated with "Emulsion No. 1".

The porosity of the egg shells was determined by measuring the rate at which air could be drawn through a portion of the dried shell by a constant pressure differential.

The egg shell to be tested was sealed securely in place (Plate I) by means of embedding it in hot plastic sealing wax which coated the lips of the rubber cup in which the shell was placed.

The pressure was reduced by 100 mm of mercury as measured on a mercury manometer. The reduced pressure was applied two minutes before readings were begun. It was found that it took this long to evacuate the tube leading from the shell when no air was passing through the shell. Following this preliminary run, the air passing through the shell was collected by turning the arm of the tube holding the shell until the jet, through which the air passes, was directly under the mouth of the burette. The air which was drawn through the shell traveled up the inside of the burette, displacing the water therein. The time of flow was measured by a stop watch and never exceeded three minutes and in some cases was less where the shell was very porous.

The diameter of the cup in which the shell was placed for measurement was 2 cm and so it was considered that the error induced by calculating the area of the shell subjected to the test as a plane was negligible.

In order to avoid errors in porosity measurements due to cracks in the shell in the area of measurement, the shells were examined by means of a strong candling light in a relatively dark room. Cracks were very noticeable under these conditions.

The porosity of one area at each end of the shell was measured. After the reading had been made, the shell was filled with water and the air collection repeated to check for leaks around the outside of the shell. If a leak was found the reading were discarded.

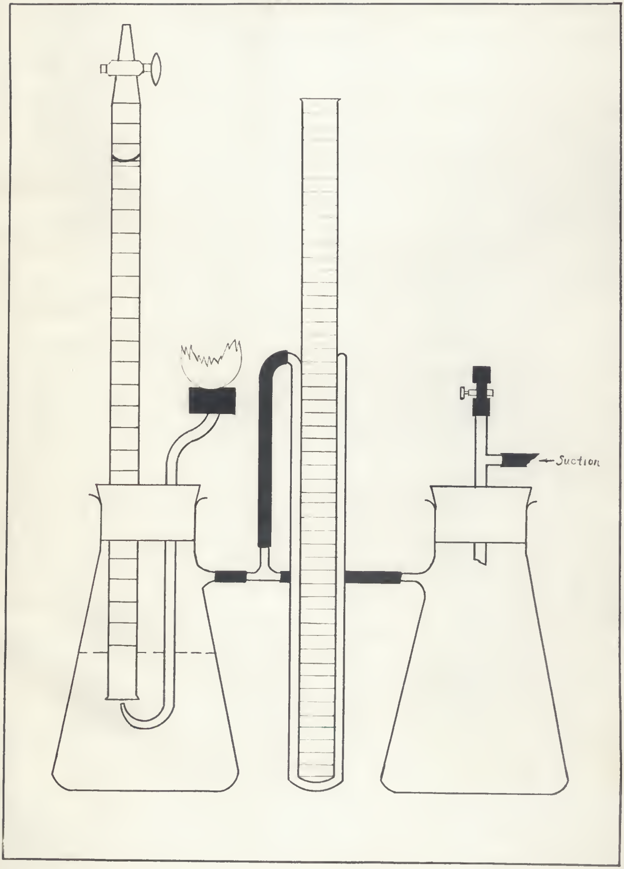
Analysis of the Emulsion

To determine the total triethanolamine in the emulsion, 50 ml aliquots of "Emulsion No. 1" were taken and analyzed by the method of Eastland, Evers and West (1937). The oleic acid was determined in the ether extracts from the above. These

EXPLANATION OF PLATE I

Apparatus for measuring porosity of shell

Plate I



were obtained in two 25 ml diethyl ether extractions. Each sample was evaporated to 5 ml on a steam bath. To this concentrated extract was added 10 ml of ethyl alcohol and the remainder of the ether removed. The acid was then titrated with 0.0192 N alcoholic sodium hydroxide using phenolphthalein as an indicator.

The determination of triethanolamine and oleic acid remaining in the emulsion after treating eggs was made on 50 ml aliquots of the emulsion remaining from an original 125 ml sample in which 34 eggs had been dipped for one and one-half to two minutes per egg in the usual manner. Thirty-four eggs per 125 ml of emulsion is equivalent to three cases (90 dozen eggs) per gallon of emulsion.

To determine the physiological action of the triethanolamine contained in the triethanolamine oleate soap, 20 g of the soap was fed a male white rat. The soap was mixed with the food fed the rat and he consumed this amount in six days. After the fourth day the rat's sense of equilibrium seemed to be disturbed slightly but he ate well and kept his fur clean. The condition of unbalanced equilibrium disappeared upon discontinuing the feeding of the soap.

EXPERIMENTAL RESULTS AND DISCUSSIONS

Commercial Storage of Treated and Untreated Eggs

To determine the applicability of the method for preserving the quality of eggs going into cold storage, it was considered advisable to try the method on eggs which had reached a produce house.

The eggs for this experiment were obtained from the Perry Packing Plant, Manhattan, Kansas. They came from surrounding farms and were candled by commercial candlers who chose four cases of "Perry's Best" (No. 1 Extras) for this experiment. The tests were set up in half case (15 dozen) lots which were obtained by taking the top layer, each time, from four cases of the candled eggs.

The eggs receiving treatment were treated three to four dozen at a time. This was accomplished by dipping the eggs contained in a wire basket, into the solutions or emulsions that the treatment called for. After the various treatments, two eggs were numbered, weighed individually to 0.01 g and placed in the center of each layer of three dozen eggs.

The eggs which were washed in this experiment were simply soaked in the washing solution for ten minutes, while the emulsion dipped eggs were left in the emulsion for one to one and one-half minutes.

When the treatments were complete the eggs were placed in egg cases having separate flats and fillers and put in cold storage at 31° F. for five months. At the end of this period the eggs were again candled by a commercial candler into the government grades. The individually weighed samples were reweighed, broken out, and the Haugh Units determined, and the pH of the whites was determined to be above pH 9 in every case.

The treatments of the various lots were as follows:

Lot 1. Controls, no treatment.

Lot 2. Treated with "Emulsion No. 1" at 110-140° F.

Lot 3. Treated with "Emulsion No. 2" at 110-140° F.

Lot 4. Washed in one per cent sodium hydroxide, rinsed in 0.6 per cent clorox and treated with "Emulsion No. 1" at 110-140° F.

Lot 5. Washed in one per cent sodium peroxide, rinsed in water and treated with "Emulsion No. 1".

Lot 6. Washed in one per cent sodium hydroxide, rinsed in 0.6 per cent clorox.

Lot 7. Treated with "Emulsion No. 1" at room temperature 75° F.

Lot 8. Treated with "Emulsion No. 2" at room temperature 75° F.

The results of this experiment will be observed in Table 1. The candling results are based on the total lot, whereas the other data are for the ten egg samples from each lot.

Table 1. Comparison of treatments.

Lot No.	Candling Results					Average wt. loss per egg in grams	Average Haugh units per egg	pH of white
	%Extras	%Stds.	%Trades	%Rots	%Checks			
1	52.5	47.5			1.6	1.40 ±.020*	61.3 ±3.5	>9
2	82.9	14.9	1.7	0.5	1.6	0.41 ±.022	61.4 ±2.8	>9
3	78.9	20.0	1.1		3.8	0.62 ±.048	64.5 ±3.7	>9
4	48.9	50.0	1.1		3.3	0.95 ±.041	60.3 ±3.1	>9
5	64.3	34.5	1.2		3.8	0.75 ±.047	59.7 ±3.8	>9
6	27.2	70.2	2.6		11.0	1.35 ±.043	56.1 ±2.3	>9
7	86.3	11.9	0.6	1.2	4.4	0.64 ±.075	60.9 ±4.4	>9
8	80.2	19.2	0.6		3.3	0.59 ±.077	58.9 ±3.6	>9
	Eggs at beginning of experiment							
	>90.0						71.5 ±1.3	8.77

*Standard Error of Mean

It will be noted that this experiment was intended to show the effect of various methods of treatment and to compare these methods.

Funk (1938) stated that dirty eggs can be effectively cleaned by using solutions of sodium hydroxide, and that the dirty eggs cleaned in this manner kept as well (as determined by the number becoming inedible) in cold storage as eggs which were not washed. Although eggs can be effectively washed in sodium hydroxide solutions, it will not remove the stains. For this reason the eggs washed in sodium hydroxide were rinsed in clorox. Sodium peroxide, which in water solution gives sodium hydroxide and active oxygen, seemed to accomplish both the washing and bleaching of stains as well as a sodium hydroxide wash and a clorox rinse.

The results of this experiment show that washing in sodium hydroxide and rinsing in clorox has a definitely detrimental effect. This lot of eggs also exhibited lower average Haugh quality than any of the other lots, although the average weight loss was approximately the same as unwashed eggs. The high percentage of checks in all lots was due to technic in handling, rather than to the treatment.

The sodium hydroxide wash and clorox rinse also had an appreciable lowering effect on candling quality of the eggs subsequently oiled in the emulsions. However, it is of advantage to oil these eggs before placing in storage. The lowering of quality of this lot was greater than that of the sodium peroxide washed eggs.

From the data obtained, it appears that there is no advantage in treating the eggs in a hot dispersion of the oil as similar results are obtained when treated at room temperature of 75° F. It was expected that the Haugh quality would be approximately the same in all the lots, as the pH was near its upper limit when the eggs were treated and the Haugh quality already low.

Taste tests were conducted on eggs from each of the various lots to determine if any off flavors could be detected. The tasting was done by three members of the Poultry Department and two members of the Chemistry Department of Kansas State College.

The eggs were coded by an assistant who did not do any of the tasting, and two eggs from each lot were passed in random order to each taster. A known fresh egg was tasted at the beginning of the test by each member. Only the yolks were tasted. Yolks of raw and of soft boiled (three minute) eggs were tasted. During the course of tasting, two unknown fresh eggs were also tasted.

The yolk was separated from the white in the raw eggs by cutting away the majority of the white and then rolling the yolk on a piece of absorbent paper.

The eggs were smelled and tasted and graded on a basis of one to ten, the highest grade for a mild flavored and mild smelling yolk was ten. The average results are given in Table 2.

There was considerable variation among individual tasters, but the differences were not consistent; the lowest graded eggs were not graded low by all tasters. It is felt that the stored eggs were not to be considered exceptionally bad, for in such a case they would likely be objectional to all tasters. The data do indicate, however, that the off flavors detected were not due to the oil, emulsifying agent, or washing agents used. Most of the tasters described the off flavor and odor detected as a musty or straw taste and odor.

Table 2. Taste and odor tests.

Lot No.	Taste		Odor	
	Raw	Boiled	Raw	Boiled
Fresh	9.0	8.8	9.8	8.6
1	5.8	6.7	7.0	6.3
2	7.5	7.3	7.4	5.1
3	5.0	6.5	5.0	6.9
4	5.0	7.7	5.7	6.7
5	4.6	6.0	4.4	6.2
6	5.8	6.5	7.0	6.1
7	5.6	5.6	7.6	5.1
8	5.3	6.9	5.6	6.6

The committee agreed that it was much more difficult to detect the off flavor in the boiled than raw eggs, however, the odor of the hot boiled eggs was more pronounced.

Early Treating of Eggs on the Farm

The following experiment was set up to determine the effect upon the apparent broken-out quality of treating eggs soon after laying, instead of waiting for treatment after reaching the produce house. It was also desired to determine how much the apparent quality was lowered by holding for short periods of time in an egg cellar.

The eggs for this experiment came from a flock of Kansas State College birds, the same flock being used for the entire experiment. The eggs were gathered daily at 4:00 P.M. Those receiving treatment were dipped one dozen at a time for one and one-half minutes in "Emulsion No. 1". Each lot consisted of three dozen eggs. After treatment, the eggs were replaced in buckets and placed in an egg cellar for the length of time indicated in Table 3. Lots which were not treated were held under the same conditions. The temperature of the cellar was 75° F. ± 5°. The eggs which were placed in cold storage following the period in the cellar were held at 37° F. in an egg case having separate flats and fillers. In order to insure uniformity of conditions for the treated and untreated eggs, they were placed in the case in a checker board fashion.

The eggs were broken out at the ages indicated and the apparent quality determined in terms of Haugh Units. The pH of a sample of the white was determined by means of a quinhydrone electrode. The results are shown in Table 3.

From the results it will be noted that there is a definite advantage in early treatment of eggs on the farm, rather than waiting until the eggs reach the produce house. It seems improbable that, on the average, eggs from farms would reach the produce house before they are two to three days old. After standing three days, eggs have lost a great deal of their carbon dioxide and the standing up quality is appreciably lowered. It has been shown elsewhere in this study (p. 12) that eggs which have a high pH when placed in storage, even though they are oiled, lose their standing up qualities to the same extent as untreated eggs.

Table 3. Results of early treating of eggs.

Lot No.	Conditions and time held	Haugh Units: Average	Haugh Units: Average loss from fresh eggs	Haugh Units: Advantage of treatment	Haugh Units: Lost during cold storage	Average pH of white
1	Broken out the day layed	88.7±1.41				7.97
2	No treatment, placed in cellar 3 days	75.7±2.32	13.0			8.78
3	Treated, placed in cellar 3 days	79.6±1.75	9.1	3.9		8.02
4	No treatment, placed in cellar 3 days, placed in cold storage 2 months	61.0±2.73	27.7		14.7	8.71
5	Treated, placed in cellar 3 days, placed in cold storage 2 months	74.5±1.43	14.2	13.5	5.1	7.97
6	No treatment, placed in cellar 7 days	69.4±2.04	19.3			8.93
7	Treated, placed in cellar 7 days	80.5±2.41	8.2	11.1		7.90
8	No treatment, placed in cellar 7 days, placed in cold storage 2 months	63.4±1.99	25.3		6.0	8.70
9	Treated, placed in cellar 7 days, placed in cold storage 2 months	73.3±1.89	15.4	9.9	7.2	7.98

The advantage of early treating of eggs becomes very noticeable when a comparison of treated and untreated eggs is made after cold storage. It appears that placing eggs in cold storage as soon after treatment as possible would be desired.

Storage of Eggs in an Egg Cellar and of Washed Eggs

This experiment was intended to show the advantages, with respect to preservation of quality of treating eggs by the method developed, when they were to be stored on the farm. It was also desired to show that the method is applicable to washed eggs which are still wet from washing.

The eggs for this experiment were taken from the same flock of birds for the entire experiment. They were gathered daily and were handled in 18 egg lots. They were candled and only "U. S. Special" grade eggs were used.

The eggs were weighed individually to 0.01 g and those receiving treatment were dipped two eggs at a time in "Emulsion No. 1". The eggs that were washed and sealed were soaked for five minutes in a one per cent sodium hydroxide solution, rinsed well with water, and then dipped while wet, two eggs at a time, in the emulsion.

In order to subject the untreated and treated eggs to conditions as similar as possible, they were placed in the egg case in checker board fashion. Except for the specified treatments, all eggs were subjected to the same handling.

The temperature of the egg cellar varied a good deal from the time the experiment was begun until it was completed. At the beginning of the experiment it was 70° F. and at the close of the experiment it was 50° F.

The eggs were left under these conditions for varying lengths of time as shown graphically in Plates II and III, and in Table 4. At the prescribed age, the eggs were removed, candled, weighed, broken out and the apparent quality determined, and the pH determined by means of a quinhydrone electrode in those cases where it was less than nine.

The data from this experiment show that the shell sealing is very advantageous. On an average the weight loss was retarded by 80 per cent, and when it is considered that the standing up quality of the white in six week old treated eggs is 22 per cent better than untreated eggs of the same age, it seems that such a method of treating eggs is justified.

Treated eggs which were candled into a lower grade were so graded because of yolk shadow rather than large air cell. The rather wide variation in the results shown on the graphs are considered to be due largely to the temperature variation in the cellar during the course of the experiment.

Effect of Washing on pH of Egg White

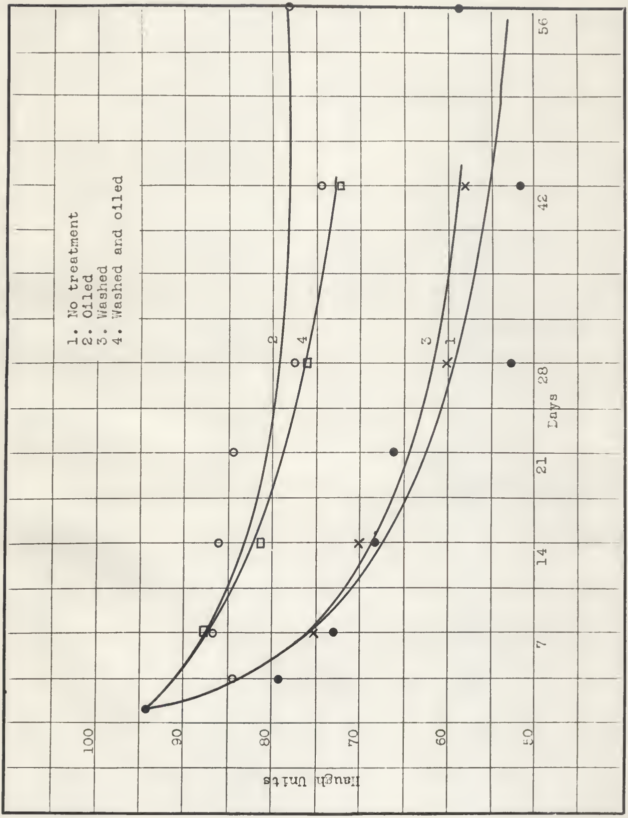
It was desired to determine if washing in basic solutions alters the pH of the white appreciably.

In this experiment, very fresh eggs were obtained in order that the pH would be as near normal as possible. Each lot consisted of one dozen eggs. These were washed in the basic solutions listed in Table 5 for ten minutes, rinsed well and treated

EXPLANATION OF PLATE II

Change in broken-out quality during storage

Plate II


1. No treatment
2. Oiled
3. Washed
4. Washed and oiled
1
2
3
4
Days
7
14
21
28
42
56
Haugh Units
50
60
70
80
90
100

EXPLANATION OF PLATE III

Weight loss during storage

Plate III

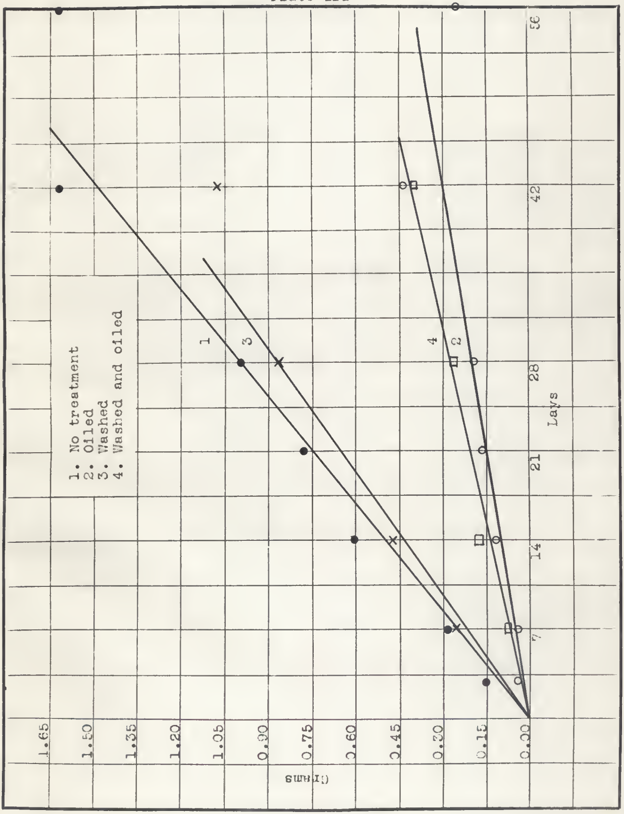

1. No treatment
2. Oiled
3. Washed
4. Washed and oiled
1
3
4
2
Grams
1.65
1.50
1.35
1.20
1.05
0.90
0.75
0.60
0.45
0.30
0.15
0.00
Days
7
14
21
28
42
56

Table 4. Advantage of treating unwashed and washed eggs.

Lot No.	Treatment	Time held	Haugh Units: Average	Haugh Units: Loss from fresh eggs	Haugh Units: Advantage of treatment	Grams: Average wt. loss per egg	Grams: Advantage of treatment	Average pH of white	Average candling results
1	None	6-12 hrs.	94.5±1.6					7.84	3.00*
2	None	3 days	79.8±2.2	14.7		0.16±.010		8.96	2.80
3	Oiled	3 days	85.4±2.3	9.1	5.6	0.04±.005	0.12	8.02	2.80
4	None	7 days	73.2±2.5	21.3		0.39±.018		9.00	2.72
5	Oiled	7 days	87.1±1.3	7.4	13.9	0.05±.005	0.24	8.05	2.72
6	None	14 days	68.8±2.1	25.7		0.61±.028		9.00	2.12
7	Oiled	14 days	86.4±1.8	8.1	17.6	0.11±.017	0.50	7.96	2.61
8	None	21 days	66.6±2.6	27.9		0.78±.051		9.00	2.17
9	Oiled	21 days	84.6±1.6	9.9	18.0	0.15±.028	0.63	8.20	2.77
10	None	28 days	53.0±2.7	41.5		0.99±.036		9.00	2.22
11	Oiled	28 days	77.7±2.2	16.8	24.7	0.18±.017	0.81	8.35	2.52
12	None	42 days	51.9±2.1	42.6		1.61±.061		9.00	1.00
13	Oiled	42 days	74.6±2.1	19.9	22.7	0.44±.026	1.17	8.44	2.00
14	None	56 days	58.9±2.1	35.6		1.62±.092		9.00	1.00
15	Oiled	56 days	78.2±1.3	16.3	19.3	0.28±.033	1.34	8.55	1.83
16	Washed	7 days	75.6±2.4	18.9		0.29±.016		8.95	2.88
17	Washed & Oiled	7 days	87.8±1.3	6.7	12.2	0.08±.007	0.21	7.90	2.77
18	Washed	14 days	70.7±2.2	23.8		0.48±.022		9.00	2.50
19	Washed & Oiled	14 days	81.5±0.9	13.0	10.8	0.17±.014	0.31	8.29	2.72
20	Washed	28 days	60.1±2.2	34.4		0.88±.021		9.00	1.77
21	Washed & Oiled	28 days	76.5±1.5	18.0	16.4	0.28±.020	0.60	8.15	2.12
22	Washed	42 days	58.7±3.1	35.8		1.08±.074		9.00	1.53
23	Washed & Oiled	42 days	72.4±2.6	22.1	13.7	0.40±.038	0.68	8.44	1.82

* 3 = U. S. Special   2 = U. S. Extras   1 = U. S. Standards

with the emulsion for two minutes. They were then placed in a combination flat and filler egg tray and placed in a 37° F. room for two days. After this time they were removed and allowed to come to room temperature, which required three and one-half hours. They were broken out and the pH of a portion of the white was determined by means of the quinhydrone electrode.

Table 5. Effect of basic washing solution on pH of the white.

Lot No.	Wash	pH of white
1	None	7.76
2	1% NaOH	7.79
3	1% NaOH 1% H_2O_2	7.88
4	1% Na_2O_2	7.83
5	1% Na_3PO_4	7.86
6	1% Na_2CO_3 1% H_2O_2	7.88

It appears that there is no significant change in the pH of the white due to washing in basic washing solutions.

Mechanism of Water and Carbon Dioxide Loss from the Egg

In preliminary experiments it had been noted that although some of the water soluble materials used in treating the eggs appeared to form a film around the shell, there was no appreciable retarding of water and carbon dioxide losses. If water and carbon dioxide escape as vapor through the pores of the shell, these losses should have been retarded if the porosity was reduced by the films around the shell. While those films which were water soluble failed to check these losses, water repellant films cut these losses markedly.

This experiment was set up to show whether or not the water and carbon dioxide losses are due to a liquid diffusion through the shell, rather than a gaseous diffusion through the pores.

Three lots of one dozen eggs layed on the day they were used were employed for this experiment.

Lot 1. The eggs were dipped one egg at a time for two minutes in a ten per cent aqueous solution of a water soluble wax (Carbowax, National Carbide and Chemical Co.).

Lot 2. The eggs were dipped one egg at a time for one and one-half minutes in "Emulsion No. 1".

Lot 3. The eggs in this lot received no treatment.

The eggs were weighed individually to 0.01 g and placed in a constant temperature room at 98° F. and 60 per cent relative humidity for seven days. After this period of storage under these adverse conditions they were reweighed to determine water loss. The carbon dioxide loss was determined by measuring the pH of a sample of the white by means of a quinhydrone electrode. When the white had a pH greater than nine, the true value was not determined but recorded as nine.

The egg shells were then subjected to the procedure for determining porosity. The porosity is expressed as ml of gas (measured at standard conditions) passing through 314 square mm of shell area per minute. The results for the three lots are shown in Tables 6, 7, and 8. A comparison of the three is made in Table 9.

Although there was a slight retarding of water loss, as shown by the weight loss in the wax coated eggs, it was not as great as one would expect if water and carbon dioxide are lost as vapor, since the porosity is comparable to that of oil treated eggs. The average porosities of these two lots are approximately the same, yet the oil treated egg lost only 15.8 per cent as much weight as the wax treated. The pH of the oil treated eggs was very nearly normal, while the wax coated eggs had apparently lost much carbon dioxide.

It seems that this evidence would substantiate the theory that water and carbon dioxide are lost by liquid diffusion through the shell rather than by vapor diffusion through the pores. It might be that the matrix of the shell or the protein "core" of the pores or both act as a "wick" which absorb the liquids and they diffuse to the surface of the shell where they evaporate. It seems very probable that the carbon dioxide could pass through the shell as bicarbonate ion (HCO_3) as easily as water.

It is possible that this method of measuring porosity might be subject to criticism because of using a pressure difference, however, in view of the fact that a quantitative method of measurement was desired, the method seems justifiable, especially when the pressure difference was only 100 mm of mercury.

Table 6. Porosity of wax coated eggs.

Egg No.	Weight loss in grams per egg	pH of white	Porosity of area 314 square mm		
			Large end	Small end	Average
1	1.48	>9	0.45	0.09	0.17
2	1.82	>9	1.40	0.00	0.70
3	1.35	>9	0.38	0.28	0.33
4	1.51	>9	1.09	0.00	0.54
5	2.21	>9	19.50	6.95	13.22
6	1.93	>9	14.10	1.00	7.55
7	2.15	>9	3.00	0.28	1.64
8	1.80	>9	0.97	0.00	0.48
9	1.96	>9	12.20	19.90	16.05
10	2.23	>9	6.23	0.38	3.30
11	1.71	>9	0.00	0.00	0.00
12	1.85	>9	4.70	4.07	4.28

Table 7. Porosity of oil treated eggs.

Egg No.	Weight loss in grams per egg	pH of white	Porosity of area 314 square mm		
			Large end	Small end	Average
1	0.12	7.75	2.65	9.90	6.27
2	0.30	7.90	18.37	0.00	9.19
3	0.19	8.25	0.00	0.00	0.00
4	0.46	8.21	26.14	0.52	13.33
5	0.37	8.05	2.60	0.00	1.30
6	0.05	7.86	9.90	0.00	4.95
7	0.15	8.12	0.62	0.00	0.31
8	0.38	8.15	0.00	0.00	0.00
9	0.30	8.25	3.03	0.38	1.70
10	0.36	8.80	1.73	0.38	1.05
11	0.58	8.10	23.00	0.67	11.83
12	0.18	8.70	0.26	0.00	0.13

Table 8. Porosity of untreated eggs.

Egg No.	Weight loss in grams per egg	pH of white	Porosity of area 314 square mm		
			Large end	Small end	Average
1	2.97	>9	5.46	35.40	20.43
2	2.08	>9	7.57	2.63	5.60
3	2.55	>9	6.90	11.50	9.20
4	2.71	>9	24.80	7.30	16.05
5	2.51	>9	6.30	6.30	6.30
6	1.80	>9	11.50	5.50	8.50
7	1.86	>9	22.60	10.40	16.50
8	2.24	>9	5.50	0.80	3.15
9	2.32	>9	9.40	18.07	13.73
10	2.08	>9	2.75	5.70	4.22
11	2.23	>9	7.10	2.63	4.86
12	3.00	>9	26.20	18.30	22.25

Table 9. Comparison of porosity measurements.

Lot No.	Average weight loss per egg (grams)	Average pH of white	Average porosity per egg
1	1.83	9.00	4.02
2	0.29	8.18	4.17
3	2.36	9.00	10.73

Fate of Triethanolamine Oleate in Treating Eggs

It was considered advisable to make an analysis of the emulsion for triethanolamine and oleic acid before and after treating of eggs. Such an analysis would help to explain the reaction taking place during the treatment and also indicate the amount of triethanolamine and oleic acid being retained upon the shell.

The emulsion used for this experiment was made using distilled water. Fifty ml aliquots of this emulsion were taken for analysis before the eggs were treated. Thirty-four eggs were then dipped in 125 ml of the emulsion, one egg at a time, in the usual manner. During this process 6 ml of the emulsion was lost, or 4.8 per cent of the volume. From the remaining 119 ml, two 50 ml aliquots were analyzed. The results of the analysis are shown in Table 10.

Table 10. Amount of triethanolamine and oleic acid in emulsion.

	Grams of triethanolamine in 50 ml			Grams of oleic acid in 50 ml		
Sample No.	Before treatment	After treatment	Average % loss	Before treatment	After treatment	Average % loss
1	0.0442	0.0437		0.134	0.119	
2	0.0437	0.0440	0.18	0.133	0.118	9.00
3	0.0440			0.131		
4	0.0438			0.132		

The indicated loss of amine obviously has no quantitative significance, since it is less than the experimental error. The data do indicate that little, if any, stays on the egg.

Triethanolamine oleate has a calcium ion tolerance above which calcium oleate is precipitated as the familiar insoluble soap. Upon this basis, and with the aid of experimental data obtained from this experiment, a logical conclusion can be drawn as to the mechanism of the emulsion in oiling eggs. It appears from the very small amount of triethanolamine lost during the treatment and from the loss in oleic acid, that on coming in contact with the shell of the egg (containing calcium ions) a double decomposition reaction takes place, the oleic acid is precipitated on the shell as the calcium salt and the triethanolamine goes into the water phase of the emulsion. The oil droplet, which had been surrounded by triethanolamine oleate, thus loses its protective coating of soap and having an affinity for the hydrocarbon chain of oleic acid is deposited upon the surface of the egg already covered with the oleate salt and in this manner a water repellant film which, on drying, does not alter the appearance of the egg seriously is obtained. Preliminary experiments further indicate this type of mechanism as emulsions containing emulsifying agents which were not affected by calcium ions failed to deposit an oil film on the eggs surface.

SUMMARY

The chief aim of this work has been to develop better methods than are now being used for preserving the quality of shell eggs. This required a study of the mechanism by which water and carbon dioxide escape from the egg. It resulted in the proposal that this escape be retarded by treating eggs with an emulsion of mineral oil in water with an appropriate stabilizing agent. This method has shown considerable promise, but is not yet thought to be ready for farm or industrial use.

Data are presented to show that: (1) to check carbon dioxide and moisture losses the coating applied to the shell must be impervious to moisture, (2) there is a decided advantage in early treating of eggs for preservation of quality, and (3) in order for emulsions to deposit their oil on the surface of the shell the emulsifying agent must be destroyed upon coming in contact with the shell.

Factors to favor the emulsion method of treatment are: (1) economy of method, (2) it is applicable to washed eggs, (3) the excess drains readily and the egg drys quickly, (4) it is applicable on the farm, thereby helping to reduce early quality losses, (5) flats and fillers are not damaged by absorbing excess oil, (6) the surface appearance of the shell after treatment is not seriously altered, (7) the amount of oil to be applied to the shell can be readily adjusted, and (8) heat need not be applied in the method.

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