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UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE  
AGRICULTURAL EXPERIMENT STATION

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# Maintaining Quality in Shell Eggs by Heat Treatment

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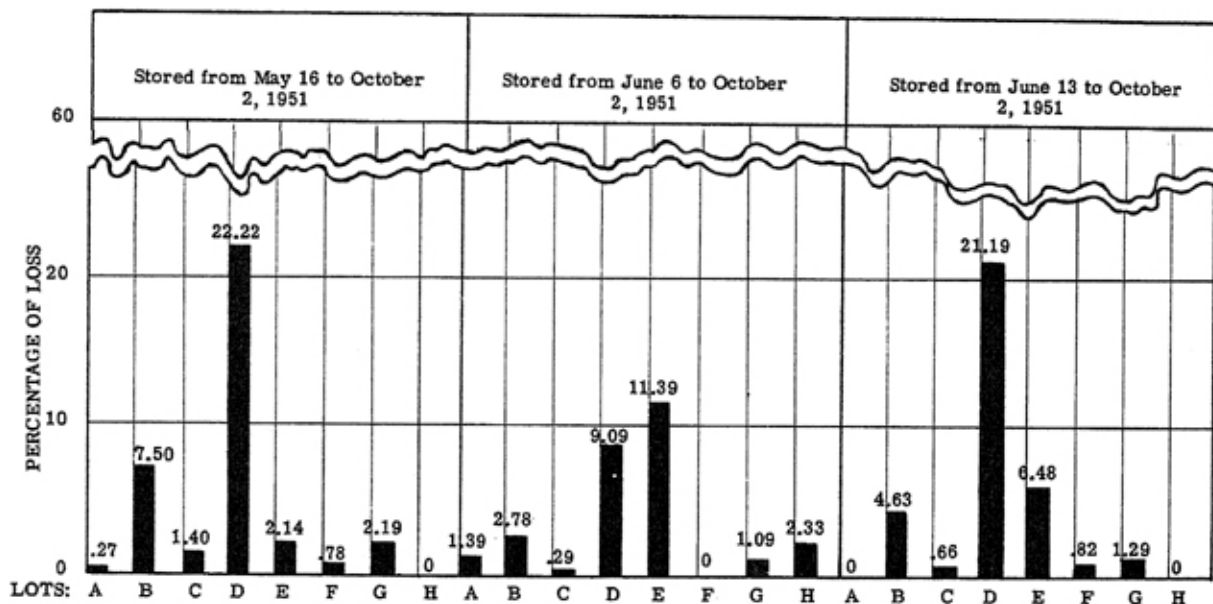
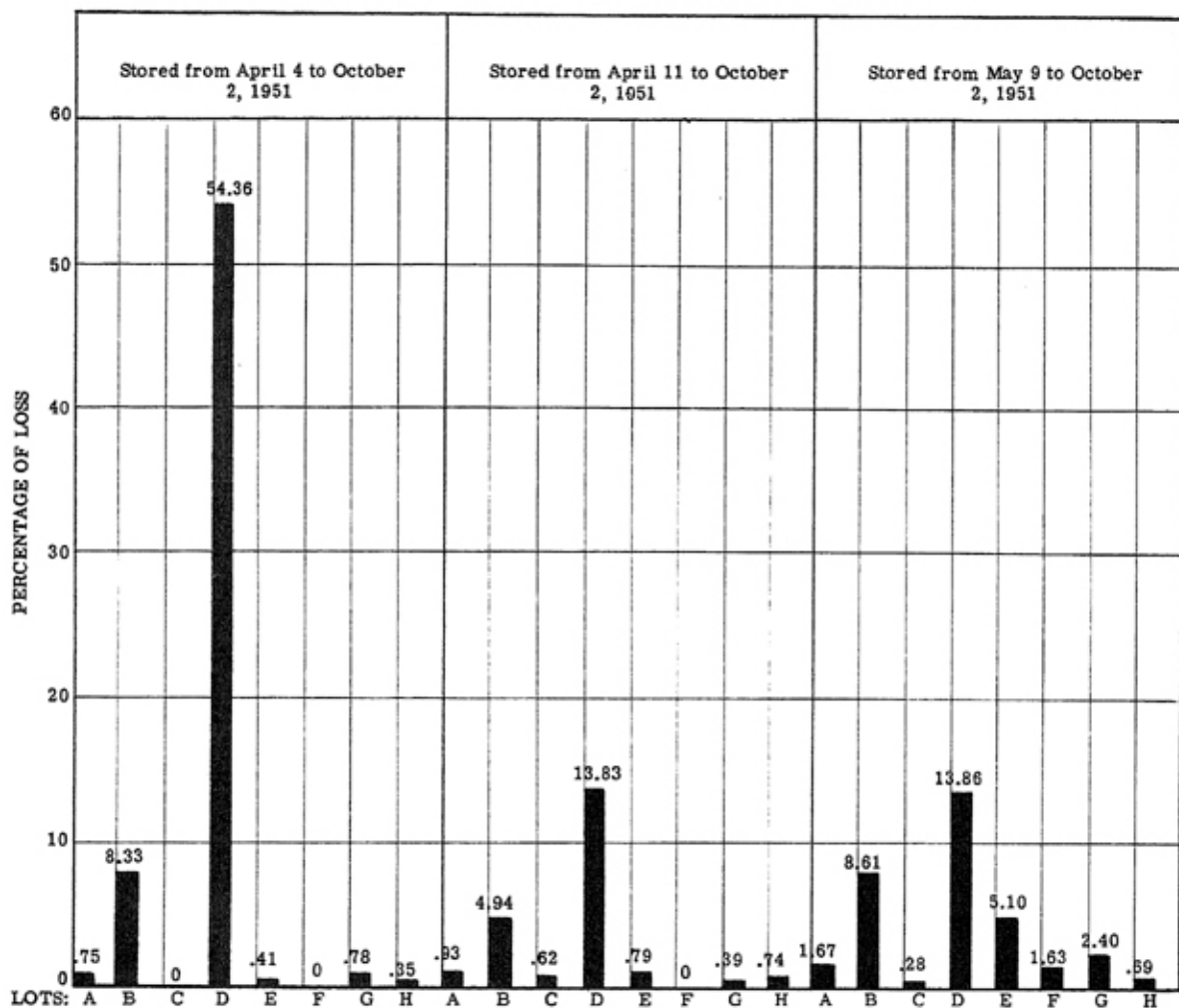


Figure 1 - Losses in storage, eggs stored as indicated: Lot A, clean eggs; lot B, soiled eggs; lot C, clean eggs stabilized in oil; lot D, soiled eggs washed in cold tap water containing Kleneg; lot E, same as D plus stabilized in oil; lot F, soiled eggs washed in water containing Kleneg for 15 minutes at 130°F; lot G, same as D plus 3 minutes in water at 145°; lot H, same as D plus 5 minutes at 140°F in water.

# Maintaining Quality in Shell Eggs by Heat Treatment

E. M. FUNK, JAMES FORWARD AND MARTHA LORAH

The use of heat as a method of preserving egg quality has been practiced for many years with uncertain results. For a review of literature up to 1950, refer to Missouri Agricultural Experiment Station Research Bulletin 467.

Murphy and Sutton (1947), in Australia, reported that they effectively pasteurized shell eggs to prevent rotting by immersing eggs in water held at 54°C (129.2°F) for 15, 22½, and 30 minutes.

Salton, Scott, and Vickery (1951), also Australian investigators, reported that they were able to prevent rotting in shell eggs very effectively by pasteurizing them at temperatures below 65°C (149°F). The lowest temperature they used was 57.5°C (135.5°F). They obtained most effective control when eggs were pasteurized for 320 seconds in water held at 60°C (140°F). They were unable to obtain effective control at temperatures of 70°C or above because coagulation occurred near the shell before the egg contents could be pasteurized.

Gorseline, Kirby, and Otte (1952) reported that Thermostabilized Grade A shell eggs stored 7½ months graded out more than 80 percent Grade A, compared to only 37.8 percent Grade A for similar oiled lots.

## UNIVERSITY OF MISSOURI RESULTS

Results secured at the Missouri Station from 1942 to 1950 were published in Missouri Agricultural Experiment Station Research Bulletins 362, 364, and 467. The results obtained since 1950 will be presented here.

### 1951 Studies

Experiments were designed and conducted for the purpose of determining the effectiveness of short period (3 and 5 minutes) heat treatments, compared to the standard thermostabilization treatment of immersing shell eggs for 15 minutes in water held at 130°F.

Each lot of eggs contained approximately 360 eggs. The eggs were purchased as clean or soiled eggs for corresponding experimental lots. They were purchased in the regular channels of trade from the F. M. Stamper Company, Moberly, Mo., trucked 35 miles to the University of Missouri where they were processed, and then shipped 135 miles by truck to St. Louis for storage in a cold storage warehouse. The eggs were stored April 4, April 11, May 9, May 16, June 6 and June 13, and removed from storage October 2, 1951. All eggs were then broken and observed for loss by the senior author and the personnel of an egg breaking plant.

The 1951 results (Figure 1) showed that storage losses were high

TABLE 1

Lot	1. Clean controls (1/2 case)
	2. Soiled controls (1/2 case)
	3a. Soiled eggs washed 6 hours after soiling using cleaning agent and quaternary. (Neutronyx 600 + BTC)* dipped in clean oil.
	3b. Same as 3a with the addition that the oil for dipping contained BTC.
	4a. Soiled eggs washed 6 hours after soiling in above wash water. Thermostabilized 16" x 130° in water. Dipped in clear oil.
	4b. Washed 6 hours later + 16" x 130° + (oil and BTC).
	5a. Same as 3a, 48 hours later.
	5b. Same as 3b, 48 hours later.
	6a. Same as 4a, 48 hours later.
	6b. Same as 4b, 48 hours later.
	7a. Same as 3a, four days after soiling.
	7b. Same as 3b, four days after soiling.
	8a. Same as 4a, four days later.
	8b. Same as 4b, four days later.

\*Neutronyx 600 is a polyester ether.

BTC = Alkyl dimethyl benzyl ammonium chloride.

(2.78 percent to 8.61 percent) in soiled eggs; very high (9.09 percent to 54.36 percent) in soiled eggs washed with tap water; erratic (0.41 percent to 11.39 percent) in eggs stabilized in oil; as compared to losses (0 to 1.67 percent) in the clean controls. Losses in all heat treated lots also were very low: clean eggs stabilized in oil, 0 to 1.40 percent; soiled and washed eggs stabilized in water (15 minutes at 130°F), 0 to 1.63 percent; soiled and washed eggs immersed for 3 minutes in water held at 145°F, 0.39 percent to 2.40 percent; soiled and washed eggs immersed for 5 minutes in water held at 140°F, 0 to 2.33 percent.

These results substantiate previous findings that losses are too high in soiled eggs to make their storage feasible. They also showed that extremely heavy losses may occur in eggs that have been cleaned by washing in tap (cold) water. The erratic results obtained by thermostabilizing shell eggs in oil by immersing them for 15 minutes at about 130°F suggested more work was needed on this problem. The average storage losses (0.58 percent) in eggs washed and then thermostabilized by immersing for 15 minutes in water held at 130°F compares very favorably with the average storage loss of 0.75 percent with clean egg controls.

The average storage loss of 1.36 percent for washed eggs immersed in water for 3 minutes at 145°F and 0.69 percent loss for washed eggs immersed for 5 minutes at 140°F also compares very favorably with the average storage loss of 0.75 percent for the clean egg controls.

Another series of tests in 1951 were designed to determine the relation of time elapsing after soiling before washing and before stabilizing or pasteurizing. The eggs were all processed and handled as described above for the other 1951 experiments. These eggs, however, were clean eggs and the soiling was artificial with a mixture of litter, droppings, soil, and water.

The lots were as given in Table 1.

Two tablespoons of Neutronyx 600 + 1 tablespoon of 50 percent BTC

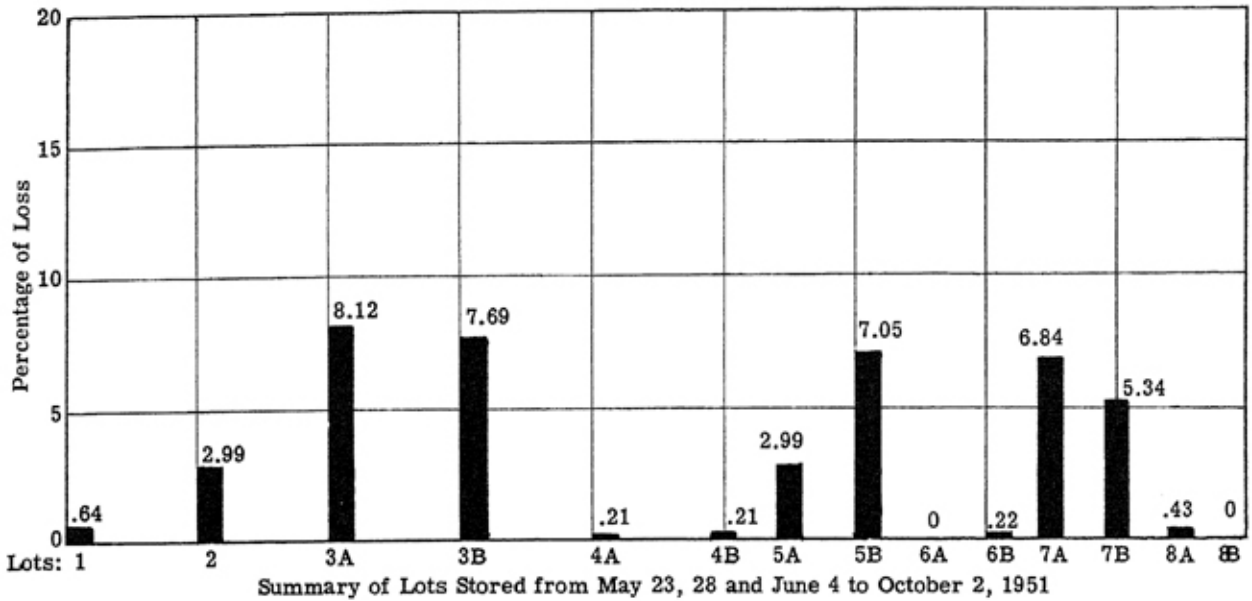


Figure 2—The effect of thermostabilization (lots 4A, 4B, 6A, 6B, 8A and 8B) on reducing loss in storage eggs. (See Table 1 for treatment of lots).

was added to a tub of cold water and baskets of eggs were kept moving in this solution. Additional hand washing was necessary after eggs were held 48 hours and longer. The oil emulsion was poured over the eggs in the 6 lots. The emulsion contained 1 tablespoon of 50 percent BTC + 4,000 cc clear oil.

The results obtained are shown in Figure 2. The average storage loss on 468 eggs per lot as found by candling and breaking was 0.64 percent for the clean egg controls and 2.99 percent for the soiled eggs. Soiled eggs (3a) washed 6 hours after soiling with a solution containing a cleaning agent and quaternary, plus oil processing, showed an average loss of 8.12 percent. Lot 3b was similar to 3a except that a quaternary was added to the oil. The average storage loss for this lot was 7.69 percent. Lots 4a and 4b correspond to 3a and 3b, respectively, except that they were thermostabilized by immersing the eggs for 16 minutes in water held at 130°F. The loss in these two lots was very low, 0.21 percent compared to 0.64 percent for the clean controls. Forty-eight hours after soiling the same treatments were made as those carried out after 6 hours of soiling. The results are quite similar except that lot 5a had less loss than 3a. The heat treatment was very effective in preventing loss.

Four days after soiling, the treatments were repeated. The losses were heavy (6.84 percent and 5.34 percent) when the soiled eggs were washed in a solution containing a cleaning agent and a quaternary. When heat was applied by immersing the eggs for 16 minutes in water held at 130°F the losses dropped to 0.43 percent and 0 percent.

Results of the 1951 experiments justify the conclusion that heat treatments may be applied to shell eggs that are sufficient to reduce spoilage in improperly washed shell eggs to a level comparable with the loss occurring in clean eggs.

### 1952 Experiments

The experiments conducted in 1952 were designed to compare different methods of cleaning soiled shell eggs on their keeping quality; including dry cleaning, washing in tap water containing a detergent and containing both a detergent and sanitizer, washing with an egg washing machine, and the use of different heat treatments for pasteurizing the eggs.

Essentially the same program as the one described for 1951 was used for procurement and handling of the lots.

The results secured are shown in Tables 2, 3, and 4 and Figure 3.

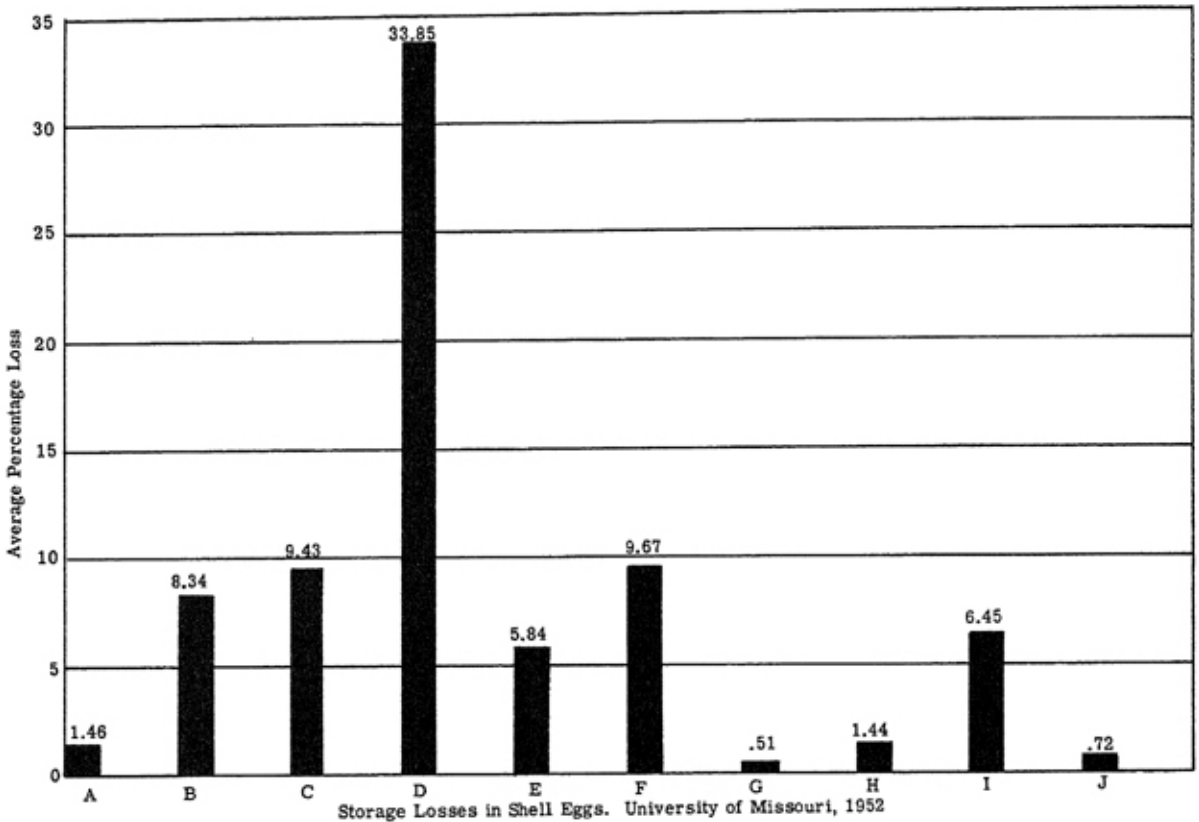


Figure 3. Effect of thermostabilization, dry cleaning, washing with an egg machine, and the use of detergents and sanitizers on the keeping quality of shell eggs. Lot A, clean; B, soiled; C, soiled eggs washed in tap water 59°F containing quaternary and a detergent; D, soiled eggs washed in tap water 64°F containing detergent; E, soiled eggs dry cleaned; F, soiled eggs washed in spray type machine, water 166°F; G, same as D plus immersion for 5 minutes in water 140°F; H, same as D plus immersion for 3 minutes in water 145°F; I, same as D plus immersion for 5 minutes in oil 144°-138°F; J, same as D plus immersion for 15 minutes in water at 130°F.

TABLE 2 -- THE EFFECT OF THERMOSTABILIZATION ON THE KEEPING QUALITY OF SHELL EGGS IN STORAGE. EGGS STORED FROM APRIL 16, 1952 TO OCTOBER 29, 1952. EGG TEMPERATURE BEFORE CLEANING, 70° F. CASE (30 DOZ.) LOTS WERE USED.

Lot	Kind of Eggs and Treatment	No. Eggs	Percentage of loss found						Stuck Yolks Not Loss %
			Candling	Breaking			Total		
	Green Whites	Sour		Other Rots	Stuck	Musty			
A	Clean Controls	274	0	.36				.36	
B	Soiled Eggs	323	.93	3.09		.31		4.33	.93
C	Soiled Eggs washed in tap water 59° F. containing quaternary and a detergent.	288	2.78	8.33		1.04		12.15	
D	Soiled Eggs washed in tap water 64° F. containing detergent	324	9.26	10.49	5.25	14.20		39.20	
E	Soiled Eggs Dry cleaned	313	1.28	3.84	.32	1.28		6.72	
F	Soiled Eggs washed in spray type machine. Water 166° F.	324	3.40	6.17		1.54		11.11	.31
G	Same as D plus immersion for 5 min. in Water 140° F.	324	0	.31				.31	
H	Same as D plus immersion for 3 min. in Water 145° F.	324	.62	2.16		.31		3.09	2.47
I	Same as D plus immersion for 5 min. in oil 144°-138° F.	288	2.08					2.08	1.92
J	Same as D plus immersion for 15 min. in Water 130° F.	324	0	.31	.31	.31	.31	1.24	1.54

TABLE 3 -- THE EFFECT OF THERMOSTABILIZATION ON THE KEEPING QUALITY OF SHELL EGGS IN STORAGE. EGGS STORED FROM APRIL 23, 1952, TO OCTOBER 29, 1952. EGG TEMPERATURE BEFORE CLEANING, 56°F.-74°F. CASE (30 DOZ.) LOTS WERE USED

Lot	Kind of Eggs and Treatment	No. Eggs	Percentage of loss found							Stuck Yolks Not Loss %
			Cand-ling	Green Whites	Sour	Other Rots	Breaking		Total	
A	Clean Controls	324	.62	.31					.93	
B	Soiled Eggs	324	.62	6.79	.93	.93	.93	.93	11.11	.93
C	Soiled Eggs washed in tap water 62° F. containing quaternary and a detergent.	322	1.54	4.94	.31	.62		.62	9.03	
D	Soiled Eggs washed in tap water 55° F. containing detergent.	324	3.70	18.52	3.09	4.63			29.94	.31
E	Soiled Eggs dry cleaned	324	0	1.85		.62			2.47	.31
F	Soiled Eggs washed in a spray type machine. Water 166° F.	324	.62	4.01	.93	.93			8.95	
G	Same as D plus immersion for 5 min. in Water 140° F.	324	.93	.31				.31	1.23	1.54
H	Same as D plus immersion for 3 min. in Water 145° F.	324	0					.31	.31	1.54
I	Same as D plus immersion for 5 min. in oil 150° F.-144° F.	324	1.54		1.85			.31	3.70	1.23
J	Same as D plus immersion for 15 min. in Water 130° F.	324	0		.31				.31	2.16



TABLE 4 -- THE EFFECT OF THERMOSTABILIZATION ON THE KEEPING QUALITY OF SHELL EGGS IN STORAGE. EGGS STORED FROM APRIL 30, 1952 TO OCTOBER 29, 1952. EGG TEMPERATURE BEFORE CLEANING, 68°F.-75°F. CASE(30 DOZ.) LOTS WERE USED.

Lot	Kind of Eggs and Treatment	No. Eggs	Percentage of loss found						Stuck Yolks Not Loss %	
			Cand-ling	Breaking				Total		
		Green Whites		Sour	Other Rots	Stuck	Musty			
A	Clean Controls	324	0	3.09					3.09	
B	Soiled Eggs	324	2.47	4.63	.31	1.54		.62	9.57	
C	Soiled Eggs washed in tap water 70° F. containing quaternary and a detergent.	324	2.47	2.78	.31	1.23		.31	7.10	
D	Soiled Eggs washed in tap water 70° F. containing detergent.	324	9.88	12.66	3.40	5.86		.62	32.41	
E	Soiled Eggs dry cleaned	324	1.23	5.86	.93			.31	8.33	
F	Soiled Eggs washed in a spray type machine. Water 166° F.	324	3.70	3.09	.31	1.85			8.95	.62
G	Same as D plus immersion for 5 min. in Water 140° F.	324	0						0	1.54
H	Same as D plus immersion for 3 min in Water 145° F.	324	.62				.31		.93	1.85
I	Same as D plus immersion for 5 min. in oil at 150°F.-144° F.	324	1.54	1.54	6.48	3.70	.31		13.58	
J	Same as D plus immersion for 15 min. in Water 130° F.	324	.31	.31					.62	1.54

TABLE 5 -- BROKEN OUT APPEARANCE OF 36 EGG SAMPLES FROM EACH LOT. THESE EGGS WERE HELD AT 34°F TO 38°F. AFTER REMOVAL FROM COLD STORAGE OCTOBER 29, UNTIL EXAMINED FROM NOVEMBER 6 TO DECEMBER 4, 1952

Lot	Stored: 4-15-52		Stored: 4-23-52		Stored: 4-30-52		Average U. S. D. A. Score for the 3 lots
	Inedibles	U. S. D. A. Alb. Score	Inedibles	U. S. D. A. Alb. Score	Inedibles	U. S. D. A. Alb. Score	
A	0	9.3	0	9.7	0	10.4	9.80
B	5	9.7	4	9.8	6	9.7	9.73
C	7	9.5	2	9.7	4	9.9	9.70
D	26	9.2	24	10.3	18	10.8	10.10
E	0	9.6	2	9.8	2	10.4	9.93
F	4	9.5	2	9.8	3	10.5	9.93
G	1	8.4	0	9.2	0	8.8	8.80
H	0	8.5	0	8.4	4	9.0	8.63
I	2	8.9	2	9.2	11	9.8	9.30
J	1	7.7	0	8.1	1	8.5	8.10

Dry cleaned eggs kept better than washed eggs but the average loss (5.84 percent) for the dry cleaned eggs was too high to make such a process at all feasible for storage.

Wet cleaning methods all failed to protect the eggs. A germicide reduced spoilage from 33.85 percent to 9.43 percent but both losses were too high to merit any practical consideration. Heat treatments in water, 3 minutes at 140°F and 15 minutes at 130°F were effective in preventing spoilage, reducing the spoilage in washed soiled eggs to less than the loss found in clean controls. Heating in oil again gave erratic results, possibly due to not enough heat being applied by this process. Machine washing was a failure.

Table 5 shows the number of inedibles and the U. S. D. A. scores for eggs that were removed from storage at the end of the storage experiment, held at room temperature for two days and then returned to a cooler where the temperature varied from 34°F to 38°F. The eggs were held from October 29 to December 4, with samples being broken at weekly intervals during that period.

There was no loss in the clean eggs and little loss in the eggs heat treated in water for 5 minutes at 140°F. All other lots showed heavy losses.

The U. S. D. A. scores for these eggs when broken out showed no detrimental effects from washing. Decided improvement in quality score was shown by those eggs given heat treatment.

### 1953 Experiments

The experiments conducted in 1953 were designed to reduce the time necessary for pasteurizing shell eggs against organisms that cause spoilage in storage, to determine the time and temperature necessary to pasteurize shell eggs in oil, to test the efficacy of stain removing substances, to test the value of detergent- sanitizers as compared to the regular heat process of thermostabilization (immersion for 15 minutes in water held at 130°F), and to test the value of thermostabilization in controlling loss in washed

eggs from several midwestern and southwestern states (Minn., Ia., Nebr., Mo., Okla. and Texas).

*Time Temperature Relationships in Pasteurizing Shell Eggs:* By repeated experiments, the Missouri Station has shown that badly contaminated shell eggs can be pasteurized against spoilage in storage by heating such eggs by immersing them for 15 minutes in water held at 130°F. Such heating produces other desirable effects; (1) devitalizes the embryo and (2) stabilizes the thick albumen.

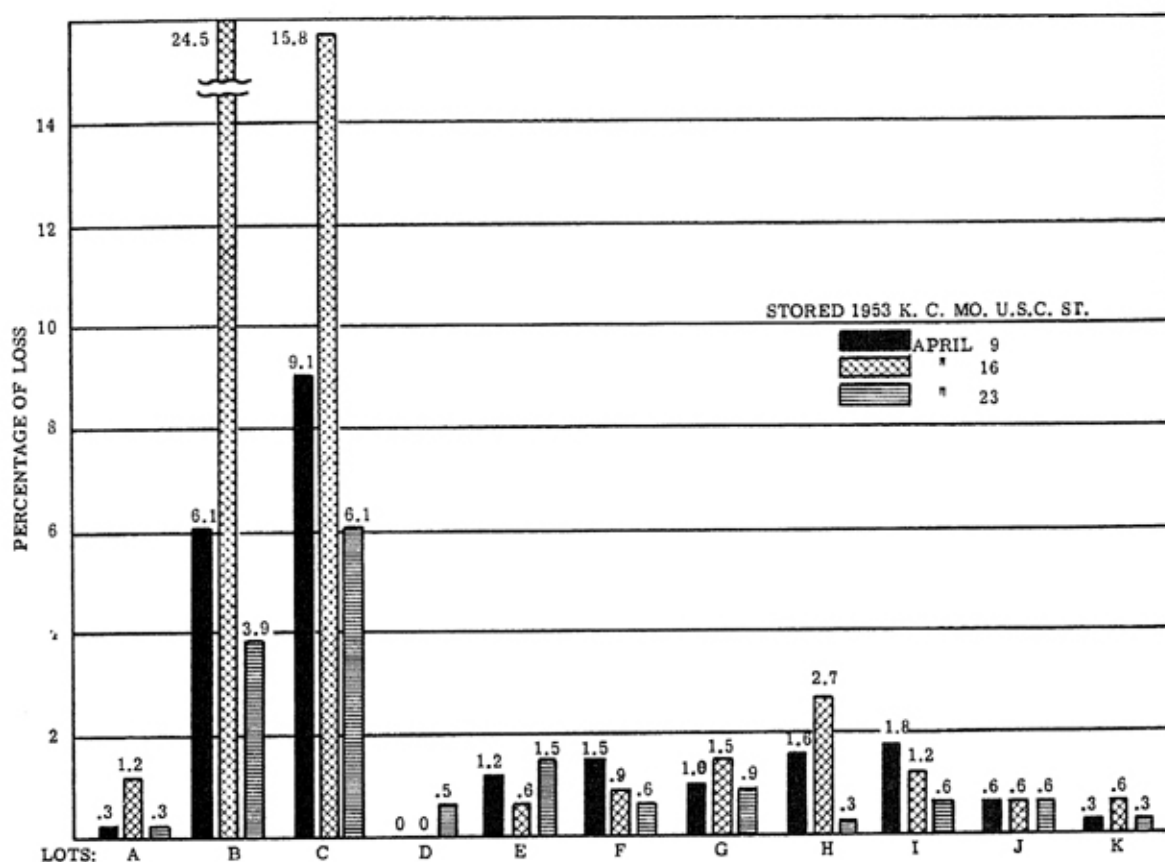


Figure 4. Effect of pasteurizing treatments on the keeping quality of shell eggs held in storage. See Tables 6, 7, and 8 for description of lots.

However, if only pasteurization is desired, previous tests have indicated that immersion in water 3 minutes at 145°F or 5 minutes at 140° would protect shell eggs.

For the 1953 tests it was deemed advisable (by preliminary tests) to reduce the time to one and one-half minutes and raise the temperature to 150°F. The results obtained (see Figure 4 and Tables 6, 7, and 8) showed that, compared to washed eggs, losses in three series of tests were reduced from 9.1 percent to 1.5 percent, from 15.8 percent to 0.9 percent and from 6.1 percent to 0.6 percent, respectively. Though not quite as effective as standard thermostabilization, the percentage of losses in storage eggs

TABLE 6 -- EFFECT OF CLEANING SOILED SHELL EGGS BY WASHING IN DETERGENT-SANITIZERS AND THERMOSTABILIZATION IN WATER AND OIL AT DIFFERENT TEMPERATURES. EGGS STORED FROM APRIL 9 TO OCTOBER 13, 1953

Lot	Treatment or Condition	No. Eggs Stored	Candling	Percentage of loss found by						
				Mold	Breaking			Total		
					Green Whites	Sour	Rots		Stuck	Musty
A	Clean Eggs	330						0.30		0.30
B	Soiled Eggs	330	1.52		1.82			0.61	2.12	6.06
C	Soiled (58-63° F.) washed in tap water at 58-64° F.	330	3.33		4.85			0.91		9.09
D	Same as lot C plus 15 min. in water held at 130° F.	330								0
E	Same as C plus 3 min. in water held at 145° F.	330	1.21							1.21
F	Same as C plus 1 1/2 min. in water held at 150° F.	330	1.21	0.31						1.52
G	Same as C plus 16 min. in oil held at 132° F.	306	0.33				0.66			0.99
H	Same as C plus 12 min. in oil held at 136° F.	306	1.31	0.32						1.63
I	Soiled eggs (68-72° F) soaked in a detergent-sanitizer solution containing 0.5% sodium perborate and then washed in Wright egg washer with water at 165° F.	282	0.71		0.71			0.71		1.77
J	Soiled eggs (68-72° F) soaked for 3 min. in detergent-sanitizer (145° F.) washed in Wright egg washer with water at 165° F. and then immersed for 12 min. in water containing 0.5% sodium perborate held at 130° F.	330	0.30	0.30						0.61
K	Same as J plus being rinsed in 0.1% acetic acid.	330			0.30					0.30

TABLE 7 -- EFFECT OF CLEANING SOILED SHELL EGGS BY WASHING IN DETERGENT-SANITIZERS AND THERMOSTABILIZATION IN WATER AND OIL AT DIFFERENT TEMPERATURES. EGGS STORED FROM APRIL 16 TO OCTOBER 13, 1953

Lot	Treatment or Condition	No. Eggs Stored	Candling	Percentage of loss found by Breaking						Total
				Mold	Green Whites	Sour	Rots	Stuck	Musty	
A	Clean Eggs	330	0.61		0.30	0.30				1.21
B	Soiled Eggs	330	2.73		1.82	0.30	0.91	0.30	18.48	24.55
C	Soiled (58-63°F.) washed in tap water at 58-64°F.	330	4.55		7.27		3.64		0.30	15.76
D	Same as lot C plus 15 min. in water held at 130°F.	330								0
E	Same as C plus 3 min. in water held at 145°F.	330		0.30			0.30			0.61
F	Same as C plus 1 1/2 min. in water held at 150°F.	322	0.62				0.31			0.93
G	Same as C plus stabilized in oil with Johnson machine 15 1/2 min. at 132°F.	330	0.30			0.30		0.92		1.52
H	Same as C plus stabilized in oil with Johnson machine 10 min. at 136°F.	330	1.21	0.30			1.21			2.73
I	Soiled eggs (68-72°F) soaked in a detergent-sanitizer solution containing 0.5% sodium perborate and then washed in Wright egg washer with water at 165°F.	330	0.30	0.30	0.30		0.30			1.21
J	Soiled eggs (68-72°F) soaked for 3 min. in detergent-sanitizer (145°F.) washed in Wright egg washer with water at 165°F. and then immersed for 12 min. in water (130°F) containing 0.5% sodium perborate held at 130°F.	325			0.31		0.31			0.61
K	Same as J plus being rinsed in 0.1% acetic acid.	329	0.61							0.61

TABLE 8 -- EFFECT OF CLEANING SOILED SHELL EGGS BY WASHING IN DETERGENT-SANITIZERS AND THERMOSTABILIZATION IN WATER AND OIL AT DIFFERENT TEMPERATURES. EGGS STORED FROM APRIL 23 TO OCTOBER 13, 1953

Lot	Treatment or Condition	No. Eggs Stored	Candling	Percentage of loss found						
				Breaking						
				Mold	Green Whites	Sour	Rots	Stuck	Musty	Total
A	Clean Eggs	330	0.30							0.30
B	Soiled Eggs	330	1.82		1.21		0.91			3.94
C	Soiled (58-63°F.) washed in tap water at 58-64°F.	330	0.61		2.42		3.03			6.06
D	Same as lot C plus 15 min. in water held at 130°F.	330						0.30	0.30	0.61
E	Same as C plus 3 min. in water held at 145°F.	330	0.30		0.91		0.30			1.52
F	Same as C plus 1 1/2 min. in water held at 150°F.	330	0.30				0.30			0.61
G	Same as C plus stabilized in oil with Johnson machine 16 min. at 132°F.	330						0.91		0.91
H	Same as C plus stabilized in oil with Johnson machine 12 min. at 136°F.	330			0.30					0.30
I	Soiled eggs (68-72°F) soaked in a detergent-sanitizer solution containing 0.5% sodium perborate and then washed in Wright egg washer with water at 165°F.	330	0.30		0.30					0.61
J	Soiled eggs (68-72°F) soaked for 3 min. in detergent-sanitizer (145°F.) washed in Wright egg washer with water at 165°F. and then immersed for 12 min. in water (130°F) containing 0.5% sodium perborate held at 130°F.	330					0.30		0.30	0.61
K	Same as J plus being rinsed in 0.1% acetic acid.	330					0.30			0.30

treated by this process (1 ½ minutes at 150°F) compared favorably with those occurring in clean egg controls; 1.5 to 0.3, 0.9 to 1.2, and 0.6 to 0.3 percent.

From the results secured to date we may recommend for pasteurization of shell eggs the following time-temperature relationships for immersing such eggs in water; 15 x 130°F., 5 x 140°F., 3 x 145°F., and 1 ½ x 150°F. If only pasteurization is desired the time may be reduced to one and one-half minutes by increasing the temperature of the water to 150°F.

Previous tests with oil as a heating medium had been erratic. Therefore, it was deemed advisable to test the effectiveness of heating shell eggs in oil under controlled time and temperature conditions. Plans were made to pasteurize washed shell eggs in egg processing oil in a laboratory with a Johnson Stabilizing Machine at the Gordon Johnson plant in Kansas City, Mo. The results obtained with six lots so treated are given in Tables 6, 7, and 8 and in Figure 4 (lots G and H). From these results it appears evident that, with controlled, proper time-temperatures, shell eggs may be pasteurized as effectively in oil as in water.

*Removal of Stains:* Washed eggs, particularly white shelled eggs, tend to show stains that make them unattractive to the consumer. By adding 0.5 percent of sodium perborate to the detergent used in washing soiled eggs and then dipping the cleaned eggs in a hot (140°F to 145°F) water solution containing 0.5 percent of sodium perborate (same bleaching agent as used in dentrifices) it was possible to present a washed egg that appeared by natural light to be clean as eggs that had never been soiled (see Figures 5 and 6).

*The Value of Detergent—Sanitizers Compared to Thermostabilization:* The question remains debatable as to the effectiveness of surface cleaning of soiled shell eggs so they will keep. In early work at the Missouri Station (See Mo. Agri. Exp. Res. Bul. 277), using lye water in 1936 and 1937, spring eggs were washed so that they kept remarkably well. However, in later tests with eggs produced during other seasons of the year, it was found that surface cleaning using either dry or wet methods would not protect such eggs against spoilage.

As a further check, lots that had been surface cleaned by washing in detergent-sanitizer solutions were incorporated into the 1953 tests. In the lots I, stored April 9, 16, and 23, the losses were very low and compared favorably with the heat treated lots. However, in lots C, stored May 18, 26, and June 2, the losses were very high: 3.39, 13.20, and 6.82 percent. (See Tables 9, 10, and 11 and Figures 4 and 6). This confirms previous work and indicates that surface cleaning, unless accompanied by heat treatment, cannot be depended upon to protect soiled eggs against spoilage.

April 1, 1952, two cases of heavy dirty eggs were purchased from the Poultry Producers of Central California; one case was dry cleaned at Petaluma on a Magic Dry Cleaner and the other case was washed and heat treat-



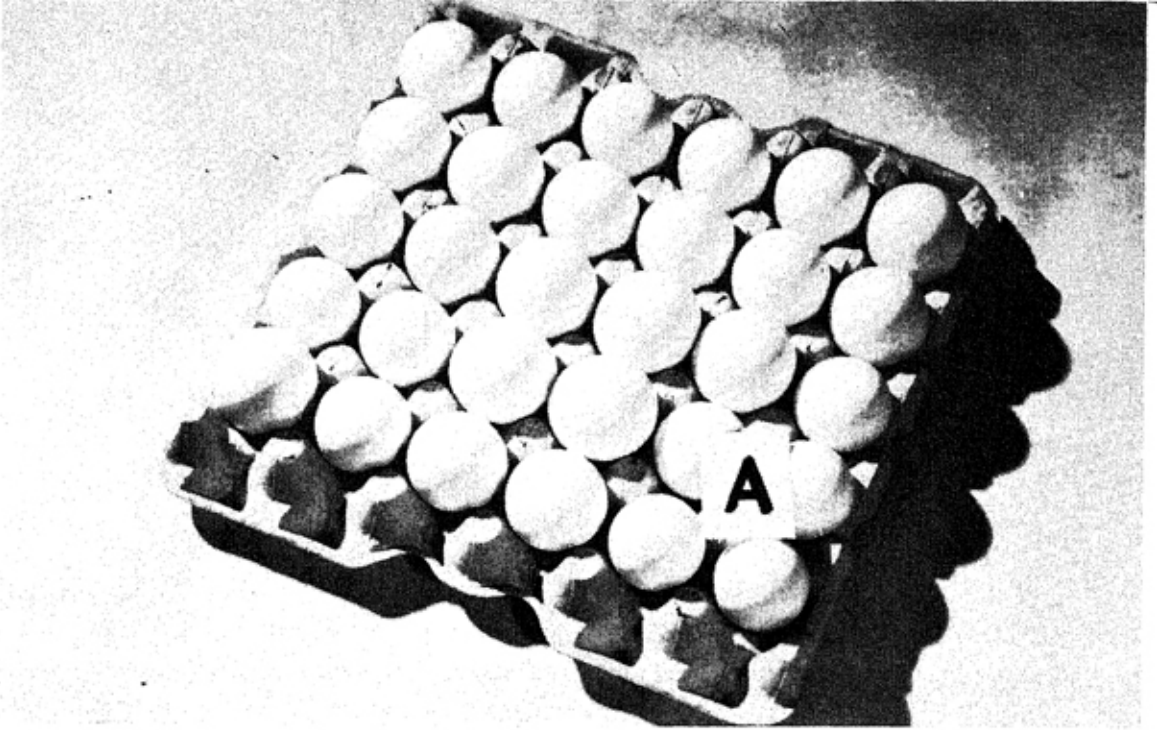


Figure 5. Clean eggs used as controls to compare with Figure 6.

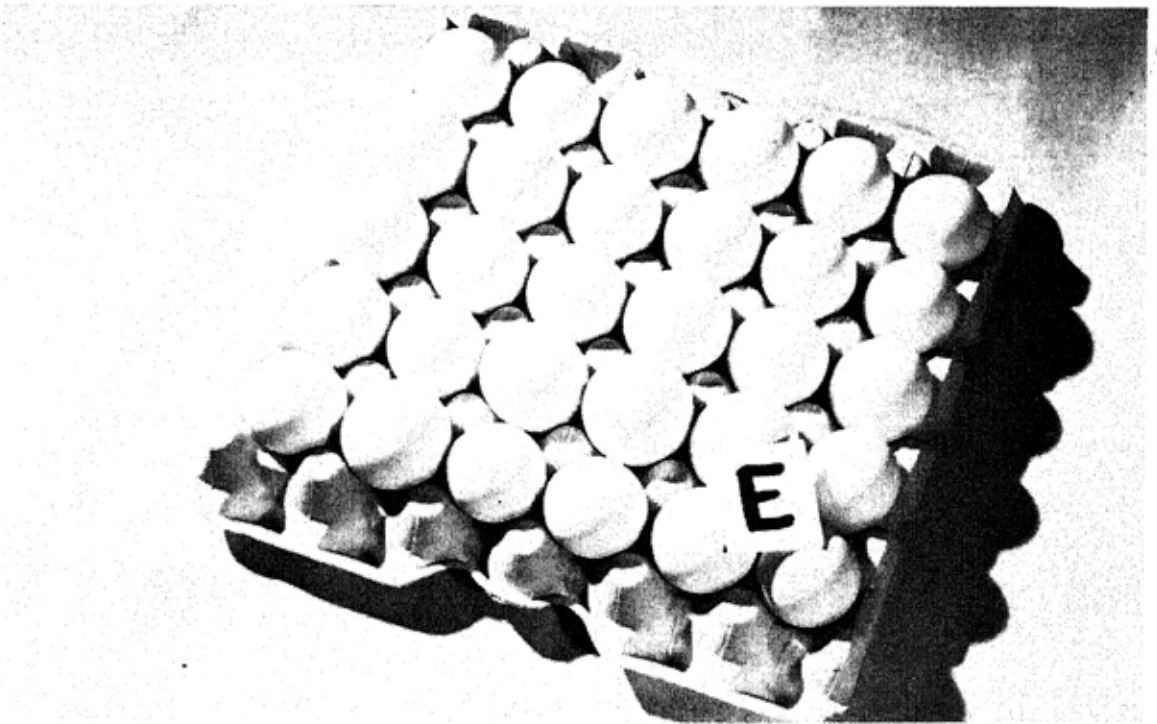


Figure 6. Eggs cleaned by washing and then dipping in a 0.5 percent sodium perborate solution to remove stains.



TABLE 9 -- EFFECT OF PASTEURIZATION AND THERMOSTABILIZATION ON THE KEEPING QUALITY OF SHELL EGGS IN STORAGE. EGGS STORED FROM MAY 18 TO OCTOBER 20, 1953

Lot	No. Eggs Stored	Cand-ling	Percentage loss found by							
			Breaking							
			Mold	Green Whites	Sour	Rots	Stuck	Musty	Total	
A	Clean eggs	360								0
B	Soiled eggs	360	0.28		2.78	0.28	1.67		0.28	5.28
C	Soiled eggs (65°F) soaked for 5 min. at 90-110°F. in a detergent-sanitizer solution and then washed with Wright egg washer with water at 165°F.	353	0.56		1.71	0.56	0.30		0.30	3.39
D.	Soiled eggs (65°F) soaked for 2 min. in a solution (145°F) containing a detergent-sanitizer and then washed in a Wright egg washer with water at 165°F.	338			0.59	0.30		0.30	0.30	1.48
E	Soiled eggs (65°F) soaked for 5 min. in a solution (145°F) containing detergent-sanitizer and washed in Wright egg washer with water at 165°F. and then held for 10 min. in water (130°F) containing 0.5% sodium perborate.	335								0
F	Soiled eggs (65°F) same as lot E plus being rinsed in a solution of 0.1% acetic acid.	338					0.30			0.30
G	Soiled eggs (65°F) soaked for 15 min. in detergent-sanitizer solution containing 0.5% sodium perborate held at 130°F. and then washed in Wright egg washer with water at 165°F.	350				0.28	0.28			0.57

TABLE 10 -- EFFECT OF PASTEURIZATION AND THERMOSTABILIZATION ON THE KEEPING QUALITY OF SHELL EGGS IN STORAGE. EGGS STORED FROM MAY 26 TO OCTOBER 20, 1953

Lot	No. Eggs Stored	Cand-ling	Percentage loss found by Breaking					Total
			Mold	Green Whites	Sour	Rots	Stuck	
A	Clean eggs	330		1.21				1.21
B	Soiled eggs	330	0.61	3.94	0.30	0.91		5.76
C	Soiled eggs (65°F) soaked for 5 min. at 90-110°F. in a detergent-sanitizer solution and then washed with Wright egg washer with water at 165°F.	313	0.99	9.57	0.66	1.98		13.20
D	Soiled eggs (65°F) soaked for 2 min. in a solution (145°F) containing a detergent-sanitizer and then washed in a Wright egg washer with water at 165°F.	318		0.31		0.62		0.94
E.	Soiled eggs (65°F) soaked for 5 min. in a solution (145°F) containing detergent-sanitizer and washed in Wright egg washer with water at 165°F. and then held for 10 min. in water (130°F) containing 0.5% sodium perborate.	298		0.34				0.34
F	Soiled eggs (65°F) same as lot E plus being rinsed in a solution of 0.1% acetic acid.	300	0.33	0.33	0.33	0.66		1.67
G	Soiled eggs (65°F) soaked for 15 min. in detergent-sanitizer solution containing 0.5% sodium perborate held at 130°F. and then washed in Wright egg washer with water at 165°F.	318				0.31		0.31

TABLE 11 -- EFFECT OF PASTEURIZATION AND THERMOSTABILIZATION ON THE KEEPING QUALITY OF SHELL EGGS IN STORAGE. EGGS STORED FROM JUNE 2 TO OCTOBER 20, 1953

Lot		No. Eggs Stored	Cand-ling	Percentage loss found by						Total
				Breaking						
				Mold	Green Whites	Sour	Rots	Stuck	Musty	
A	Clean eggs	360	0.28							0.28
B	Soiled eggs	360	2.50		1.67	0.56	1.67		0.56	6.94
C	Soiled eggs (65°F) soaked for 5 min. at 90-110°F. in a detergent-sanitizer solution and then washed with Wright egg washer with water at 165°F.	352	0.85		4.26	0.28	1.42			6.82
D	Soiled eggs (65°F) soaked for 2 min. in a solution (145°F) containing a detergent-sanitizer and then washed in a Wright egg washer with water at 165°F.	354	1.41				0.28			1.69
E	Soiled eggs (65°F) soaked for 5 min. in a solution (145°F) containing detergent-sanitizer and washed in Wright egg washer with water at 165°F. and then held for 10 min. in water (130°F) containing 0.5% sodium perborate.	346			0.29		0.58			0.86
F	Soiled eggs (65°F) same as lot E plus being rinsed in a solution of 0.1% acetic acid.	329								0
G	Soiled eggs (65°F) soaked for 15 min. in detergent-sanitizer solution containing 0.5% sodium perborate held at 130°F. and then washed in Wright egg washer with water at 165°F.	360			0.28		0.28			0.57

ed (15 minutes in water held at 130°F) at Columbia, Mo. Both cases were shipped by express to Columbia. One case (½ dry cleaned and ½ washed and thermostabilized) was stored at Columbia and one case was returned by express to San Francisco for storage. The senior author observed the eggs stored in California in July, 1952. It was evident both lots were of poor quality and contained a high percentage of loss.

When the eggs stored in Columbia were broken October 2, 1952, both lots showed heavy spoilage and the case stored in California was considered total loss.

Since this was the first failure with the process of thermostabilization in several years of experiments (all other eggs were Missouri eggs), plans were made in 1953 to purchase both clean and soiled eggs from Swift and Co. plants located in Minnesota, Nebraska, Iowa, Missouri, Oklahoma and Texas. These eggs were shipped to Columbia by express where the clean and soiled eggs were treated as indicated in Tables 12, 13, and 14.

The losses in one lot of Iowa and Oklahoma clean eggs ran high (6.67 and 4.38) but the loss in the Oklahoma eggs was due to olive colored yolks. Losses in two lots of soiled eggs washed in a detergent-germicide were high (Missouri, 4.29 percent and Texas, 5.96). The washed soiled eggs that were thermostabilized kept well except for one lot (Texas, 3.36 percent). The lots of clean eggs, thermostabilized, all showed less than 1 percent of spoilage except one lot (Okla. 3.21 percent) but this loss was due to olive colored yolks.

These results appear to justify the conclusion that thermostabilization

TABLE 12 -- EFFECT OF CLEANING BY WASHING WITH A DETERGENT-GERMICIDE AND THERMOSTABILIZATION ON THE KEEPING QUALITY (PERCENTAGE OF LOSS) OF EGGS IN STORAGE. EGGS STORED FROM MAY 5 TO OCTOBER 20, 1953.

Lot	Eggs from:	A	B	C	D	E	F
		Mo.	Ia.	Neb.	Okla.	Texas	Minn.
1.	Clean eggs	0.63	1.28	3.13	4.38	0.63	0.63
2.	Soiled eggs cleaned by washing in a detergent germicide	0	0	1.36	2.40	5.96	0
3.	Same as 2 plus thermostabilization	0	0	0	0.76	3.36	0
4.	Clean eggs thermostabilized	0	0.63	0	3.21	0	0
The loss in lots D1, D2 and D4 was from olive-colored yolks							

TABLE 13 -- EFFECT OF CLEANING BY WASHING WITH A DETERGENT-GERMICIDE AND THERMOSTABILIZATION ON THE KEEPING QUALITY (PERCENTAGE OF LOSS) OF EGGS IN STORAGE. EGGS STORED FROM MAY 12 TO OCTOBER 20, 1953

Lot	Eggs from:	A	B	C	D	E	F
		Mo.	Ia.	Neb.	Okla.	Texas	Minn.
1.	Clean eggs	0	1.67	0.60	0	2.77	2.22
2.	Soiled eggs cleaned by washing in a detergent germicide	4.29	0	0	2.38	0	0
3.	Same as 2 plus thermostabilization	0	0	0	0	1.16	0
4.	Clean eggs thermostabilized	0	0	0	1.11	0	0

TABLE 14 -- EFFECT OF CLEANING BY WASHING WITH A DETERGENT-GERMICIDE AND THERMOSTABILIZATION ON THE KEEPING QUALITY (PERCENTAGE OF LOSS) OF EGGS IN STORAGE. EGGS STORED FROM MAY 18 TO OCTOBER 20, 1953.

Lot:	Eggs from:	B	C	D	E	F
		Ia.	Neb.	Okla.	Texas	Minn.
1.	Clean eggs	6.67	0.56	0.56	0.56	0
2.	Soiled eggs cleaned by washing in a detergent germicide	0.56	0.56	0	0	0
3.	Same as 2 plus thermostabilization	0	0	1.18	1.14	0
4.	Clean eggs thermostabilized	0	0	0	0	0

was effective in minimizing spoilage in shell eggs produced in the midwest and southwest.

We are unable to explain the heavy losses found in the California eggs. The organisms (possibly fungi and not bacteria) causing spoilage were apparently resistant to the heat treatments given. Some fungi were recovered from the eggs examined at Columbia.

### Conclusions

Soiled eggs washed within 6 hours after soiling suffered as heavy loss as similar eggs washed 48 hours and 96 hours after soiling. Pasteurization was equally effective in preventing loss in lots washed and pasteurized 6 hours, 48 hours, and 96 hours after soiling.

Losses in storage were heavy in both soiled eggs and dry cleaned eggs. Neither kind of eggs should be stored.

Surface cleaning (wet or dry) gives erratic results and cannot be depended upon as a process for cleaning soiled eggs so they will keep.

Washed eggs do not necessarily show low broken out scores.

Shell eggs may be pasteurized in oil as well as in water if the correct time-temperature relationships are maintained.

If pasteurization, only, is desired, shell eggs may be protected against loss by immersing them in water for 1½ minutes at 150°F.

Stains may be removed from washed soiled eggs by washing and dipping them in warm water containing 0.5 percent of sodium perborate.

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