EFFECT OF HEAT TREATMENT AND STORAGE ON THE INTERIOR QUALITY OF THERMOSTABILIZED EGGS

ISIL İŞLEM VE DEPO KOŞULLARININ TERMOSTABİLİZE EDİLMİŞ YUMURTALARIN İÇ KALİTE FAKTÖRLERİ ÜZERİNE ETKİSİ

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ÖZET: Bu çalışma, termostabilizasyon işleminde optimum sıcaklık-süre ilişkisini tayin etmek amacıyla gerçekleştirilmiştir. Bu amaçla, yumurtalar 50°C ve 69°C arasında değişen sıcaklık derecelerinde ve 2 ile 30 dakika arasında değişen sürelerde işleme tabi tutulmuşlardır. Yedi haftalık depolama süresi boyunca gruplar arasında bazı iç kalite faktörleri açısından karşılaştırmalı bir çalışma yöntemi izlenmiştir. Yumurtaların iç kalitesini belirleyici olarak ak indeksi, sarı indeksi, Haugh birimi ve % ağırlık kayıpları hesaplanmıştır. Deney sonuçları iç kalitenin korunumu ve tüketicinin görsel beğenisi açısından, 58°C'de 15 dakika süre ile uygulanacak olan termostabilizasyon işleminin en iyi sıcaklık-süre kombinasyonu olduğunu göstermiştir.

ABSTRACT: This study was performed to determine the optimum time-temperature relation in thermostabilization of shell eggs. For this purpose, eggs were processed at temperatures ranging from 50°C to 69°C using process times ranging 2 to 30 minutes. During a storage period of 7 weeks a comparative study was conducted in terms of interior quality factors. The interior quality of all eggs was assessed by albumen index, yolk index, Haugh unit and per cent weight loss. eggs treated at 58°C for 15 minutes were found to be the best considering both interior and broken-out quality of processed eggs.

INTRODUCTION

Practically all eggs are at their highest quality at the time when they are laid. Deterioration of eggs starts at once and proceeds rapidly. Refrigeration is the most common treatment for inhibiting these deteriorative changes in eggs. Shell treatment has been shown to be suitable alternative to refrigeration (KAHRAMAN and BAYINDIRLI, 1990; OBANU, 1984). The application of heat to prevent carbon dioxide loss and successive quality decline is an area that requires additional study. Thermostabilization is a method of shell treatment by the application of heat. Application of heat to coagulate a thin film of albumen nearest to egg shell results in formation of a protective barrier. HARD (1963) extended the idea of heat treatment to retain the initial quality by using low temperatures and a prolon ged treatment. The heat coagulability of the egg white determines to great extend the maximal heat that can be given to the shell. By using a temperature below the normal coagulation point of egg albumen (i.e. 57.7.-62.2°C) and extending the time of heat exposure, stabilization of the albumen is obtained, which results in better interior quality (BABU, 1983).

The present enquiry was instituted to compare the interior quality of eggs thermostabilized at 50 °C, 54 °C, 58 °C, 62 °C, 65 °C and for 2, 3, 5, 10, 15, 20 and 30 minutes during a storage period for seven weeks. An untreated control was also used and two storage temperatures were utilized. Also the effect of the age of egg at the time of processing was studied.

MATERIAL AND METHODS

Brown layer hybrid hen's eggs purchased from Ankara Poultry Research Institute (Ankara-TURKEY) having similar genetic history, and gathered within two hours after laying were used in this study. Eggs were obtained from the strains of commercial layers of the same age and under identical management and nutritional regimens. Average egg weight was 65±5 grams. Before application of appropriate treatments, eggs with visible cracks, dirt and those contaminated with excreta were eliminated. Moreover, the eggs were allowed to equilibrate to room temperature for one hour before they were subjected to interior quality measurements.

In order to determine the optimum time and temperature of thermostabilization, 1080 eggs were divided into eighteen groups of 60 eggs. The eggs were weighed to the nearest 0.01 gram, they were labelled according to their group numbers. One group was kept untreated as control while others were processed at temperatures ranging from 50 to 69°C and for durations of 2 to 30 minutes (Table 1). Eggs were subjected to heat by placing them in wire basket and dipping in water for specified durations. The water was maintained at constant temperature using a thermostatically controlled water bath. After removal from hot water, eggs were drained and allowed to cool and dry on bench top. To determine the effect of the age of the egg at the time of processing an arbitrary temperature of 69°C for 3 minutes was selected as the process condition, and one of the groups was processed one week later. All eggs were stored according to their groups given in study plan.

Table 1. Plan of the Study

	Process Temp.	Process Time	Storage Temp.	Time of Application
A	Untreated control group		Room	First day
B	50°C	30 min.	Room	First day
C	50°C	20 min.	Room	First day
D	54°C	20 min.	Room	First day
E	54°C	20 min.	Refn.	First day
F	54°C	15 min.	Room.	First day
G	54°C	15 min.	Refn.	First day
H	58°C	15 min.	Room.	First day
I	58°C	10 min.	Room.	First day
J	62°C	10 min.	Room.	First day
K	62°C	5 min.	Room.	First day
L	65°C	5 min.	Room.	First day
M	65°C	3 min.	Room.	One week later
N	65°C	3 min.	Room.	First day
O	69°C	3 min.	Room.	First day
P	69°C	3 min.	Refn.	First day
R	69°C	2 min.	Room.	Firsy day
S	69°C	2 min.	Refn.	First day

A comparative study was conducted to determine the optimum time and temperature required for heat stabilization of shell eggs by comparing various interior quality factors calculated along a storage period of seven weeks. At the time of treatment and at 3-day intervals during the storage period, sample cases of eggs were with drawn for quality determination by means of visual inspection and by opening eggs to observe the internal quality. Changes in egg weight, yolk index, albumen index, albumen pH and Haugh unit values were evaluated by taking four eggs from each group for each treatment. Albumen and yolk indices, Haugh unit values were measured according to BRANT (1951).

Analysis of variance and Duncan's New Multiple Range Tests were used where appropriate to establish the significance of the different process conditions at 5% probability level under the assumption of an F distribution.

RESULTS AND DISCUSSION

In this study, the interior quality characteristics of the thermostabilized eggs were affected in a manner similar to that reported by other workers (HARD, 1963; FEENEY, 1955). Changes in albumen index, yolk index, Haugh unit values and moisture loss for eighteen different treatment groups during storage were given in the Tables 2 to 5. Using the experimental data interior quality versus storage time plots were prepared and comparisons were made according to several different process and storage conditions.

Table 2. Effect of Various Combination of Processand Storage Conditions on Haugh Units of Thermostabilized Eggs

Time	l	de	hi	d	ab	cd	ab	a	cd	a	cd	c	ghi	gh	ef	ab	fg	b
(day)	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S
0	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7
7	75.5	78.9	69.1	82.6	90.6	73.9	82.3	88.2	83.8	87.8	80.5	80.4	75.7	71.7	73.2	85.9	74.0	84.6
14	56.4	71.7	63.8	76.5	86.5	68.2	85.3	88.2	79.8	82.3	74.9	75.6	65.7	71.7	69.9	83.1	60.2	81.8
21	50.4	69.9	57.6	71.7	83.9	73.8	85.8	85.7	76.5	87.4	73.8	69.7	61.0	61.3	69.0	81.3	60.0	81.0
28	46.9	67.5	43.6	65.8	82.3	76.3	86.7	84.3	64.2	86.8	67.6	78.7	46.4	56.6	61.5	82.0	50.6	80.9
35	41.1	63.8	41.2	62.1	81.4	69.4	82.2	81.5	66.0	85.7	62.8	75.1	42.5	57.7	60.5	80.9	52.5	78.0
42	41.3	57.3	51.0	60.2	82.0	57.1	80.7	81.1	67.9	84.9	61.2	79.4	50.2	56.8	59.4		51.2	
49	43.8	48.0	53.0	53.3	82.8	55.4	79.2	79.6	68.1	79.9	58.7	67.0	44.9	57.6	58.8		50.4	

Columnswith the same letters (i.e. a, b, c) within the groupsare not significantly different at the p= 0.05 level.

Table 3. Effect of Various Combination of Processand Storage Conditions on Albumen Indices of Thermostabilized Eggs

Time	l	d	ghi	cd	ab	c	ab	a	cd	a	hi	cd	gh	ef	fg	b	de	ab
(day)	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S
0	109.7	109.7	109.7	109.7	109.7	109.7	109.7	109.7	109.7	109.7	109.7	109.7	109.7	109.7	109.7	109.7	109.7	109.7
7	64.6	73.7	69.5	88.0	100.9	94.4	100.3	106.0	93.5	105.8	69.7	78.9	75.6	66.0	79.8	88.8	83.0	96.9
14	46.2	72.0	67.6	74.8	94.0	79.4	97.2	103.6	77.0	100.7	53.2	68.4	69.6	73.4	68.2	83.7	73.0	80.1
21	42.0	69.0	61.8	62.0	94.5	66.9	97.8	103.0	73.6	98.5	55.2	65.0	56.1	57.3	52.5	83.0	56.0	81.2
28	39.8	65.8	55.8	60.5	92.0	65.0	96.0	101.4	57.8	94.6	42.2	67.9	55.1	60.0	53.4	78.6	51.3	89.0
35	22.2	57.6	41.1	49.4	83.1	63.0	93.1	86.8	60.7	93.5	38.4	70.8	44.3	58.0	49.4	74.5	49.0	70.4
42	19.0	50.3		44.5	81.7	69.5	86.0	79.3	59.0	87.8	40.7	60.6	30.2	50.0	46.6		40.8	
49	18.4	42.6		41.4	80.9	55.6	80.1	75.7	54.5	79.5	43.7	51.5	27.6	47.3	43.6		44.9	

Columnswith the same letters (i.e. a, b, c) within the groupsare not significantly different at the p= 0.05 level.

Table 4. Effect of Various Combination of Processand Storage Conditions on Yolk Indices of Thermostabilized Eggs

Time	de	cde	de	cde	a	cde	a	bc	cde	cd	cde	cde	e	de	cde	ab	de	a
(day)	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S
0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0
7	45.3	41.2	41.0	42.7	50.7	41.8	45.4	49.0	44.3	43.2	43.9	42.4	39.9	36.7	43.7	49.3	43.9	45.4
14	36.8	40.5	41.0	39.2	49.8	40.0	45.6	42.4	42.9	40.2	37.6	42.9	39.6	37.5	40.1	46.8	37.6	47.2
21	36.0	37.8	35.1	37.6	47.0	37.1	48.0	40.3	38.4	40.0	36.8	38.5	33.9	33.3	36.9	44.9	36.6	46.8
28	38.5	35.0	35.6	36.8	46.5	34.7	48.5	37.8	33.7	38.5	34.7	35.9	33.0	33.2	34.8	42.5	30.1	46.6
35	30.8	33.7	31.2	31.7	46.3	37.5	49.1	37.7	32.8	35.2	32.9	35.7	31.2	32.4	33.4	40.2	32.2	44.6
42	30.7	30.7	30.3	33.1	45.1	31.1	46.8	33.5	31.4	34.4	31.9	32.1	26.9	29.9	32.2		30.9	
49	30.4	29.6	29.2	27.9	47.2	27.5	47.9	33.0	30.1	31.0	29.8	30.5	26.2	28.3	31.1		29.9	

Columns with the same letters (i.e. a, b, c) within the groupsare not significantly different at the p= 0.05 level.

Table 5. Effect of Various Combination of Processand Storage Conditions on Weight Loss of Thermostabilized Eggs

Time	b	b	b	b	a	b	a	b	b	b	b	b	b	b	b	a	b	a
(day)	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	1.5	2.3	2.8	2.5	1.2	2.5	1.4	2.2	2.0	2.5	1.9	2.1	1.9	1.8	1.7	1.2	2.0	0.9
14	2.9	4.6	4.8	4.1	1.9	4.2	2.0	3.9	3.9	4.0	3.5	3.8	3.9	3.4	3.4	1.8	3.8	1.6
21	4.5	6.3	6.4	5.8	2.4	6.0	2.4	5.3	5.2	5.7	5.9	5.7	5.4	5.5	5.5	2.4	4.8	2.4
28	6.1	7.3	7.6	7.4	2.9	6.8	3.2	7.2	7.3	7.0	7.0	7.2	7.6	6.4	7.3	3.1	8.5	3.0
35	7.8	9.4	8.7	9.2	3.6	9.3	3.5	8.5	9.1	8.8	8.2	8.5	8.2	8.0	8.8	3.8	8.2	3.6
42	8.9	10.9	10.6	10.3	4.5	10.3	4.1	9.6	10.2	10.9	10.2	9.7	11.2	10.3	8.9		9.6	
49	10.6	12.3	11.9	11.7	5.4	12.0	5.3	11.6	11.9	12.6	11.4	11.2	12.5	10.9	10.3		12.0	

Columns with the same letters (i.e. a, b, c) within the groupsare not significantly different at the p= 0.05 level.

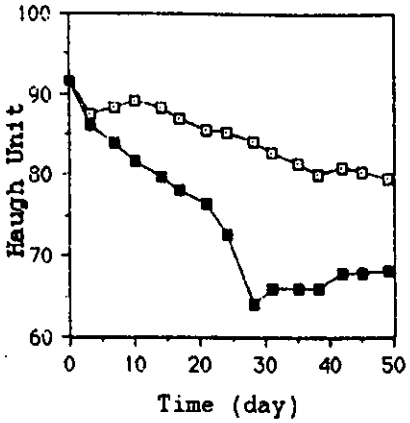

Figure 1. Effect of process temperature on albumen quality.
(-▫-): 58°C for 10 minutes (Group-I),
(-●-): 62°C for 10 minutes (Group-J).

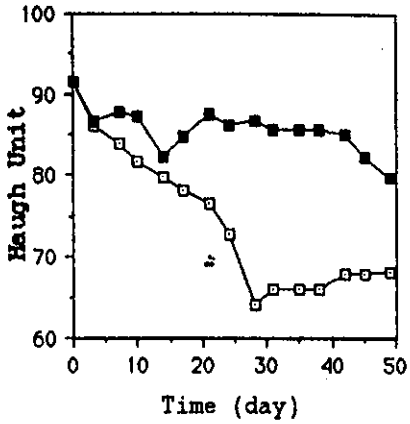

Figure 2. Effect of process time on albumen quality.
(-▫-): 58°C for 15 minutes (Group-H),
(-■-): 58°C for 10 minutes (Group-I).

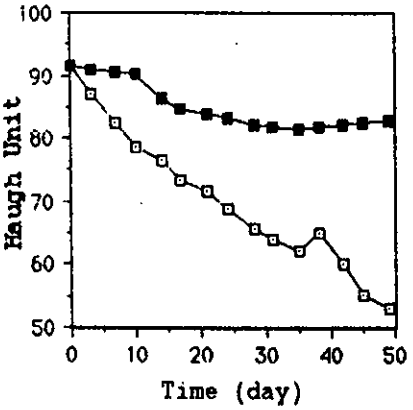

Figure 3. Effect of storage temperature on albumen quality.
(-▫-): room temperature (Group-D),
(-■-): refrigeration temperature (Group-E).

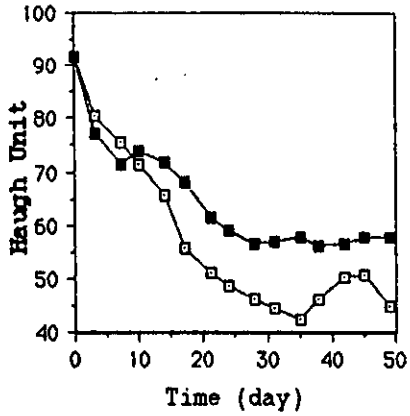

Figure 4. Effect of the age of the egg at time of processing
(-▫-): One day old (Group-N),
(-■-): Seven days old (Group-M).

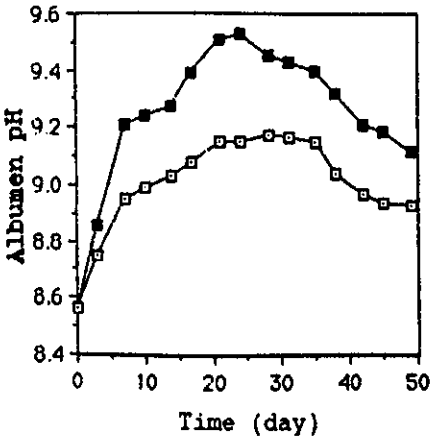

Figure 5. Changes in albumen pH during storage.
(-▫-): One day old (Group-N),
(-■-): Seven days old (Group-M).

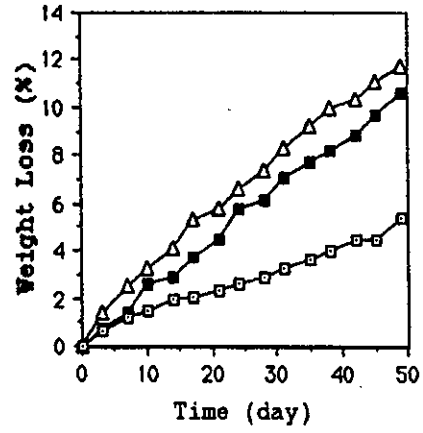

Figure 6. Weight loss of shell-eggs as affected by storage temperature and heat treatment.
(-■-): Control (Group-A),
(-△-): Room temperature (Group-D),
(-▫-): Refrigeration temperature (Group-E).

Effect of process temperature:

Keeping the process time constant, eggs were subjected to two different process temperatures for each one of the heating periods of 2,3,5,10,15,20 and 30 minutes. At higher temperatures better Haugh unit values and significant improvement in egg white quality were observed (Figure 1). Many investigators related this result to the nature of egg white lysozyme. COTTERILL (1955) and FEENEY (1955) suggested that the thinning of thick white may be due to the action of lysozyme on ovomucin, and the beneficial effect of thermostabilization is due to alteration of lysozyme activity during heat treatment. This alteration may result in higher quality characteristics in thermostabilized eggs. Therofore, as the process temperature increased amount of active lysozyme might be decreased to an extend which leads to retention of initial quality.

Effect of process time:

Keeping the process temperature constant, eggs were subjected to two different heating periods for each one of the process temperatures of 50, 54, 58, 62, 65 and 69°C. With the same reasoning of the previous case, when the process time increased the better Haugh unit values were observed (Figure 2). Exposure of eggs to heat for longer period of times may lead to better inactivation of lysozyme and thus higher albumen quality.

Effect of storage temperature:

Use of low temperatures is the primary and the most common method of egg preservation. The role of low temperature in retaining interior quality in shell eggs is mostly related to the increased solubility of carbon dioxide at that temperatures. Refrigeration also retards evaporation and drying of cutide; thus, less carbon dioxide and moisture are lost from the albumen; the pH increase is inhibited, which in turn prevents albumen liquefaction (HEATH, 1977).

In the eggs stored at refrigeration temperatures interior quality factors were protected better than the groups stored at room temperature (Figure 3). With respect to keeping quality both thermostabilized and untreated eggs held at refrigerated storage temperature for short-times came out of storage with approximately the same albumen condition as when stored at room temperature. Due to the excellent effect of low storage temperatures on keeping quality of eggs, it can be concluded that it is not practical to thermostabilize the eggs if they would be stored at refrigeration temperatures because of excessive energy costs.

Effect of the age of the egg at the time of thermostabilization:

To study the influence of the age of egg at the time of thermostabilization on the quality of white, the temperature of 65°C for 3 minutes were selected arbitrarily as process conditions. One group was seven days old while the other was one day old when thermostabilized. Each group was examined in the same manner with other treatment groups for interior quality factors. The usual improvement in quality was observed in both ages compared to control group, however, a greater improvement in interior quality occurred in seven days old eggs (Figure 4). Haugh unit of seven days old eggs were significantly better ($p<5$).

Above results are probably due to the pH of the white at the time of processing. COTTERILL (1955) stated that the egg white has an initial pH of about 9.5 upon ageing.

In this study, retention of albumen quality in the older eggs, which have the higher pH values (Figure 5), agrees with the observations of other investigators (MEYER, 1973) that lysozyme is less stable when alkaline conditions prevail. This emphasizes the importance of using different thermostabilization conditions for relatively fresh eggs as contrasted with older eggs, the latter group being more heat sensitive.

Changes in albumen quality:

A greater retention of thick white, as shown by higher Haugh unit values (Table 3), in stabilized eggs during storage than in untreated eggs were observed. Moreover, it was noted that in general the thick white remaining in the untreated eggs was of poorer quality than that remaining in the stabilized eggs. The white in the control eggs spread over a greater area, thus lower in height, and was of poorer consistency.

The effect of heat processing on albumen index (Table 2) shows the extend to which thermostabilization keeps the quality characteristics of the eggs. Increase in viscosity of the albumen of thermostabilized eggs, which was even readily apparent to the eye, was obvious when these eggs were compared with the untreated controls. However, in the absence of untreated controls, one might not be aware of the difference in viscosity of eggs stabilized at the lower temperatures. In many of the eggs processed at temperatures higher than 62°C there were gelatinous masses, a rough appearance, and opalesoence which would be evident even to the casual observer. In some of the eggs, the albumen that was adjacent to the shell was quite opaque. These results indicated that the time interval for heat treatment at temperatures above 62°C is extremely critical and an increase in opacity in the albumen adjancent to the shell was observed with a very slight increase in time of immersion. During the experiments, the groups proessed at 58°C for 15 minutes, and at 62°C for 10 minutes, which is even better than the former, were the best in terms of almost all interior quality factors studied. Since the eggs treated for 15 minutes at 58°C were the samples entirely free of any visible evidences of coagulation, treatment at 58°C for 15 min was found to be the best from this stand point.

Changes in yolk quality:

According to experimental results thermostabilization had almost no effect on yolk quality. In terms of yolk indices there was no significant difference between almost all groups stored at room temperature. Only the refrigerated groups showed better retention of yolk index values as well as other quality factors during storage (Table 4).

Weight loss:

Studies were done to determine the relative protection against moisture loss by the various treatments. Although there was no significant difference ($p<5$) between the thermostabilized and control groups stored at room temperature (Table 5), slightly poorer results with thermostabilized eggs may have been associated with the removal of cuticle during the shell treatment. Storage under refrigeration resulted in a 50-51% less weight loss than the groups stored at room temperature (Figure 6).

Liquid egg yield:

In all of the thermostabilized eggs, the heat treatment caused the albumen nearest the shell to gel slightly which made it tend to cling to the shell. In this study, yields of albumen from thermostabilized eggs were considerably lower than that from control group with a noticeable decrease in yield as the temperature of processing was raised from 50°C to 69°C. The great increase in the amount of egg white adhering to the shell of eggs processed at 65 and 69°C was readily apparent to the eye.

For the groups processed above 65°C, during the breaking of the eggs, it seemed obvious to us that the consumer would have had to remove mechanically the adhering egg white from the thermostabilized eggs because it would not come out by the usual method of inverting the shell. However, there was no such problems in groups treated below 62°C. Although there are no supporting data, it was observed that during breaking and separation of the eggs a special caution was necessary to avoid breaking the yolks of thermostabilized eggs.

Broken out appearence:

Although the data on indices of heat treated eggs indicated that storage had a slight effect on albumen, during the broken out examination of the eggs it was noticed that a definite retention in the amount of thin white had occurred during storage. The thermostabilized eggs usually had a larger amount of thick white, whereas the untreated eggs had a small amount of thick white and most of the egg white was thin and spread over a large area.

Broken out appearance of the processed eggs is very important as far as the consumer acceptance is concerned. During the experiments it was observed that a 10 minutes exposure at temperature of 62°C, or above, produced a progressive bluish opalescence or milky appearance and a marked thickening of the albumen. The lower temperatures produced viscous egg white without altering the darity. This showed that a temperature of 58°C was the upper limit that could be used without resulting in a condition that would influence the acceptability of the eggs in market channels.

Besides various beneficial effects, as described previously, thermostabilization may also have some negative effects on albumen quality. HARD (1963) have reported a lowered beating volume, leavening power and whipping quality of egg white from shell eggs heated to 60°C which they attributed to a partial coagulation of albumen during processing. Indications that some of the functional properties altered by this treatment led to a need for further studies of the functional properties.

In view of the above results that thermostabilization influences the rate of egg white deterioration, and the indication that this process might affect the causative agent or mechanism responsible for egg white thinning, the effects of thermostabilization on one of theoretical mechanisms of egg white deterioration should be studied in more detail.

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