SOME FACTORS AFFECTING GELATION OF FROZEN EGG YOLK[a, b]

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Freezing at temperature below -6° C (21°F) produces irreversible physico- chemical changes (gelation) in egg yolk. Colloid milling of yolk inhibited gelation to a large extent. None of the many chemical substances examined inhibited gelotion and produced a yolk of normal flavor. Very quick freezing combined with rapid thawing had a pronounced gelation inhibiting effect. Frozen shell eggs that were defrosted by dielectric heating did not thaw uniformly.

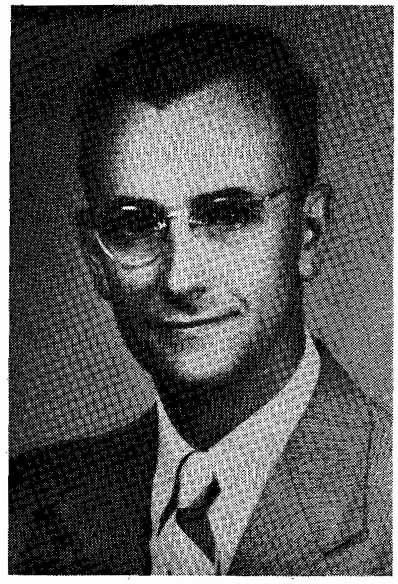
Introduction

Freezing shell eggs in such a way that they would retain their fresh egg characteristics after thawing and cooking would offer many advantages for civilian and military uses. The quality of the eggs would remain substantially constant during long storage periods. It would also be advantageous to be able to freeze egg yolk without changes in quality caused by the freezing process, and without changes in flavor due to substances added to avoid the loss of its normal appearance when thawed. The fundamental mechanisms of the physico-chemical changes (gelation) which take place in egg yolk upon freezing at a temperature below –6° C (21° F) have received only scant attention. This report describes the effect of several different treatments of egg yolk upon gelation.

Review of Literature on Freezing of Shell Eggs, Egg Yolk, and Egg White

Egg yolk has an average freezing point of –0.65° C (30.8° F), while the albumen has a freezing point of –0.45° C (31.2° F). According to Moran[7], whole eggs may be cooled somewhat below these temperatures without actual freezing of the contents. The changes that take place in egg white as a result of freezing are much less pronounced than the changes that occur in the yolk. At all temperatures of freezing, there is an increase in the proportion of the liquid portion with a corresponding decrease in the viscous portion. This increase is controlled by the minimum temperature reached during the freezing process, the lower the temperature, the larger the increase. When yolk is frozen between the limits –0.65° C (30.8° F) and –6° C (21.2° F) normal fluidity is regained on thawing. If, however, the temperature is carried below –6° C and the yolk kept at the lower temperature for a short time, the yolk on thawing becomes a paste, like putty. Yolks have been supercooled as low as –11° C (12.2° F) for 7 days without the yolks changing to the pasty state. When egg yolks are frozen in liquid air, upon thawing they pass into the pasty state; but if thawed rapidly in mercury at 30° C (86° F) they completely regain normal fluidity. Therefore, the irreversible yolk changes may be produced either in the freezing or in the thawing process. Even at the temperature of liquid air (–190° C) (–310° F) egg yolk requires an appreciable time to change over into the irreversible condition. At – 11° C (12.2° F) it was shown that a period of not less than 20 hours is required.

Thomas and Bailey[12] showed that in pure egg magma (mixed whites and yolks) the degree of gelation (pastyness) is a function of the mechanical treatment of the magma prior to freezing. Colloid-milled specimens showed practically no gelation. Sodium chloride, sucrose, and dextrose lowered the degree of gelation of the whole egg magma. The maximum degree of gelation is reached in 60 to 120 days of storage at – 21 to –18° C (–5.8 to 0° F).



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Quick freezing yields a better egg product than delayed slow freezing according to Swenson and Thomas[11]. Carbonation of the egg batter before freezing improves the quality of the egg on thawing. The combined use of 10 percent salt and quick freezing is effective.

Pasty yolks which have been frozen quickly in liquid air are firmer in texture, after thawing, than yolks that have been frozen slowly. (Quoted by Romanoff and Romanoff[9]), Tongur and Ragosin[13] showed that alteration of the colloid state can be avoided by homogenizing the egg mixture with a milk homogenizer. A patent on the use of pancreatin and other enzymes for inhibiting gelation of yolk upon

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TABLE 1—EFFECT OF CHANGE OF pH UPON GELATION OF YOLK[1]

Yolk sample	pH after addition of acid or alkali	Relative Viscosity[2]		Degree of Gelation[3]
		Before freezing	After Thawing	
Fresh (control) pH 6.2	Not added	0.1	Over 100	High
Test 1 (NaOH added)	6.6	0.2	Over 100	High
Test 2 (NaOH added)	7.0	1.2	Over 100	High
Test 3 (H_2SO_4 added)	5.1	3.7	Over 100	High
Test 4 (H_2SO_4 added)	4.6	5.0	Over 100	High
Test 5 (H_2SO_4 added)	3.2	Over 100	Over 100	High

[1]All the values are the mean of three replications
[2]Measured with a Brookfield Viscometer
[3]Observed organoleptically

freezing was granted to Tressler[14] in 1932. Schaible and Card[10] described a procedure for producing frozen eggs for home use. The procedure consists essentially in placing individual mixed yolks and whites in rectangular shaped containers, freezing, and packaging the resulting blocks in water vapor-proof film. In this publication, no reference is made to gelation of yolks, or to any change produced by freezing.

Kaloyereas[5] patented a method by which eggs can be frozen in the shell without cracking or breaking of the shell during the freezing operation. This is accomplished by removing 5 - 10 percent water from the shell eggs either by placing them *in vacuo* or over some strong dehydrating agent. The egg yolk, however, has a waxy consistency.

Urbain and Miller[15] state that the physical character of the yolk portion is altered on freezing due to the separation and coagulation of lecithin. Gelation is prevented by adding 10 percent by weight of dextrose or levulose. Sucrose is not nearly so effective. None of the sugars form permanent combinations with the yolk while freezing.

It has been found by Colmer[2] that *Bacillus cereus* and related species produce a hardening of the yolk when the yolk of fresh shell eggs is inoculated with one of these species, and incubated at 37° C (98.6° F). The explanation given is that the lecithoprotein of yolk is broken down by the action of the lecithinase produced by these bacteria on the lecithin. With the loss of the binder action of the lecithin, the fat and protein change from their dispersed state to that found after the bacteria have grown in the egg.

Jordan *et al.*[4] found that when egg yolks and whole egg magma, treated with salt, sugar, or white corn syrup were frozen and stored at −18° C (0° F) they retained to a high degree the functional properties necessary for satisfactory performance in plain cakes and custards. On the other hand, frozen untreated yolks were unsatisfactory.

TABLE 2—EFFECT OF COLLOID MILLING OF YOLK UPON ITS GELATION[1]

Yolk sample No.	Mill clearance (inches)	Viscosity[2]			Degree of gelation
		Before milling	After milling before freezing	After freezing	
1	.003[3]	4.5	6.0	8.0	Very low
2	.003	3.2	3.7	9.1	Low
3	.003	4.5	3.5	9.3	Low
4	.020	3.2	3.8	17.3	Medium
5	.020	3.1	3.7	16.1	Medium
6	.040	3.2	5.2	14.6	Medium
7	.040	7.0	3.8	15.4	Medium
8	.060	5.5	3.1	14.5	Medium
9	.060	3.0	1.5	14.9	Medium
10	.083	3.7	2.5	18.7	Medium
11	.083	3.0	2.0	19.8	Medium
Control[4]	......	3.3	....	Over 100	High

[1]All the values are the mean of three replications
[2]A Brookfield viscometer was used
[3]Run three times through the .003″ clearance
[4]The control was not colloid milled

EXPERIMENTAL PROCEDURES AND RESULTS

The eggs used in these experiments were strictly fresh eggs from mixed breeds from the University flocks. Since many of the experiments here reported led to negative results, only limited data are included.

1. *Effect of Freezing upon the pH of Egg Yolk*

The pH of 12 individual fresh yolks was determined, then the yolks were sealed in polyethylene bags, and maintained at −18° C (0° F) for 72 hours. After defrosting by immersing the bags in water at 50° C (122° F), the pH values were again determined. The mean pH value of the fresh yolks was found to be 6.16, and that of the frozen thawed yolks, 6.19. Therefore, freezing did not significantly affect the pH of fresh egg yolk.

2. *Effect of Change of pH upon the Gelation of Yolk*

Sulfuric acid (4 N) was added to fresh mixed yolk that had a pH of 6.20, and the pH of different samples modified to different values. Using a Brookfield viscometer the relative viscosity of each sample was determined before and after the addition of sulfuric acid. The samples were placed in polyethylene bags, frozen at −18° C (0° F) and kept frozen for 72 hours. They were thawed by immersion in water at 50° C (122° F), and their relative viscosity was again determined. A similar experiment was run using 0.214 N sodium hydroxide. The results are presented in Table 1. The degree of gelation was high in all cases. The reversibility of the change produced in yolk by the addition of sulfuric acid was also studied. To fresh yolk (pH 6.2) 4-normal sulfuric acid was added until its pH was 3.2 and mixed well. The resultant mass was sticky and of high viscosity, having a relative viscosity value of over 100 on the Brookfield viscometer. Then, 0.214 N NaOH was added to the yolk until its pH was brought to the original value of 6.2. It was observed that the yolk became even more viscous and stringy. Thus, the reaction was found to be non-reversible.

3. *Effect of Cooking before Freezing upon the Onset of Gelation in Mixed Yolk and in Shell Eggs.*

Fifteen-gram samples of mixed yolk packaged in polyethylene bags, and shell eggs were immersed in water at 55° C (131° F) and at 100° C (212° F) for different lengths of time (5 seconds to 120 seconds). They were then frozen at –18° C (0° F) and kept frozen for four days at the same temperature. The samples were thawed by immersion in water at 50° C (122° F). A high degree of gelation was observed in all samples.

4. *Effect of Different Degrees of Dilution and of Dehydration of Yolk upon Its Gelation.*

Samples of fresh yolk material were dehydrated in vacuum oven at 50° C until different samples had lost 5, 10, and 15 percent of their weight. Other samples were diluted with different amounts of water (10, 25, 40, 70, and 100 percent). Viscosity readings were taken before freezing them and storing them in a freezer at –18° C for 4 days, and after thawing by exposure to air at 23° C (73°F). Gelation of yolks was not prevented by dilution or concentration. All samples showed a high degree of gelation except the 70 and 100 percent dilution samples, which were liquid probably due to the degree of dispersion of the yolk particles.

5. *Effect of Colloid Milling of Fresh Yolk upon Its Gelation.*

In the literature there are references to the colloid milling of whole egg material previous to freezing it, but the effect of colloid milling upon the onset of gelation in yolk material has not been reported.

TABLE 3—EFFECT OF COLLOID MILLING OF FRESH YOLK MATERIAL CONTAINING SODIUM CHLORIDE UPON ITS GELATION

Sample Number	NaCl percent	Viscosity[1]			Degree of gelation
		Before milling	After milling	After freezing	
A-1	0.2	3.0	3.5	Over 100	High
A-2	0.2	3.0	Not milled	Over 100	High
B-1	0.5	3.5	8.0	Over 100	High
B-2	0.5	3.5	Not milled	Over 100	High
C-1	0.8	5.6	7.4	100	High
C-2	0.8	5.6	Not milled	85	High
D-1	1.0	8.0	10.0	73	High
D-2	1.0	8.0	Not milled	58.5	High
E-1	1.5	10.0	10.0	65.0	High
E-2	1.5	10.0	Not milled	38.0	Medium
F-1	2.0	13.0	16.0	Over 100	High
F-2	2.0	13.0	Not milled	73	Medium
G-1	5.0	17.0	29.0	84	High
G-2	5.0	17.0	Not milled	35	Medium
H-1	10.0	56.0	84.0	Over 100	High
H-2	10.0	56.0	Not milled	16.5	Low
Untreated	0	5.2	....	....	High

[1]Clearance of mill in all cases was 0.003 inch. All the values are the mean of three replications.

The following procedure was followed. Well mixed 500-gram portions of yolk were prepared and their relative viscosities determined. They were run through different clearances of a colloid mill. The clearances (distance between the rotor and the stator of the mill) ranged between 0.083 and 0.003 inch. The samples were then placed in glass jars and frozen at–18° C in a freezer provided with air circulation. The samples were held for three days. They were thawed by letting them stand overnight at 4° C (40° F). Their relative viscosity was again determined and the degree of gelation of the samples was visually observed. It was found that colloid milling decreases the degree of gelation of frozen yolk; the smaller the clearance of the mill, the less the gelation. The best sample was the one which was passed consecutively three times through the smallest clearance (0.003 inch). This sample was found to be a thick liquid, somewhat more viscous than free untreated yolk material. That is, it had experienced a low degree of gelation. Its consistency was about

TABLE 4—GELATION INHIBITING PROPERTIES OF SOME SUGARS

Sugar	Percent added to yolk	Degree of gelation[1]	Flavor	Color and odor
Arabinose	5	Medium	Too sweet	Normal
Arabinose	10	None	Too sweet	Normal
Galactose	5	Medium	Too sweet	Normal
Galactose	10	None	Too sweet	Normal
Cellobiose	10	High	(2)	(2)
Lactose	10	High	(2)	(2)
Maltose	10	High	(2)	(2)
Raffinose	3	High	(2)	(2)
Raffinose	10	High	(2)	(2)
Sucrose	3	High	Too sweet	Normal
Sucrose	10	Low	Too sweet	Normal
Dextrose	3	Medium	Too sweet	Normal
Dextrose	10	Low	Too sweet	Normal

[1]Determined organoleptically
[2]Flavor, odor and color not recorded because of high degree of gelation produced

the same as that of yolk treated with 10 percent sucrose or 5 percent salt prior to freezing. The frozen, untreated control was a plastic solid; that is, its degree of gelation was high. The experimental data are presented in Table 2.

The least gelled colloid milled egg yolk sample was fried in Crisco, and compared in panel acceptance tests with fried fresh, untreated yolk. The flavor, color, and texture of the colloid milled sample were very similar to those of fresh yolk. No off flavor was detected in the colloid milled sample. The untreated gelled yolk was also fried. Its texture was rubbery and its color bleached as compared with the fried fresh, untreated yolk. The flavor was flat, i.e., it lacked egg flavor, although no off-flavor was detected. This colloid milled product possesses the advantage of having neither a sweet nor a salty flavor. Such a product has market possibilities.

6. *Effect of Colloid Milling of Fresh Yolk Material Containing Sodium Chloride upon Its Gelation*

The method followed was the same as that described in Section 5 with the difference that the clearance of the colloid mill was kept at 0.003 inch for all samples, and that all the samples, except the control, contained sodium chloride in concentrations varying from 0.2 to 10.0 percent in different samples.

The results are presented in Table 3. They show that the degree of gelation of frozen colloid milled yolk containing sodium chloride was higher than that of frozen non-milled yolk containing the same concentration of salt. It was also observed that the addition of sodium chloride to fresh, untreated yolk up to 0.5 percent had the effect of decreasing its viscosity, and that a concentration of salt of 0.8 percent or higher, increased the viscosity of the fresh yolk material.

7. *Effect of Dilution of Fresh Yolk Material Previous to Colloid Milling*

Mixed yolks were diluted with 5 and with 15 percent of water, then colloid milled and frozen. The milling and freezing methods were the same as followed in Section 6. After thawing overnight at 4° C (40° F), all test samples showed a high degree of gelation, as high as an untreated control.

8. *Colloid Milling and Freezing of Yolk Material That Had Already Suffered Gelation.*

Fresh, untreated mixed yolks were frozen at –18° C (0° F), thawed overnight at 4° C (40° F) and were found highly gelled, as normally occurs under these conditions. This gelled yolk material was mixed in a Waring blendor with 10 percent added water. It then became fluid. Different samples of this fluid were colloid milled through 0.003, 0.040, and 0.083 inch clearances respectively, placed in glass jars which were taken to a freezing room, and held at –18° C (0° F). They were kept for five days, and thawed by leaving overnight at 4° C (40° F). All samples again showed a high degree of gelation.

9. *Effect of Stability of Emulsion upon the Properties of Frozen Yolk*

The purpose of this phase of the work was to study the effect of added emulsion stabilizers and destabilizers upon the onset of gelation in frozen-thawed yolk. Several different substances were used in an attempt to increase the stability of the yolk emulsion. The substances used, and their concentration in yolk, were the following: Glyceryl monolaurate, 0.5 and 3.0 percent; glyceryl monoleate, 0.5 and 3.0 percent; soluble starch, 1.0 percent; Irish moss extract, 0.25 percent; the compounds known commercially[d] as Aldo 28, 0.5 and 3.0 percent; Aldo 25, 0.5 and 3.0 percent; and Peg 42, 0.2 and 1.0 percent. Calcium chloride, 0.5 and 3.0 percent, and a water-in-oil emulsifier, Aldo 33, 0.5 percent, were used to attempt to break the emulsion or make it less stable.

The following experimental procedure was followed: The compound to be used was dispersed or dissolved in a small amount of water when necessary, and mixed with yolk in a definite proportion by means of a Waring blendor. The amount of yolk treated was divided in two portions, one of which was run through a colloid mill with a clearance between rotor and stator of 0.003 inch, then frozen at 0° F in a freezer with air circulation. The other portion, which was not run through the mill was used as a control. Another control sample was made up of untreated fresh yolk and was frozen together with the other samples. After six days of frozen storage all samples were thawed by leaving them at 4° C (40° F) overnight.

The criteria for ascertaining the results were based on determinations of relative viscosity of the frozen-thawed samples and in organoleptic observations of the onset of gelation.

Under the conditions of these experiments, the samples and controls showed approximately the same high degree of gelation. None of the substances tested had any influence in decreasing the degree of yolk gelation.

10. *Testing of Gelation Inhibiting Properties of Several Substances*

The following substances, in the concentrations indicated, are used commercially for inhibiting the gelation of yolk material or of egg magma (mixed yolk and albumen): sucrose, up to 10 percent; sodium chloride, up to 10 percent; glycerol, up to 5 percent; dextrose, up to 10 percent and levulose, up to 10 percent. Yolks and egg magma so treated possess good qualities for use in the baking, candy, and mayonnaise industries, but their sweet or salty flavor makes them unsuitable for other purposes. The inhibiting properties of other substances were investigated as follows:

A) *Trisodium citrate.* Trisodium citrate prevents coagulation of blood. In three experiments, 3 percent sodium citrate in yolk prevented its gelation, but imparted to the yolks a strong citrate flavor. Yolks with one percent sodium citrate gelled and also had some citrate flavor.

B) *Sequestrene Na_3*[e]. In order to ascertain whether metallic ions have direct influence upon the gelation of yolk, a chelating agent was tested. Sequestrene Na_3 (trisodium ethylenediaminetetracetate) was used in concentrations of 0.05, 0.2 and 1.0 percent. The results show that Sequestrene Na_3 under the conditions of the experiment did not prevent the gelation of yolk.

C) *Sugars.* Since there are some sugars that prevent the onset of gelation in frozen yolk, it was decided to determine whether other sugars would also inhibit gelation. Some pentoses, monosaccharides, disaccharides and trisaccharides were tested. Sugars with most neutral flavor were selected. Sucrose was used as a control. The frozen storage period was 7 days. The experimental data are presented in Table 4. The results show that only arabinose, a pentose, and galactose, a monosaccharide, inhibited gelation. These two sugars, in the concentrations in which they were found effective, also give an objectionable sweet flavor to yolk.

Mixed yolks treated with either 10 percent arabinose or 10 percent galactose after a frozen storage period of 7 days had a lower viscosity than yolk material treated with either dextrose or sucrose. Because of the higher cost of arabinose and galactose, as compared with sucrose and dextrose, these results have little commercial significance at present. However, the fact that other sugars did not inhibit gelation appears to disprove the theory that sucrose, glucose, and levulose are effective in inhibiting gelation because they lower the freezing point of water present in yolk. If this were the case, cellobiose, lactose, and maltose should also have inhibited the gelation of yolk. No common physical or chemical property among the sugars that inhibit gelation, or among those that do not inhibit gelation, has been found which could be offered as an explanation of their behavior. The best we can do at present is to suggest that some sugars "protect" egg yolk constituents against gelation caused by freezing.

D) *Miscellaneous substances.*

The following substances, in the concentrations indicated were tested: mannitol 3.0 and 10.0 percent; dextrin, 2.0 percent; ethylene glycol, 2.0, 4.0, 6.0, 8.0, and 10.0 percent; propylene glycol, 5.0, and 10.0 percent; ethyl ether, 2.0 percent; ethyl alcohol, 5.0 percent; sodium gluconate, 10.0 percent; galacturonic acid, 10.0 percent; inositol, 10.0 percent; choline chloride, 0.5 percent; sorbitol, 10.0 percent; potassium chloride, 1.0 percent; potassium dihydrogen phosphate, 1.5 percent; monosodium glutamate, 1.0 percent; pectin, 0.25, 0.50, and 1.0 percent; gum tragacanth, 2.0 percent; gum arabic, 2.0 percent; gum Karaya, 2.0 percent; ascorbic acid, 0.2 percent; potassium permanganate, 0.1 percent; potassium metabisulfite, 0.1 percent. sodium chloride, 1.0, 1.5, 2.5, 3.0, and 4.0 percent. and glycerol, 10.0 percent, were used as controls.

Of the substances named above, ethylene glycol and propylene glycol, both at the 10.0 percent level, inhibited gelation, but the yolk had a marked sweet flavor. Sorbitol (10.0 percent), partially inhibited gelation, but the yolk had an off-flavor. Sodium chloride at 4.0 percent inhibited gelation completely, and at 3.0, 2.5 and 1.5 percent, the inhibition was partial, and directly proportional to salt concentration. Glycerol, at 10.0 percent concentration inhibited gelation completely. None of the other substances was effective in inhibiting gelation totally or partially.

11. *Freezing of Yolks and of Mixed Yolk Material in Solid Carbon Dioxide-Acetone Mixture and in Liquid Nitrogen*

A) Ten yolks from fresh shell eggs were carefully separated, unbroken, from the whites. They were dipped in the freezing acetone-CO_2 mixture, (temperature approximately –70° C, –94° F). In all cases the vitelline membrane of these yolks broke during the freezing operation. For thawing, they were allowed to stand at room temperature (24° C, 75° F). All these yolks were gelled to a high degree.

B) Each of ten polyethylene bags was filled with 15 grams of fresh mixed yolk. The thickness of the yolk in the bags was of approximately one-fourth inch. Then, they were frozen in acetone-dry ice mixture and thawed by immersion in water at 54° C (130° F). The degree of gelation of the yolk varied from low to very low; that is, the yolk had a somewhat higher viscosity than fresh yolk, but it was a flowing liquid. The degree of gelation of yolk was high when similar bags were frozen in acetone-dry ice as before, but thawed slowly by leaving them at room temperature, or when frozen at a slower rate in air at –18° C (0° F) and quickly thawed in water at 54° C.

C) Experiments were performed using liquid nitrogen as a freezing medium. Twenty polyethylene bags were filled with 15 grams of fresh mixed yolk and heat sealed. Ten of them were dipped in liquid nitrogen for two minutes. Together with the ten untreated bags, they were immediately transferred to a freezer maintained at –18° C. After 7 days, five of the nitrogen frozen bags and five untreated bags were thawed by immersion in water at 54° C (130° F). Five nitrogen frozen bags and five untreated bags were thawed by leaving them at room temperature. Results showed a very low degree of gelation in all samples frozen in nitrogen and thawed in water at 54° C. The degree of gelation was medium in samples frozen in nitrogen and thawed by leaving them at room temperature. All samples that were frozen in freezer at –18° C showed a high degree of gelation.

The experiments using an acetone-dry ice freezing medium, and those using liquid nitrogen, confirm Moran's results[7] on the beneficial effects of very rapid freezing and thawing, upon gelation. In the work reported herein it was also observed that both quicker freezing and quicker thawing, independently, decrease the degree of gelation of frozen yolk, and that faster freezing and faster thawing, when combined, are more effective than either of these two variables independently.

12. *Preliminary Experiments on the Effect of Sonic and of Supersonic Vibrations upon Gelation in Shell Eggs*

Fresh shell eggs were exposed to sonic and to supersonic vibrations under the following conditions: 10,000 cycles per second for 1 minute; 10,000 cycles per second for 3 minutes; 10,000 cycles per second for 5 minutes; 27,000 cycles per second for 1 minute; 27,000 cycles per second for 3 minutes; 27,000 cycles per second for 10 minutes; 1,000,000 cycles per second for 1 minute; 1,000,000 cycles per second for 5 minutes; 1,000,000 cycles per second for 10 minutes. Five fresh shell eggs were exposed to each set of conditions. The eggs, one at a time, were suspended in water, through which medium the vibrations were transmitted to the eggs. Immediately after they were frozen by surrounding them with dry ice. They were held in this condition for three hours, afterwards being placed in a freezer maintained at −18° C. After 3 days they were thawed by letting them stand at room temperature. A high degree of gelation was observed in all samples.

13. *Preliminary Experiments on Thawing of Frozen Eggs by Dielectric Heating*

Ten fresh shell eggs were frozen by dipping in liquid nitrogen and stored at −18° C for 7 days. While still in the frozen condition, they were dielectrically heated, one egg at a time. It was observed in all samples that, under the conditions of the experiment, the heat concentrated at a few points or spots in the egg yolk and albumen, with the effect of thawing and heating only those points to the temperature of coagulation of the proteins before the rest of the yolk and albumen had thawed. It was not possible to defrost uniformly the frozen shell eggs. After thawing completely by letting them stand at room temperature, the portions that had not coagulated by heat showed a high degree of gelation. This phenomenon of unequal heat distribution is characteristic of the dielectric heating of many substances. Should the proper dielectric heating conditions be found, it is thought that shell eggs quickly frozen by immersion in a very low temperature liquid freezing medium, and rapidly and uniformly thawed by dielectric heating, would gel to a very low degree. This very low degree of gelation might not significantly affect the consumer acceptability, or it might open to frozen shell eggs or to frozen yolks certain markets now closed to sugar, salt, or glycerine yolks.

SUMMARY

Freezing and frozen storage did not significantly affect the pH of fresh egg yolk. Changing the pH of yolks, cooking yolks for different lengths of time at different temperatures, and diluting and dehydrating yolks previous to freezing did not inhibit gelation.

Under certain conditions the colloid milling of yolks before freezing inhibited gelation to a large extent. The flavor, color, and texture of the cooked, colloid milled yolk were very similar to those of cooked, fresh yolk. The addition of sodium chloride to yolk previous to colloid milling, freezing, and frozen storage, produced yolk with a higher degree of gelation as compared with colloid milled samples with no added sodium chloride.

The use of emulsion stabilizers and destabilizers had no effect on inhibiting gelation totally or partially, either with or without the use of colloid milling treatments. The gelation inhibiting properties of a number of chemical substances was tested. Not one of the many chemical substances examined, inhibited gelation and produced a yolk of normal flavor. While sugar, salt, and glycerol were effective in partially preventing gelation, the flavor was markedly affected.

Very quick freezing of shell eggs and of egg yolk by immersion in dry ice-acetone mixture and in liquid nitrogen partially inhibited gelation. The more rapid the rate of freezing, the lower the degree of gelation of yolk. Very quick freezing combined with rapid thawing had a more pronounced effect of inhibition. Further research is needed on quick freezing combined with rapid defrosting of shell eggs and yolks.

In preliminary experiments, shell eggs subjected to sonic and to supersonic vibrations, previous to freezing and frozen storage, showed a high degree of gelation upon thawing.

When frozen shell eggs were defrosted by dielectric heating, the eggs did not thaw uniformly; a part of the contents was coagulated by the heat, and the rest was found highly gelled.

Chemical and enzymic studies on yolk gelation are in progress.

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[d]Manufactured by Glyco Products Co., Inc., Brooklyn 1, N.Y.

[e]Manufactured by Alrose Chemical Co., Providence 1, R.I.

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BALTIMORE HEALTH DEPARTMENT REQUIRES BRUCELLOSIS-FREE MILKING HERDS

The City of Baltimore, Md., on July 7, 1954, adopted a new dairy farm regulation requiring that all cows supplying milk for the city be tested for, and certified to be free from, brucellosis. This same requirement is now in force for all of Maryland, as required by the Maryland State Board of Agriculture, the Maryland State Board of Health, and the Maryland Cooperative Producers', Inc. All brucellosis testing of the herds must be completed by January 1, 1956, the date on which this regulation will take effect.