

SOME FACTORS AFFECTING THE QUALITY OF  
A YELLOW ANGEL FOOD CAKE

by

EVA ELIZABETH LISK

B. S., Kansas State College  
of Agriculture and Applied Science, 1933

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## INTRODUCTION

The purpose of this investigation was to study the factors affecting the quality of a yellow angel food cake. As the result of the experiment, the investigator hoped to develop a recipe for a cake of good eating quality made by using only the yolks of the eggs.

## REVIEW OF LITERATURE

A study of available literature revealed no recorded studies on yellow angel food cake made by using only the yolks of eggs. Some literature was found on sponge cakes and angel food cakes.

According to Lowe (1937), sponge cake like angel cake depends chiefly upon the extent of whipping the egg whites, the mixing, and good proportions to produce a tender cake.

Lowe continues by saying that probably the most common fault in making sponge cake is the insufficient beating of egg yolks and sugar. These two ingredients, plus the liquid, if water or lemon juice is used may be beaten until they are extremely light and foamy. This is successfully

done by rapid beating, preferably with an electrically operated beater or a rotary beater rather than with a whisk. Excellent sponge cakes may be made from egg yolks only provided some water is added and the yolks and sugar are beaten rapidly until light. When flour is mixed too long with the sugar and egg yolks, the cake is more compact and tough. But in some types of sponge cake in which considerable water is added, it is often necessary to fold the flour and egg yolk a long time to obtain a cake with thin cell walls and a uniform texture. This can be interpreted to mean that for each recipe in which the proportion of ingredients varies from those in another recipe, the amount and kind of manipulation to produce a cake of best texture vary.

Halliday and Noble (1928) state that the chief difficulty in making angel food and sponge cake is to get the whites well mixed with the other ingredients without at the same time stirring out the air in the beaten whites. It is the expansion of air which makes the cake light; hence, if air is lost, the cake will be compact and heavy. On the other hand, if the egg whites are not well mixed with the other ingredients, the cake will have a coarse and uneven texture. The knack here consists in being able

to do much mixing with gentle movements. Reed (1931) found in her study that two minutes of folding after all the ingredients had been added improved the texture and grain of the angel food cake.

Lowe reports that sponge cake made from egg yolks only is more desirable when baked at 350° F. than 325° F. But she concludes by saying that it is likely most sponge cakes should be baked at the same temperature as angel cakes.

Clayton (1928) in referring to egg yolks, says that the effect of rise in temperatures is in general to make emulsification easier. Reduction of viscosity is obviously a factor concerned. The main interest, however, lies in the relation of temperature to the interfacial tension and the absorption of the emulsifier at the interface. With an emulsifying agent soluble in one liquid, change of solubility with temperature may introduce complications. Unfortunately, so little data are available in this field that any emulsion problem must be dealt with as a special case. Where egg albumin or egg yolk is used as an emulsifying agent, the temperature factor is, of course, of first importance, as the heat-coagulated forms undoubtedly differ in emulsifying efficiency from the raw colloids.

The principal protein of the egg yolk is ovovitellin. Lowe (1937) states that no record of the isoelectric point of ovovitellin could be found in literature. When lemon juice is added to egg yolk, the mixture is thickest at a pH between 4 and 5. This greatest thickening occurs with about 5 cc. of lemon juice to an egg yolk.

The addition of an acid like vinegar or fruit juice to the white and yolk beaten together tends to curdle the mixture. This occurs when the acidity is in the vicinity of the isoelectric point. When sufficient acid is added to lower the pH below the isoelectric point of the egg protein, and when the salt formed, such as protein citrate, is soluble, the coagulum dissolves and the mixture becomes smooth. With the exception of salad dressings and a few sauces, there are probably not many instances in which enough acid is added to lower the pH of the food mixture below the isoelectric point of the egg protein.

Peptization of egg proteins increases the tenderness of some products. Freundlich (1929) states that peptization of proteins is frequently brought about by low concentration of electrolytes, though to accomplish this the electrolyte must be intimately mixed with the substance to be peptized. The hydroxyl, citrate, acetate, and tartrate

ions are effective for peptizing egg proteins. For example, when tomato or lemon juice is added to egg in amounts to bring the pH of the egg slightly above or about the isoelectric point of egg albumin, the tenderness of omelets is definitely increased. In some instances peptization of the egg protein is detrimental. Sugars (sucrose, dextrose, and levulose) through peptization tend to prevent coagulation of egg protein.

Lowe (1937) in discussing viscosity of colloidal systems says that the viscosity of water is approximately six times as great at 0° as at 100° C. The viscosity of sols usually decreases with an increase in temperature, part of this being due to the effect of temperature upon the intermicellar liquid. She continues by saying that viscosity is closely related to the consistency of the finished product in food preparation. So close is this relation in many cases that the ten factors listed by Ostewald (1) concentration, (2) temperature, (3) degree of dispersion, (4) solvation, (5) electrical change, (6) previous thermal treatment, (7) previous mechanical treatment, (8) the presence or absence of other lyophilic colloids, (9) the age of the lyophilic sol, (10) the presence of both electrolytes and non-electrolytes, and

(11) the rate of shear, added by Gartner, may be taken as the commandments of food preparation.

Lowe quotes from Loeb that viscosity in general may be affected by many factors. As a rule acids and alkalies tend to increase it until certain limits are reached. Salt has a depressing effect due to the chlorine ion. Non-electrolytes as sugar have little or no effect. Temperature, time of standing, and method of manipulation are known to change this property.

Platt (1931) gives the definition of texture as determined by the American Institute of Baking as follows: Texture is an expression of elasticity, softness or pliability, and smoothness or silkiness of the crumb. It is determined by the sense of touch. It is also determined by the physical condition of the crumb and to a minor degree is influenced by the grain. Speaking in physical terms - texture is principally a combination of compressibility, elasticity, and tensile strength.



## PROCEDURE

Experimental work included the study of four different factors.

### Variation of Temperature and Time of Baking

Temperature and time of baking were tested for cakes with 200 grams of sugar or 250 grams of sugar, and then for cakes containing 250 grams of sugar and varying amounts of lemon juice. Cakes were baked at 300° F., 312° F., 325° F., and 350° F. Cakes also were baked at 312° F. and the temperature lowered to 300° F. the last 10 minutes of the baking period. Time of baking was varied from 60 minutes to 75 minutes.

### Variation of Temperature of Water Added to Egg Yolks

Variations in temperature of water added to egg yolks included: 2° C., 22° C., 40° C., 50° C., 70° C., 80° C., 90° C., and boiling water.

Variation of the Different Ingredients of the Cake

Varying the Amount of Baking Powder.

Calumet baking powder teaspoons	Sugar gms.
2	200
1 1/2	200
1	200
2	250
1 1/2	250
1	250

Varying the Amount of Sugar.

Weight gms.	Approximate measure cups
200	1
225	1 1/8
250	1 1/4

Varying the Amount of Water.

cubic centimeters	Approximate measure tablespoons	cups
180	12	3/4
165	11	11/16
150	10	5/8

Varying the Amount of Flour.

Weight gms.	Approximate measure cups
175	1 3/4
150	1 1/2

Varying the Flavoring Material.

- (a) 1 teaspoon of vanilla was added to each cake  
This amount was an increase of 1/2 teaspoon  
over the basic recipe
- (b) Addition of lemon rind  
Grated lemon rind  
1/2 teaspoon or rind of approximately 1/2  
lemon  
1 teaspoon or rind of approximately 1 lemon  
3 teaspoons or rind of approximately 3 lemons
- (c) Addition of lemon juice and 1 teaspoon of  
lemon rind

Lemon juice	
1 teaspoon	5 cc.
2 teaspoons	10 cc.
1 tablespoon	15 cc.
2 tablespoons	30 cc.
3 1/2 tablespoons	50 cc.

- (d) Addition of lemon juice, lemon rind, and  
lemon extract  
15 cc. lemon juice  
1/2 teaspoon lemon extract  
1 teaspoon lemon rind

Variation of Method of Mixing

(1) Beat sugar into egg yolk mixture with a rotary  
egg beater. Fold in 1 cup of flour, sift remainder of  
flour with baking powder and fold in. Fold in extracts.

(2) Beat 2/3 sugar into beaten egg yolks. Sift 1/3  
flour and 1/3 sugar together and fold in. Sift remaining

flour with baking powder and fold into batter. Fold in extracts and continue folding for 2 minutes.

(3) Beat  $1/2$  sugar into beaten egg yolks. Fold in  $1/2$  sugar and  $1/2$  flour sifted together. Fold in other half of flour sifted with baking powder. Fold in extracts and continue folding for 1 minute.

(4) Same as 3 but varied amounts of end folding -  $1/2$  minutes, 2 minutes, and 3 minutes.

(5) Beat  $3/4$  cup of sugar into beaten egg yolks. Fold in 1 cup sugar and 1 cup of flour sifted together. Fold in  $3/4$  cup of flour and baking powder sifted together. Fold in extract and continue folding 2 minutes.

(6) Add lemon juice and water to the egg yolks and beat 5 minutes. Continue as in 5.

(7) Same as 5 but fold in lemon juice and rind alternately with flour and baking powder mixture.

(8) Same as 5 but fold in lemon juice and rind alternately with flour and baking powder and fold in lemon extract with vanilla.

The basic recipe used for the investigation was taken from Practical Cookery (3).

Ingredients	Weights	Approximate measure
egg yolks	216 gms.	12
salt		1/4 teaspoon
sugar (sifted)	200 gms.	1 cup
cake flour	175 gms.	1 3/4 cups
baking powder		2 teaspoons
vanilla		1/2 teaspoon
lemon extract		1/2 teaspoon

Add salt and water to egg yolks. Beat until very light and thick. Add sugar, gradually beating while adding. Fold in 1 cup of sifted flour. Sift baking powder with the rest of the flour (3/4 cup) and fold in. Add flavoring. Bake about 60 minutes at 300-325° F. Twenty servings.

In order that there might be the minimum of variation with respect to ingredients, all supplies, with the exception of egg yolks and lemons, were obtained in a large quantity and stored at the beginning of the experiment. Fine granulated sugar, Softasilk cake flour, and Calumet baking powder were used in all of the cakes.

The same utensils were used throughout the entire experiment. The cakes were mixed in an earthenware bowl. The egg yolks were beaten with a large rotary beater. The cakes were baked in medium-weight aluminum tube pans of 4000 cc. volume. The flour, sugar, and eggs were weighed on a Harvard Trip balance. Water and lemon juice were

measured in a graduate cylinder. Salt, baking powder, and lemon rind were measured in standard measuring spoons. The cakes were baked in two Magic Chef ovens. The temperature regulators were set and checked with two Taylor thermometers in each oven.

Two cakes were made to test each variation. If these two cakes had practically the same characteristics, it was assumed that the properties of the cake were due to the factor being varied. If there was doubt as to the results, more cakes were made. The temperature of the finished batter and the consistency of the batter were recorded for each cake. The consistency of the batter was determined by means of a glass funnel with a stem which had two marks 4.65 centimeters apart. The average diameter of the stem between the two marks was 5.9 millimeters. The time required for the batter to move from the upper mark to the lower mark was recorded in seconds and regarded as an indication of the consistency of the batter. One rounding teaspoonful of batter was taken from each cake for the test.

A chemical thermometer was used in checking temperatures of water and batter. An Eastman timer was used for all determinations where time was a factor.

Approximate increase in volume was determined by making marks on the pans for the depth of the batter and then for the finished cake. The amount of water, measured in cubic centimeters, required to fill the pan to the marks was then taken as a measure of volume. A few cakes that went above the pan and remained that way after baking could not be measured accurately.

After baking, each cake was allowed to stand inverted in the pan for 45 minutes. This factor was standardized after having difficulty in removing several of the first cakes that remained in the pan over night. The cakes were then stored over night in the experimental laboratory in metal boxes. The cakes were stored approximately 21 hours before they were tested. A one inch slice of cake for the penetrometer test, 5 slices for the judges, one slice to be stored in a formaldehyde-glycerine solution as suggested by Markley (1934), and one slice to be photographed were cut from the cake. The formaldehyde-glycerine slice and photograph were kept for future study.

All data were recorded according to Form 1.

Form 1.

Chart for Recording Data for Individual Cakes.

Date

Cake number

Amounts of ingredients

Temperature of water added to egg yolks

Temperature of finished batter

Volume of batter \_\_\_\_\_ cc. finished cake \_\_\_\_\_ cc.

Penetrometer readings    top \_\_\_\_\_  
                                   middle \_\_\_\_\_  
                                   bottom \_\_\_\_\_

Results:

Four faculty members of the Department of Food Economics and Nutrition and the investigator scored each cake according to the score chart and directions (Form 2). Because of the absence of one of the scorers it was necessary to substitute a new member for the last 45 cakes. The scorers marked the cakes with abbreviations and then the investigator substituted number values - X = 100, E = 90, G = 80, F = 70, and B = 60. Plus and minus signs were given values in between. A score of 900 represented a perfect cake.



Form 2  
Yellow Angel Food  
Score Card

Cake number \_\_\_\_\_

Date \_\_\_\_\_

Judge \_\_\_\_\_

	Score	Remarks
I. General appearance (external)		
1. Shape-regular, evenly rounded _____		
2. Size - suitable to ingredients, light in proportion to ingredients. _____		
3. Crust		
A. Color - even, light brown _____		
B. Texture - not sticky, not sugary, thin crust _____		
II. General appearance (internal)		
1. Texture - tender, moist _____		
2. Grain - small uniform cells, thin cell walls, free from large air spaces _____		
3. Color _____		
III. Flavor		
1. Taste _____		
2. Odor _____		
IV. Remarks		

### Directions for Use of Score Card

#### Abbreviations to be used in scoring:

Perfect	X	No detectable fault
Excellent	E	Of unusual excellence, but not perfect
Good	G	Average good quality
Fair	F	Below average, slightly objectionable
Bad	B	Highly objectionable (not edible)

Plus or minus signs may be used where fine distinctions are to be made. Thus, if two samples are good in flavor, but one slightly better than the other but not excellent, mark G+ and the other G-.

Any remarks as to why certain samples were graded high or low will be particularly helpful.

Attempts were made to test the tensile strength and compressibility of yellow angel food cake by the method Reed (1931) used in her study. An apparatus described by Platt and Kratz (1933) was made for testing tensile strength. Both of these proved unsatisfactory because of the extreme tenderness of the cake. A type of penetrometer was then made for yellow angel food by the College<sup>1</sup>. The apparatus was designed to give an indication of the tenderness and compressibility of the cake. Plate I is a picture of the penetrometer. The blue print follows (Plate II).

The device consists of an arm attached to a platform. A movable centimeter scale A and a cone shaped piece of metal B is connected to the arm. The cone is attached to a metal stem D-E. A metal pointer moves up and down with the cone and stem to record the degree of penetration. The total weight of the pointer cone and stem is 20 grams.

The sample for testing was cut one inch in thickness by a piece of metal shaped to fit over the cake. One cut was made in the cake and then the metal slipped in over the cake and an inch slice cut off with a sharp knife. A knife dipped in boiling water cut the cake more easily.

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<sup>1</sup>Professor G. A. Sellers, Shop Practice Department, Kansas State College of Agriculture and Applied Science.

Plate I

Explanation of Plate I

Device for testing cake

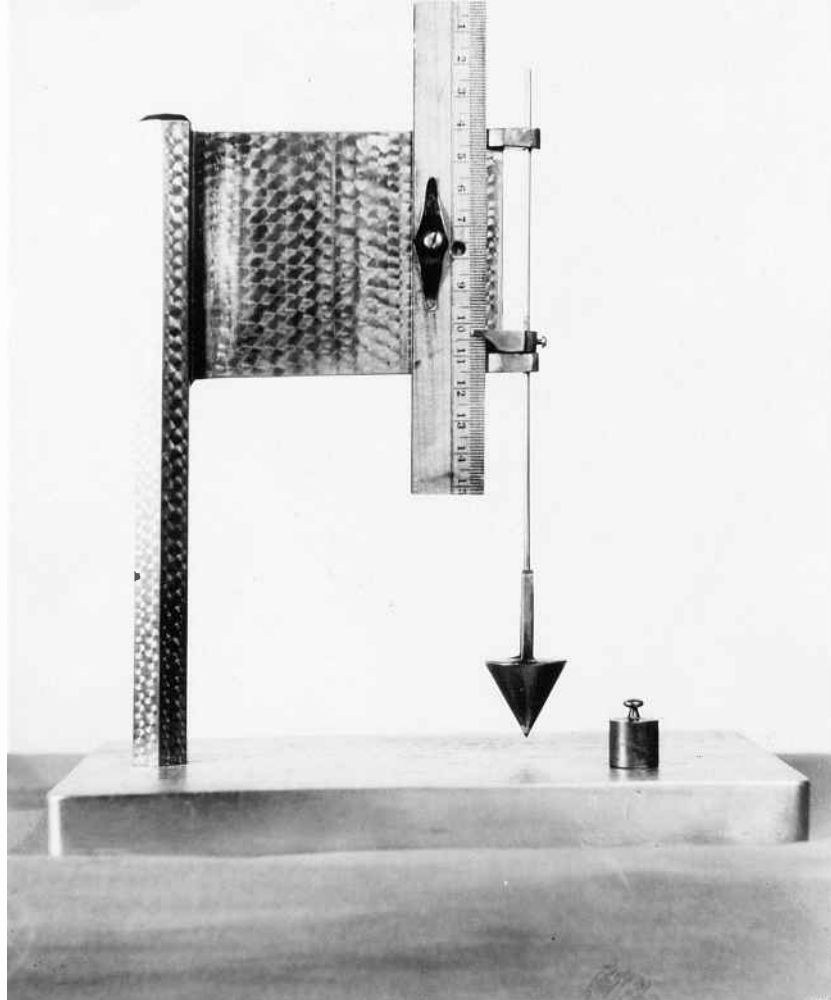


Plate II

Explanation of Plate II  
Blue print of penetrometer



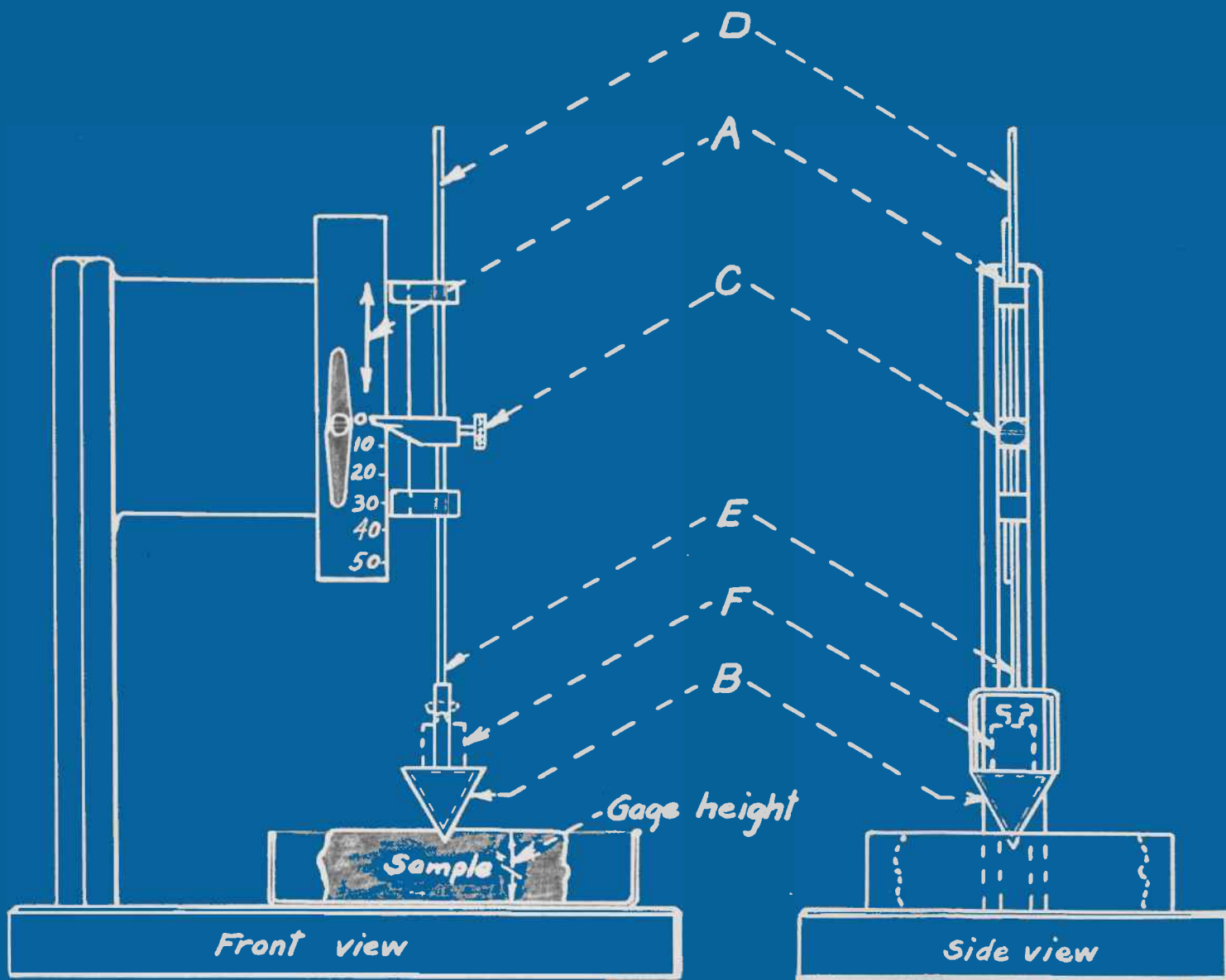


Plate 2 - Penetrometer

(One-half size)

The slice of cake was laid upon the platform under the cone; each time the center of the cake faced the arm. The cone was allowed to penetrate into the cake 15 seconds, the centimeter scale was adjusted, and then a 20 gram weight F was carefully slipped on top of the cone. The weight and cone were allowed to penetrate into the cake for 30 seconds and the reading was taken and recorded in centimeters. After several trials, three-fourths inch was taken as the minimum distance from the crust and sides of the cake. The cone was placed near this position unless there was a decided unevenness of the texture of the cake at that point. Five tests were made on each slice of cake - two at the top, one at the middle and two at the bottom. The average of the top readings, the middle reading, and the average of the bottom readings were recorded in the tables.

#### DISCUSSION OF RESULTS

##### Variations of Temperature and Time of Baking

The first cakes were baked according to the basic recipe directions. After being removed from the oven, the

cakes fell out of the pan. Slices cut from the cakes were found to be soggy and undesirable, indicating insufficient baking. When cakes were baked at an oven temperature of 350° F. as suggested by Lowe (1937), for sponge cakes, the top and sides of the cakes were a dark brown as shown in Plate III, Figure 1. An oven temperature of 325° F. was used. This temperature for 60 minutes was satisfactory for cakes made with 200 grams of sugar, but as the amount of sugar was increased, the color of the crust became too brown. For cakes made with 250 grams of sugar, a lower temperature with a longer baking period seemed better. Cakes made with 250 grams of sugar and the addition of lemon juice were baked most successfully at 312° F. for 60 to 65 minutes and then with the temperature lowered to 300° F. during the remaining 10 minutes of the baking period. As shown in Plate III, Figure 2, cakes made with 250 grams of sugar and 30 cc. of lemon juice were too brown when baked at 325° F. for 70 minutes. Between 70 and 75 minutes were necessary to bake these cakes thoroughly.

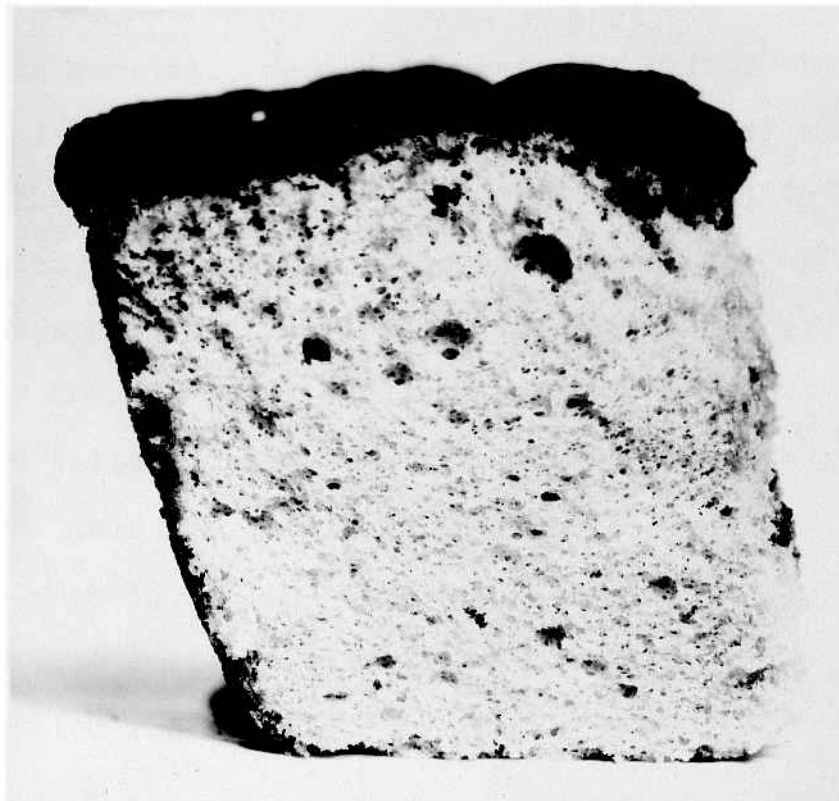
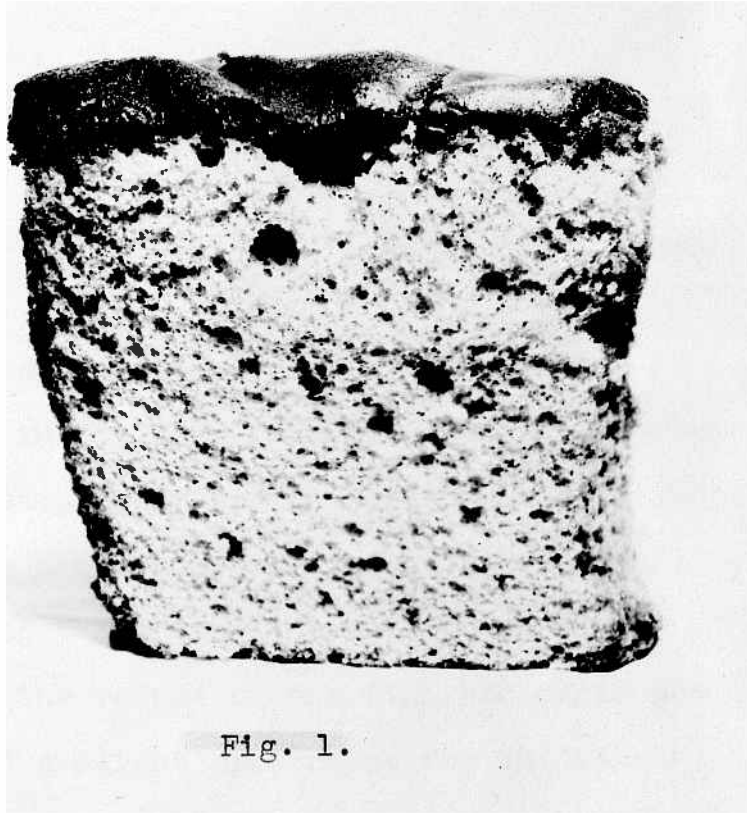
Plate III

Explanation of Plate III

Variation in temperature and time of baking

Figure 1 - Baked at 350° F. for 60 minutes

Figure 2 - Baked at 325° F. for 70 minutes



### Variations of Temperature of Water Added to Egg Yolks

Table 1 shows the results of using water at different temperatures in the cake formula containing 200 grams of sugar, one teaspoon of baking powder and extract flavorings. As the temperature of the water was increased, the temperature of the batter increased, the batter also became thicker, and the volume of the finished cakes was greater. Judges showed a slight preference for the texture and flavor of cakes made with boiling water over those made with water at 22° C.

Cakes were also made using water at different temperatures and replacing a small amount of the water with lemon juice. The cakes contained 250 grams of sugar, 30 cc. of lemon juice, one teaspoon of lemon rind and one and one-half teaspoons of baking powder. Results are shown in Table 2. The egg yolks and salt did not beat up well when the lemon juice and water at 22° C. were added. The cake batter was thin and difficult to mix. The volume of the batter was small and the finished cake had a concave bottom. In some instances the cakes were apparently clinging to the bottom and sides of the pan to such a small degree

Table 1. Increase in temperature of water added to egg yolks<sup>1</sup>.

Cake number	Temperature of water	Oven temperature	Temperature of batter	Consistency of batter	Volume		Penetrometer			Penetrometer
	: °C.	: °F.	: °C.	: seconds	: Batter: cc.	: Finished cake: cc.	: Top: centimeters	: Middle: centimeters	: Bottom: centimeters	: Av. reading: centimeters
96	: 22	: 312	: 22	: 39	: 1900	: 2850	: 3.7	: 4.0	: 3.7	: 3.7
105	:	:	: 25	: 39	: 2500	: 3500	: 3.7	: 3.5	: 3.5	: 3.6
Average:	:	:	: 23.5	: 39	: 2200	: 3175	:	:	:	:
97	: 70	: 312	: 29	: 95	: 2500	: 4000	: 4.7	: 5.0	: 3.8	: 4.4
99	:	:	: 29	: 95	: 2450	: 4000	: 5.2	: 5.0	: 4.0	: 4.7
Average:	:	:	: 29	: 95	: 2475	: 4000	:	:	:	:
98	: Boiling	: 312	: 30	: 96	: 2350	: 4000	: 4.0	: 5.0	: 4.0	: 4.3
100	:	:	: 29	: 96	: 2355	: 4000	: 4.2	: 5.0	: 4.0	: 4.4
Average:	:	:	: 29.5	: 96	: 2352	: 4000	:	:	:	:

<sup>1</sup>Cake recipe using 200 grams sugar, 1 teaspoon baking powder and lemon extract.



Table 2. Increase in temperature of water added to egg yolks<sup>1</sup>.

Cake number	Temperature of water	Oven temperature	Temperature of batter	Consistency of batter	Volume		Penetrometer			Penetrometer
	: °C.	: °F.	: °C.	: seconds	: Batter cc.	: Finished cake cc.	: Top centimeters	: Middle centimeters	: Bottom centimeters	: Av. reading centimeters
70	: 22	: 325	: 21	: 48	: 2000	: 3000	: 4.2	: 4.0	: 3.5	: 3.7
71	:	:	: 22	: 41	: 1400	: 2850	: 3.5	: 4.0	: 3.5	: 3.6
Average:	:	:	: 21.5	: 44.5	: 1700	: 2925	:	:	:	:
72	: 40	: 325	: 25	: 45	: 1900	: 3100	: 4.0	: 3.5	: 3.2	: 3.6
80	:	:	: 25	: 39	: 1850	: 2950	: 4.0	: 4.0	: 3.7	: 3.9
Average:	:	:	: 25	: 42	: 1875	: 3025	:	:	:	:
73	: 50	: 325	: 29	: 63	: 2000	: 3300	: 4.7	: 4.0	: 3.5	: 4.1
81	:	:	: 28	: 53	: 2000	: 3000	: 4.2	: 5.0	: 4.5	: 4.5
Average:	:	:	: 28.5	: 58	: 2000	: 3150	:	:	:	:
74	: 70	: 325	: 30	: 92	: 2100	: 3500	: 5.0	: 4.0	: 4.0	: 4.5
82	:	:	: 27	: 90	: 1900	: 2850	: 3.5	: 3.5	: 3.0	: 3.3
Average:	:	:	: 28.5	: 91	: 2000	: 3675	:	:	:	:
75	: 80	: 325	: 25	: 95	: 2100	: 3500	: 4.2	: 4.0	: 4.5	: 4.2
83	:	:	: 27	: 85	: 2000	: 3100	: 4.0	: 4.0	: 3.8	: 3.9
Average:	:	:	: 26	: 90	: 2050	: 3300	:	:	:	:
76	: 90	: 325	: 25	: 105	: 2150	: 4000	: 4.7	: 5.0	: 3.7	: 4.7
84	:	:	: 26	: 100	: 2100	: 3500	: 4.7	: 5.5	: 4.7	: 4.9
Average:	:	:	: 25.5	: 102.5	: 2125	: 3750	:	:	:	:
77	: Boiling	: 325	: 25	: 105	: 2100	: 4000	: 4.7	: 5.0	: 4.7	: 4.8
79	:	:	: 26.5	: 105	: 2100	: 4000	: 5.0	: 5.0	: 4.7	: 4.9
Average:	:	:	: 25.5	: 105	: 2100	: 4000	:	:	:	:

<sup>1</sup>Cake recipe using 250 grams of sugar,  $1\frac{1}{2}$  teaspoons of baking powder and 2 tablespoons lemon juice, mixed with and added as part of the water.

that they fell out of the pan after being inverted a few minutes. When the cakes were cut, there was a rather heavy compact layer near the bottom, but the cakes appeared to be sufficiently baked. As the temperature of the water increased, the concave appearance on the bottom disappeared to a certain extent and the volume of the cakes increased. This is quite plainly shown in Plates IV and V. It seemed impossible to make cake of excellent outside appearance and good texture by adding the lemon juice as part of the water; however, some of the judges scored the eating quality of these cakes high. The cakes seemed to have a pleasing flavor and moistness that was desirable. The outside appearance and the heavy layer near the bottom of the cakes were scored against them.

#### Variations of Ingredients of the Cake

Varying Amount of Baking Powder. Calumet baking powder was used in this entire study. Two teaspoons of baking powder as given in the basic recipe could be detected in the flavor of the cakes and the cakes had a tendency to run over in the oven. One and one-half teaspoons of baking powder produced a cake of good volume and the flavor of

Plate IV

Explanation of Plate IV

Variation of temperature of water  
added to egg yolks

Figure 1 - Water temperature 22° C.

Figure 2 - Water temperature 40° C.

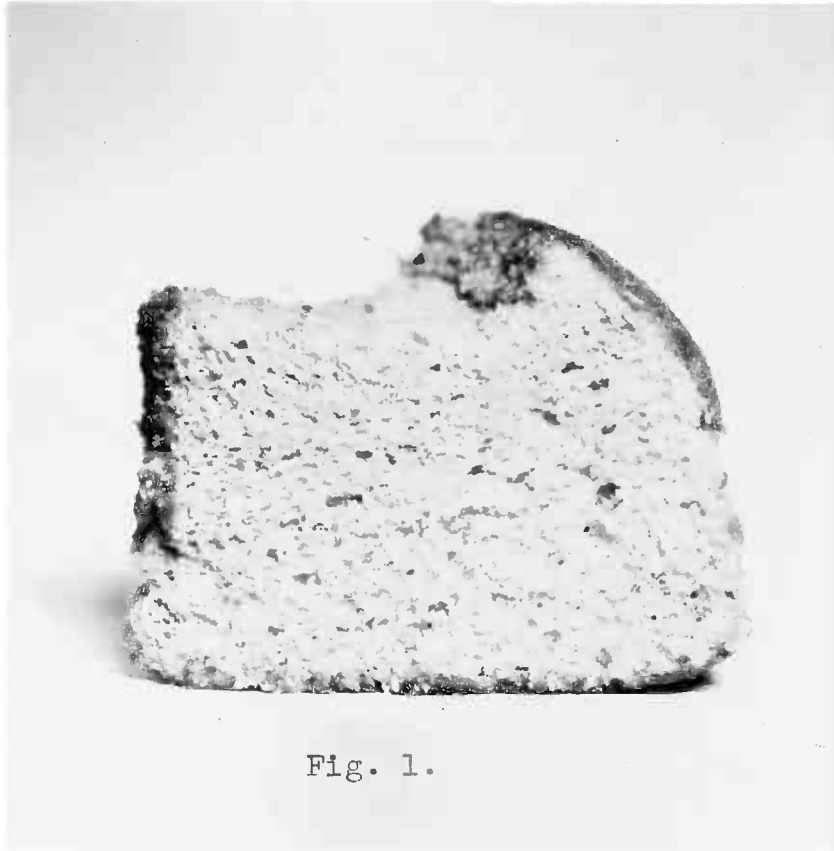


Fig. 1.

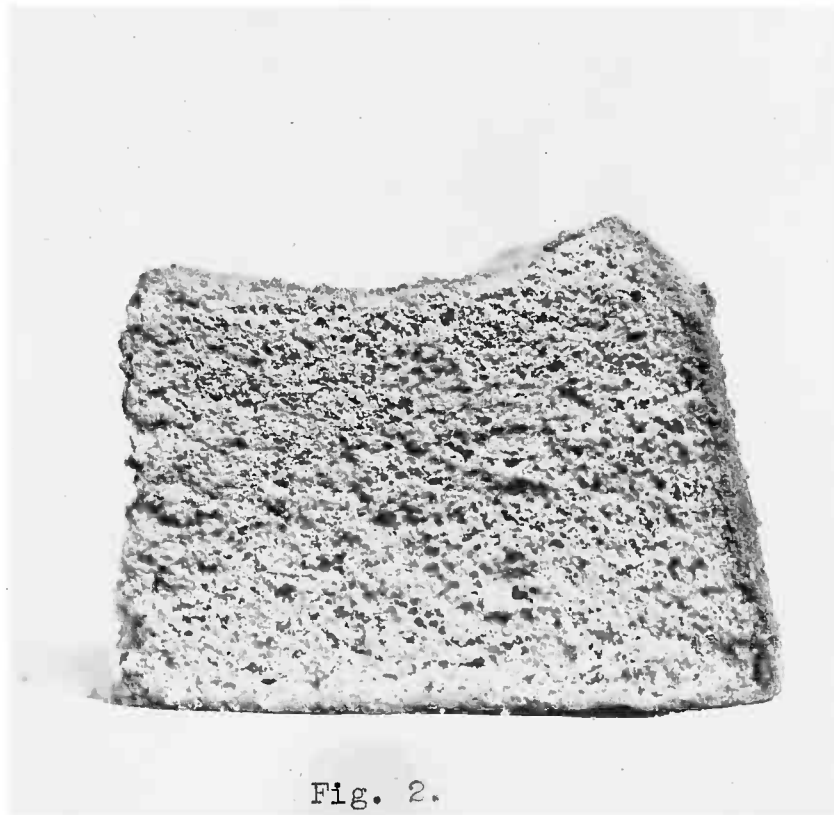


Fig. 2.

Plate V

Explanation of Plate V

Variation of temperature of water  
added to egg yolks

Figure 1.- Water temperature 70° C.

Figure 2 - Water temperature boiling

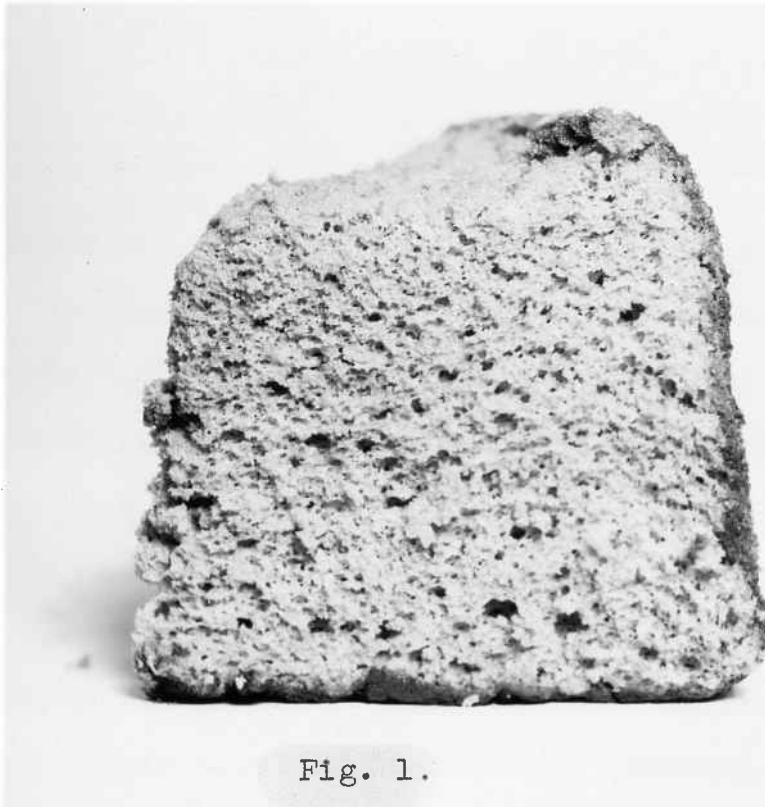


Fig. 1.

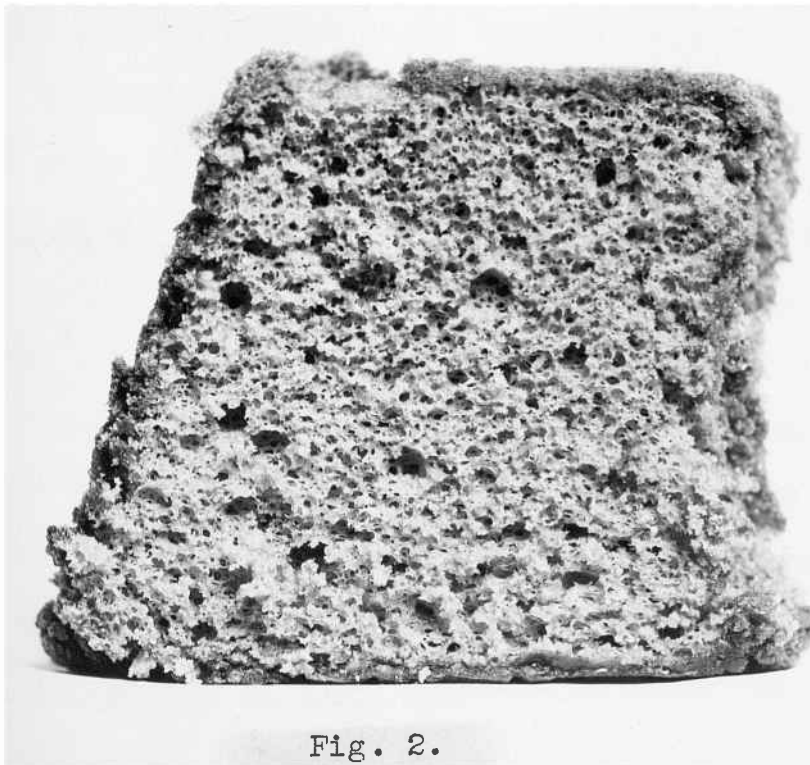


Fig. 2.



baking powder was not noticed. The volume of cakes made with one teaspoon of baking powder did not seem to be satisfactory. Since one and one-half teaspoons of Calumet baking powder was most desirable, that amount was used in the rest of the cakes.

Varying Amount of Sugar. An increase of 25 grams of sugar to the basic recipe made no appreciable difference in the flavor of the cakes. But with the addition of 50 grams, the judges noted an increase in sweetness. The judges preferred the cakes made with 250 grams of sugar. The size and appearance of the cake was slightly improved by the increase in sugar, but probably the most important reason for increasing the sugar was the improvement of flavor. The rest of the cakes in this study were made with 250 grams of sugar.

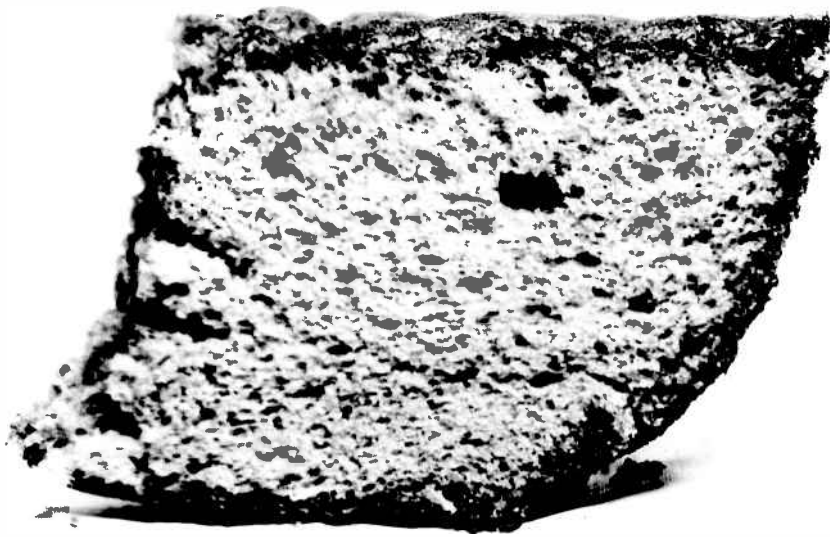
Varying Amount of Water. Best results were obtained when the amount of liquid was 180 cc. Greater amounts of water made the cakes run over the pan during the baking period or fall out of the pan when inverted to cool. The top crusts of the cakes were sticky and the crumb had a wet compact appearance. Cakes with decreased water were too dry and did not have good eating quality.

Varying Amount of Flour. Plate VI shows that cakes

Plate VI

Explanation of Plate VI

Cake made with 150 grams of flour



Explanation of Plate VI

Cake made with 150 grams of flour

made with decreased amounts of flour were decidedly undesirable. They ran over in the oven and fell out of the pan when inverted for cooling. The cakes were crumbly and would not hold together when cut.

Varying Amount of Flavoring Material. For this part of the study, 250 grams of sugar and one and one-half teaspoons of Calumet baking powder were used. The amount of vanilla in the recipe did not seem to give the cakes sufficient flavor; therefore, it was increased to one teaspoon. This seemed to be enough vanilla flavoring. Recipes for sponge cakes usually used lemon rind and lemon juice as the flavoring. It was thought that the flavor of these cakes might be improved by the use of lemon rind or lemon rind and lemon juice in place of the lemon extract in the basic recipe. One teaspoon of lemon rind was used with the lemon juice varying in amount from two teaspoons to three and one-third tablespoons. Table 3 shows the amounts of lemon juice used. Pictures showing the results of adding different amounts of lemon juice are shown in Plates VII and VIII.

The maximum quantity of lemon juice that could be added was found to be two tablespoons. Any over this amount made seemingly well baked cakes fall out of the pan

Table 3. Variation of amount of lemon juice<sup>1</sup>.

Cake number	Lemon juice : cc.	Oven temperature : °F.	Temperature of batter : °C.	Consistency of batter : seconds	Volume		Penetrometer			Penetrometer Av. reading : centimeters
					Batter : cc.	Finished cake : cc.	Top : centimeters	Middle : centimeters	Bottom : centimeters	
39	10	325	21	56	2150	3000	5.2	6.0	5.7	5.6
40			23	60	2200	3100	5.0	6.0	5.0	5.3
Average:			22	58	2175	3100				
41	18	325	27	59	2200	4000	6.0	6.0	6.2	6.0
42			27	56	2200	4000	6.2	6.0	6.2	6.2
Average:			27	57.5	2200	4000				
43	30	312	27	50	2500	3450	6.0	6.0	5.7	5.9
47			30	56	2000	3000	4.0	4.0	3.2	4.0
Average:			28.5	53	2250	3225				

<sup>1</sup>Cake recipe using 250 grams sugar, 1½ teaspoons baking powder and water at 22° C.

Plate VII



Explanation of Plate VII

Variation in amounts of lemon juice

Figure 1 - 10 cc.

Figure 2 - 18 cc.



Fig. 1.

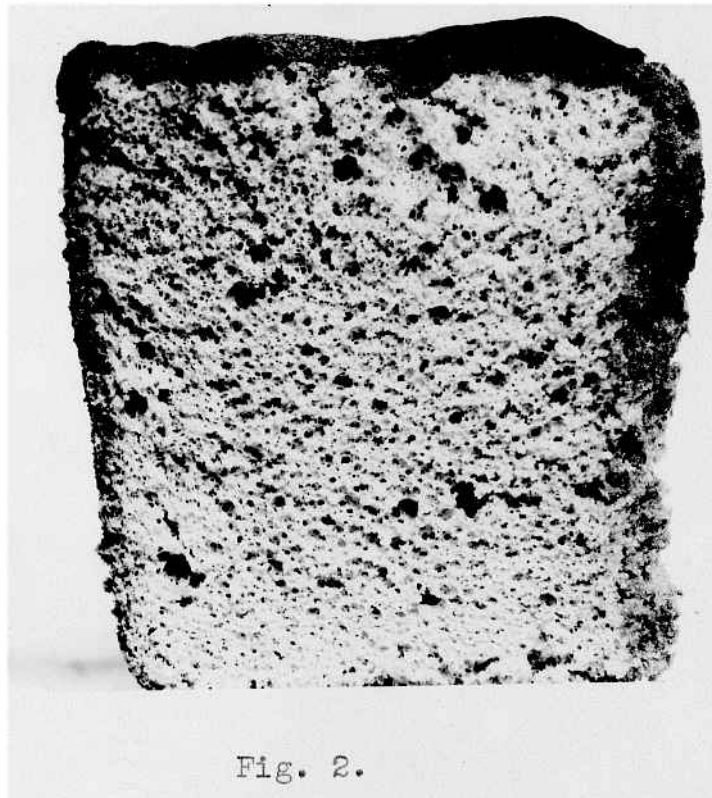


Fig. 2.

Plate VIII

Explanation of Plate VIII

Variation in amounts of lemon juice

Figure 1 - 30 cc.

Figure 2 - 50 cc.

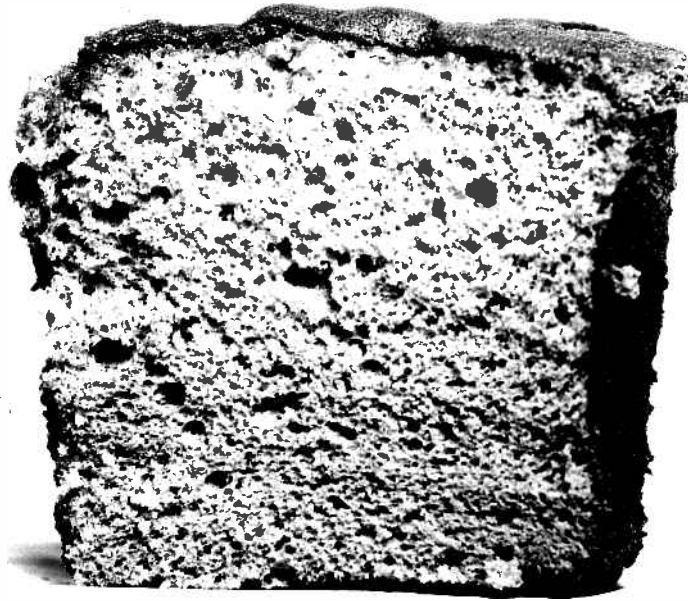


Fig. 1.

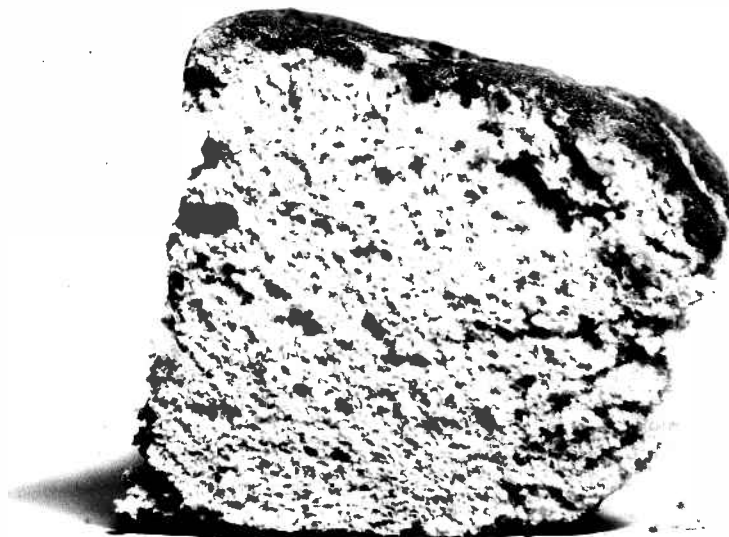


Fig. 2.

when cooling and gave the cake too tart a flavor. Cakes made with two tablespoons of lemon juice had good flavor and seemed to have moistness that was liked by the judges. A cake of good eating quality was made by using one tablespoon of lemon juice and one-half teaspoon of lemon extract.

#### Variations of Methods of Mixing

Best methods of mixing the cake were obtained when the egg yolks, water and salt were beaten five minutes. Longer lengths of beating did not seem to add to the volume of the mixture, but resulted in a drier product; therefore, five minutes was taken as the optimum beating time. Beating each tablespoon of the three-fourths cup of sugar thoroughly into the egg yolk mixture seemed to stabilize the mixture and partly dissolve the sugar. The remaining sugar and one cup of the flour were sifted together three times and carefully folded in. Then the lemon juice and lemon rind, and remaining flour and baking powder mixture were alternately folded into the batter. The vanilla was added and the folding continued for two minutes. This folding produced a product of more even grain and texture.

Under two minutes did not seem sufficient for a thorough combining of ingredients; over two minutes seemed to be forcing the air out of the batter and producing a smaller, more compact cake.

After skill in manipulation had been gained, it was found that ingredients could be combined with less folding.

Table 4 shows the effects of the method of adding lemon juice to the cake with water at 22° C. and boiling water. In both instances the egg yolks beat up stiffer and to a greater volume when the lemon juice was not added to the water, but was folded in alternately with the flour and baking powder mixture. The resulting cakes had a larger volume and not so compact a crumb when the lemon juice was folded in. Adding the lemon juice mixed with the water to the egg yolks and salt slowly did not seem to prove desirable. The thickening and thinning of the egg yolks after the first additions and then a gradual thinning left the final batter thin. Compact cakes resulted.

The best product was obtained when boiling water was added to the egg yolks and salt and beaten until very light and fluffy, about five minutes. The lemon juice and rind were folded in alternately with the flour and baking

Table 4. Effect of change of water temperature and method of adding lemon juice<sup>1</sup>.

Cake number	:Method of adding lemon juice	:Temperature of water °C.	:Temperature of batter °C.	:Consistency of batter seconds	: Volume		: Penetrometer			:Penetrometer Av. reading
					:Batter cc.	:Finished cake cc.	:Top centimeters	:Middle centimeters	:Bottom centimeters	
	:Mixed with									
77	:water & add-	Boiling	: 25	: 105	: 2100	: 3200	:4.7:	5.0	: 4.7	: 4.8
79	:ed to egg yolks		: 26	: 105	: 2100	: 3100	:5.0:	5.0	: 4.2	: 4.2
Average:			: 25.5	: 105	: 2100	: 3150	: :	:	: :	: :
78	:Water added	Boiling	: 26	: 95	: 2500	: 4000	:6.0:	6.0	: 5.5	: 5.8
90	:to egg yolks		: 27	: 100	: 2400	: 4000	:6.0:	6.0	: 5.7	: 5.9
93	:Lemon juice		: 27	: 90	: 2450	: 4000	:4.2:	6.0	: 5.0	: 5.0
Average:	:folded in		: 26.7	: 95	: 2450	: 4000	: :	:	: :	: :
	:Water added									
87	:gradually	Boiling	: 27	: 131	: 2500	: 4000	:6.0:	6.0	: 5.5	: 5.8
89	:to egg yolks		: 27	: 131	: 2400	: 4000	:5.0:	5.0	: 4.6	: 4.8
91	:Lemon juice		: 27	: 148	: 2400	: 4000	:6.0:	7.0	: 5.5	: 5.7
Average:	:folded in		: 27	: 137	: 2400	: 4000	:5.7:	5.7	: 5.2	: 5.4
	:Mixed with									
70	:water & add-	22	: 21	: 48	: 2000	: 3000	:4.2:	4.0	: 3.5	: 3.7
71	:ed to egg yolks			: 45	: 1400	: 2850	:3.5:	4.0	: 3.5	: 3.6
Average:	:yolks			: 46.5	: 1700	: 2925	: :	:	: :	: :
	:Water added									
	:to egg yolks									
86	:Lemon juice	22		: 67	: 2000	: 3500	:4.0:	4.0	: 3.5	: 3.8
88	:folded in			: 68	: 2000	: 3775	:4.0:	4.0	: 3.7	: 3.9
Average:				: 67.5	: 2000	: 3637	: :	:	: :	: :
	:Water added									
	:gradually									
85	:to egg yolks	22		: 30	: 1650	: 3000	:3.7:	3.0	: 2.7	: 3.0
104	:Lemon juice			: 31	: 1700	: 3050	:3.7:	3.0	: 3.0	: 3.1
Average:	:folded in			: 30.5	: 1675	: 3025	: :	:	: :	: :

<sup>1</sup>Cake recipe using 250 grams of sugar and 1½ teaspoons baking powder.



powder mixture. Table 5 shows the effect of folding in lemon juice alternately with the baking powder-flour mixture. Boiling water seemed to lessen the concave effect on the bottom of the cake.

The following recipe was evolved using two tablespoons of lemon juice, one teaspoon of lemon rind and one teaspoon of vanilla extract as flavoring. Plate IX, Figure 1 shows a slice of the cake.

Ingredients	Weight gms.	Approximate measure
egg yolks	216	12
boiling water	150 cc.	5/8 cup
salt		1/4 teaspoon
sugar	250	1 1/4 cups
cake flour	175	1 3/4 cups
baking powder		1 1/2 teaspoons
lemon juice	30 cc.	2 tablespoons
lemon rind		1 teaspoon
vanilla extract		1 teaspoon

Mix one-half cup sugar with one cup of flour and sift three times. Add salt and boiling water to egg yolks. Beat with a rotary beater for five minutes. Add three-fourths cup of sugar to eggs, one tablespoon at a time, beating in well with egg beater. Add flour-sugar mixture gradually, folding in lightly. Fold in flour-baking powder mixture alternately with lemon juice and rind. Add vanilla and continue folding for two minutes. Bake in a

Table 5. Effect of folding in lemon juice alternately with baking powder-flour mixture<sup>1</sup>.

Cake number	Temperature of water	Oven temperature	Temperature of batter	Consistency of batter	Volume		Penetrometer			Penetrometer
	: °C.	: °F.	: °C.	: seconds	: Batter cc.	: Finished cake cc.	: Top centimeters	: Middle centimeters	: Bottom centimeters	: Av. reading centimeters
51	: 22	: 325	: 27	: 70	: 2000	: 4000	: 6.0	: 6.0	: 5.3	: 5.7
52	:	:	: 27	: 75	: 2300	: 4000	: 5.2	: 5.0	: 4.5	: 4.9
Average:	:	:	: 27	: 72.5	: 2150	: 4000	:	:	:	:
53	: 22	: 312	: 27	: 90	: 2500	: 4000	: 5.5	: 5.0	: 5.0	: 5.2
55	:	:	: 27	: 102.5	: 2500	: 4000	: 4.5	: 5.5	: 5.0	: 5.0
57	:	:	: 27	: 90	: 2500	: 4000	: 6.0	: 5.5	: 5.5	: 5.6
Average:	:	:	: 27	: 94.2	: 2500	: 4000	:	:	:	:
66	: 22	:	: 24	: 75	: 2400	: 4000	: 5.8	: 6.0	: 5.2	: 5.7
67	:	:	: 24	: 75	: 2400	: 4000	: 6.0	: 6.5	: 6.0	: 5.7
Average:	:	:	: 24	: 75	: 2400	: 4000	:	:	:	:
78	: Boiling	: 312	: 26	: 95	: 2500	: 4000	: 6.0	: 6.0	: 5.5	: 5.8
90	:	:	: 27	: 100	: 2400	: 4000	: 6.0	: 6.0	: 5.7	: 5.9
93	:	:	: 27	: 90	: 2450	: 4000	: 4.2	: 6.0	: 5.0	: 5.0
Average:	:	:	: 26.7	: 95	: 2450	: 4000	:	:	:	:
87	: Boiling	: 312	: 27	: 131	: 2500	: 4000	: 6.0	: 6.0	: 5.5	: 5.8
89	:	:	: 27	: 131	: 2400	: 4000	: 5.0	: 5.0	: 4.6	: 4.8
91	:	:	: 27	: 148	: 2400	: 4000	: 6.0	: 7.0	: 5.5	: 5.7
Average:	:	:	: 27	: 137	: 2450	: 4000	: 5.7	: 5.7	: 5.2	: 5.4

<sup>1</sup>Cake recipe using 250 grams sugar,  $1\frac{1}{2}$  teaspoons baking powder and 30 cc. lemon juice.

Plate IX

### Explanation of Plate IX

Figure 1 - Cake made with 30 cc. lemon juice. Lemon juice folded in alternately with flour and baking powder mixture.

Figure 2 - Cake made with 15 cc. lemon juice and one-half teaspoon of lemon extract. Lemon juice folded in alternately with flour and baking powder mixture.

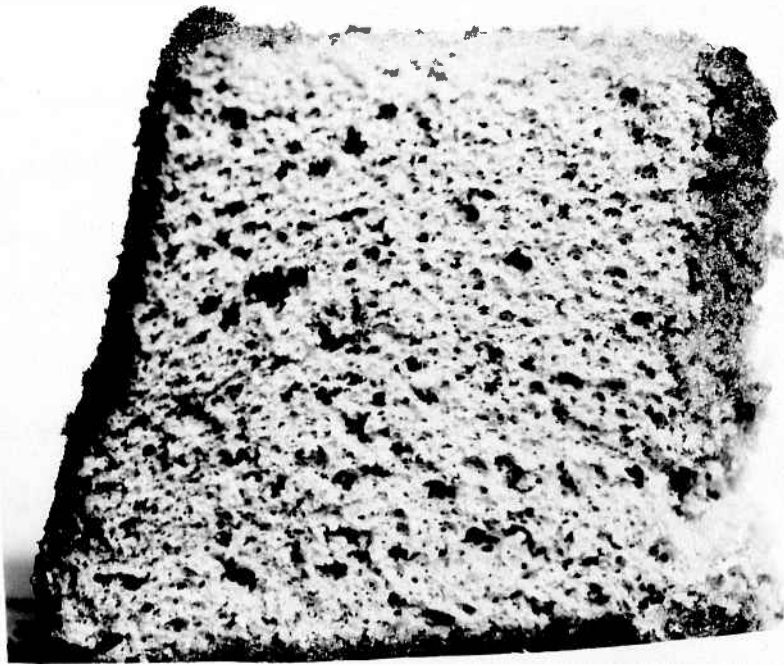


Fig. 1.

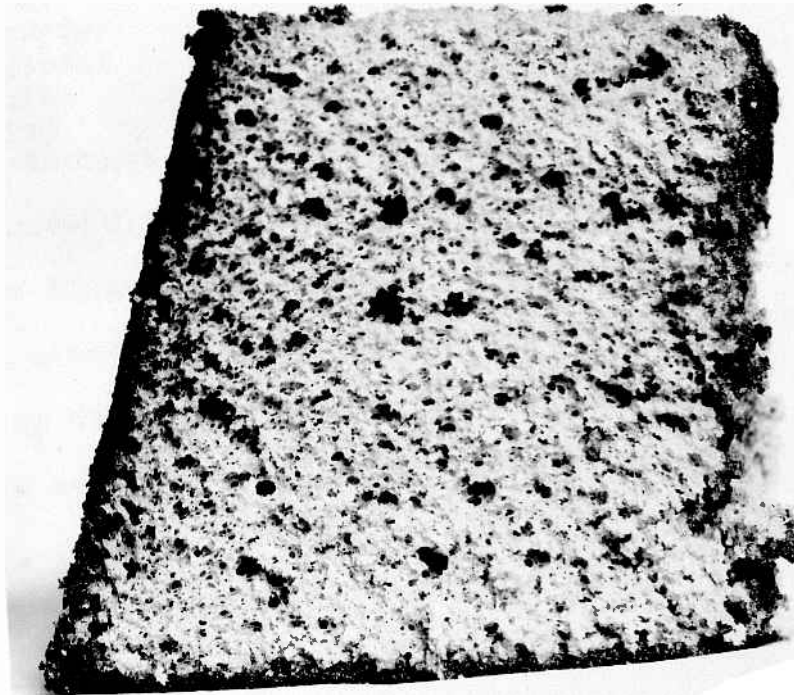


Fig. 2.

slow oven (312° F.) from 60 to 65 minutes. Lower the oven temperature to 300° F. for 10 minutes. An extra size angel food pan will be needed. This will make 18 to 20 servings.

Another recipe using a combination of one tablespoon of lemon juice and one-half teaspoon lemon extract with the lemon rind and vanilla was formulated as a result of the study (Plate IX, Figure 2).

Ingredients	Weight gms.	Approximate measure
egg yolks	216	12
boiling water	160 cc.	11 tablespoons
salt		1/4 teaspoon
sugar	250	1 1/4 cups
cake flour	175	1 3/4 cups
baking powder		1 1/2 teaspoons
lemon extract		1/2 teaspoon
lemon juice	15 cc.	1 tablespoon
lemon rind		1 teaspoon
vanilla extract		1 teaspoon

Mix one-half cup sugar with one cup of flour and sift three times. Add salt and boiling water to egg yolks. Beat with a rotary beater for five minutes. Add three-fourths cup of sugar to eggs, one tablespoon at a time, beating in well with egg beater. Add flour-sugar mixture gradually, folding in lightly. Fold in flour-baking powder mixture alternately with lemon juice and lemon rind. Add vanilla and lemon extract and continue folding for two minutes. Bake in a slow oven (312° F.) from 60 to 65 min-

utes. Lower the oven temperature to 300° F. and bake 10 minutes. An extra size angel food cake pan will be needed. This will make 18 to 20 servings.

#### SUMMARY

Consistency of the batter was affected by the temperature of the water added to the egg yolks and by the method of adding the lemon juice to the cakes. As the temperature of the water was increased, the batter became thicker. When the lemon juice was mixed with the water and added, the batter was thin, and it was difficult to combine the flour and sugar to get a smooth mixture.

The consistency of the batter seemed to have a direct relationship to the size of the finished cake. The slower the rate of flow of the batter, the greater the finished volume of cake.

Boiling water was the most satisfactory temperature to add the water to the egg yolks. When boiling water was added, the egg yolks beat up light and fluffy.

The optimum time of beating egg yolks, salt and water was five minutes.

The addition of one-fourth cup of sugar to the basic

recipe improved the flavor of the cake.

The flavor and eating quality of the cake were improved by increasing the amount of vanilla and substituting lemon rind and lemon juice for the lemon extract.

Better flavor and texture were obtained when the amount of baking powder was decreased from two teaspoons to one and one-half teaspoons.

Varying the amount of flour or the amount of water in the basic recipe did not produce a cake of good quality.

With an increase in sugar and the addition of lemon juice, the crust of the cake became too brown with an oven temperature of 325° F. The outside color of the cake was best when baked at 312° F. for 60 to 65 minutes and the temperature lowered to 300° F. for 10 additional minutes. Seventy to 75 minutes were necessary for baking the cakes sufficiently.

Recipes using only the yolks of eggs were evolved from this study.



## ACKNOWLEDGMENT

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