CREAMING PROPERTIES OF VARIOUS FATS AS RELATED TO THE SPECIFIC GRAVITY OF THE BATTER AND TO THE QUALITY OF PLAIN CAKE

by

RUTH ALICE KRAMER

B. S., Northwest Missouri State Teachers College, 1933

A THESIS

submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1935

TABLE OF CONTENTS

INTRODUCTION

A study of the literature on cakes made with butter and those made with other fat shows that there is considerable disagreement in regard to the desirability of such fats as margarin, lard of different types and hydrogenated oils when used as substitutes for butter. Some work has been done comparing creaming time to creaming volume of fats, but there is little record of work considering the relationship between creaming volume and quality of the finished cake.

This investigation is an attempt to find the effect of time of creaming of the fat and sugar mixture on the specific gravity and to note the relationship between this, the specific gravity of the batter and the quality of the finished product.

REVIEW OF LITERATURE

A good quality cake has the following characteristics, according to Halliday and Noble (1928): it is of fine, even grain, which is to say it has small holes evenly distributed, and in addition, a quality which cannot be photographed and is difficult to describe, which the authors call "velvetiness", meaning that to the tongue and fingers it has the

feeling of soft velvet.

Barackman (1930) listed the properties of cake under four headings: internal and external characteristics, flavor and odor. Of these qualities, odor and flavor, and most of the internal characteristics, as tenderness, velvetiness, and springiness must be determined by referring the product to a committee of judges. Platt (1933) has devised an apparatus to successfully measure the compressibility of cake, and also an apparatus for determining tenderness by breaking. Those qualities of the cake as odor, eating quality and feel cannot be measured by an apparatus.

Shortening has been defined by Davis (1921) as "a fat, which, when baked in a dough under standard conditions, gives to the product a minimum breaking strength, and a minimum crushing strength, when tested on a Shortometer." According to Sweetman (1932), the value of a shortening depends on flavor, color, and shortening power. Platt (1923) lists several fats in order of their importance as shortening agents as follows: lard, lard compound, cotton-seed oil, butter and coconut oil. Ahlborn (1926) found lard, lard compound, Crisco and oleomargarine to be satisfactory as shortening in cookie making. A definition for shortening as used in batters was not found.

The quality of cakes made with fat has for some time been associated with the kind of fat used, but comparatively

little has been done to show the effect that the time of creaming has on the volume of the creamed fat and sugar mixture, and the relation of this to the quality of the finished cake. The fat used has been related to the flavor of the finished product. Halliday and Noble (1928) prefer to use butter, or part butter, merely for the added flavor. As far as quality is concerned, they successfully used three hydrogenated fats, Snowdrift, Crisco, and a Sprague Warner product under the brand of Richelieu.

Lard as a substitute for butter in cake baking has only recently been widely advocated. Lowe (1933) reported a series of experiments with cakes in which lard was found to produce a satisfactory product. Formerly, Lowe (1932) recommended the use of butter in preference to lard because of the added flavor of the former. In a recent article Cawood (1934) brought out the point that heretofore butter was thought to be the only shortening suitable for cakes. She also states that at this particular time, when economy is of great importance, that lard and less expensive fats should have a special place in any food preparation where fat is needed. Cline (1934) states that as lard has the greatest shortening value of any of the plastic fats used in cookery, that when substituting lard for butter only four-fifths as much lard as butter will be needed. There is considerable controversy regarding the superiority of smooth

lard over grainy. The graininess, or texture of the lard, according to Denton and her associates (1921) does not mean a superior or inferior product. However, Lewis (1934) believes the smooth lard to be highly desirable.

Commercial bakers have for some time recognized the effect of the specific gravity of the creamed fat and sugar mixture on the quality of the finished cake. Work on the effect of temperature on creaming bulk or volume of the fat and sugar mixture has been done by Fisher (1930). He found that a temperature of between 70-80°F. was best as related to the volume of the finished cake, but he did not relate this to the quality of the finished product. Alexander (1931) suggests that a definite relationship exists between the specific gravity of the creamed mixture and the quality of the finished cake. He states that sugar and fat should be a smooth emulsion of maximum volume and lightness. Instead of creaming for a definite time, he suggests building the mixture to a definite specific gravity. By taking the weight of a sample of the creamed mixture at 70°F. at short intervals while creaming until the weight no longer decreases one can determine when the maximum volume has been reached. By referring this to the weight of an equal volume of water, a useful curve can be plotted, using time intervals and specific gravity figures to show the progress of the creaming action. He also suggests the importance of mixing the

batter to a definite specific gravity, although he cited no results of any experiments. Cawood (1934) in her study on lard, butter and hydrogenated cotton seed oil made specific gravity determinations on the batter, but not on the creamed mixture. She found that the judges' scoring of eating qualities were shown to be independent of the specific gravity of the batter and the volume of the cake.

The method of mixing a batter is of importance as to the quality of the finished product. This subject has had considerable study and the results differ widely. Allen (1925) studied the effect of different methods of mixing on the texture of cakes, and she found that a quick method of mixing produced a cake of as good texture as one made by the conventional method which is most commonly used by the housewife. This method as described by Halliday and Noble, is briefly: cream all of the fat and sugar until the mixture is light and fluffy, beat the egg yolks into the mixture; add the flour and milk alternately and beat a short time after each addition; add the beaten whites and stir quickly but gently until the mixture can be beaten without spattering.

The use of lard as shortening in cakes has tended to modify the method of mixing, as well as the proportions used. Cline (1934) and Cawood (1934) both report satisfactory results when using a modified conventional method,

which is as follows:

Sift flour once and measure; add baking powder and salt to flour and sift three times.
Measure sugar and place three-fourths in mixing bowl. (Reserve the other one-fourth for beating into egg whites.)
Measure the fat, and milk.
Separate the yolks from the whites of the eggs; drop the yolks into the milk and stir thoroughly.
Measure vanilla and add to milk.
Add a little milk to the fat and sugar and cream until light and fluffy.
Beat the egg whites until stiff but not dry and add the remaining sugar; beat until sugar barely disappears.
Add flour and milk alternately to creamed mixture in the usual way.
Carefully fold in egg whites.

Lowe (1933) reports that the "Modified flour-batter" method of mixing gives good results when a number of fats are being considered. This method is as follows:

> "One half the sugar, the salt and fat were creamed 30 minutes; first speed. One tablespoon flour was folded in the creamed mixture, then one tablespoon of milk. The remaining flour and milk were added in two portions. Next one half of the sugar and the eggs were beaten until very thick, light and creamy. This mixture somewhat resembles a meringue in texture. It is folded into the mixture last."

In commenting on lard as a shortening for use in cakes, Lowe (1932) says, "Contrary to our experience a year ago, our results indicate that lard can be used successfully in cakes, producing cakes of good texture, volume and flavor."

METHOD

Seven fats were used in this study. The work was divided into two series. In the first Clix, home-rendered

lard, butter and Crisco were used, and in the second Armour's Texturated Lard, butter, Wilson's bulk lard, and Armour's Silver Churn Margarine. Three checks were made on the first series, and two on the second.

Seven different times of creaming were used, 2, 5, 7, 9, 15, 20, and 25 minutes. Four cakes were baked each day, all with the same time of creaming, but with the different fats of one series. Hence cakes tested at one time were made of the fats for one series and with one creaming time.

Ingredients for the study were as nearly identical as possible. Swansdown flour, finely granulated sugar, salt, tartrate baking powder, and vanilla sufficient for an entire series were taken from one lot and stored in the experimental room.

Eggs of practically the same quality were used throughout the experiment. They were obtained from a flock of hens on controlled rations, and enough were procured at one time for one week, and stored in the refrigerator in Calvin Hall (40-50°F.) until needed.

Fresh, pasteurized, whole milk was obtained from the College Dairy each morning that cakes were baked.

The fats for an entire series were obtained from one lot, and stored in the hardening room (0 to -10°F.) at the College Dairy, and enough for one week removed to the refrigerator in Calvin Hall.

All experimental work was done in a room with controlled heat and humidity. The baking was done in the Experimental Cookery Laboratory on the floor above.

All data obtained were recorded according to Form 1.

The same apparatus was used throughout the experiment. All ingredients except the salt and vanilla were carefully weighed on a torsion balance.

A Kitchen-Aid electric mixer, with 2 bowls of 3 quart capacity, each, and provided with three speeds was used for the mixing process. The cakes were baked in heavy tin pans, seven and one-half inches square. The bottom was covered with waxed paper, and the sides were unoiled.

A gas oven, equipped with a Lorain regulator was used. Each cake was baked at 350°F. for a period of 35 minutes. A Taylor oven thermometer was used to check the temperature.

A stop watch was used for all procedure where time was a factor.

The "specific gravity" of the fat and sugar mixture and of the batter was determined by filling and weighing an aluminum cup with straight sides and of a known weight. This weight was recorded in grams. By dividing the weight of the sample by the weight of an equal volume of water, the "specific gravity" was obtained.

The consistency of the batter was measured by a simple

Form 1

CHART FOR RECORDING DATA FOR INDIVIDUAL CAKES

Fat	Time of creaming (min.)	Temperature: Room °C.	Temperature: Creamed mixture °C.	Temperature: Batter °C.	Relative humidity	Specific gravity: Creamed mixture	Specific gravity: Batter	Rate of flow of batter minutes and seconds	Wt. of batter cc.	Wt. of pan	Cake + pan	Cake volume	Tensile strength: degrees	Tensile strength: grams	Compressibility mm.

apparatus designed by Clark*. It consists of a glass funnel, with marks six centimeters apart on the stem. The length of time required for the batter to run from one mark to the other gave an indication of the consistency.

After baking and weighing, each cake was allowed to stand ten minutes before removing from the pan. It was then turned out on a wire cake rack, and when sufficiently cool, covered with the pan in which it was baked and allowed to stand in the "controlled room" until the following day.

On the morning after the baking, tests were made on the product. To obtain comparable results it was necessary that all slices be uniform in width. This was accomplished by using an apparatus made of hard wood, similar to a miter box, one end of which was enclosed, against which the cake was placed (Plate I). The kerf was made one inch from this closed end, making it possible to cut through these grooves with a long bladed knife and obtain a uniform slice of cake one inch in thickness. The cake, with the ends discarded, was cut into 7 slices.

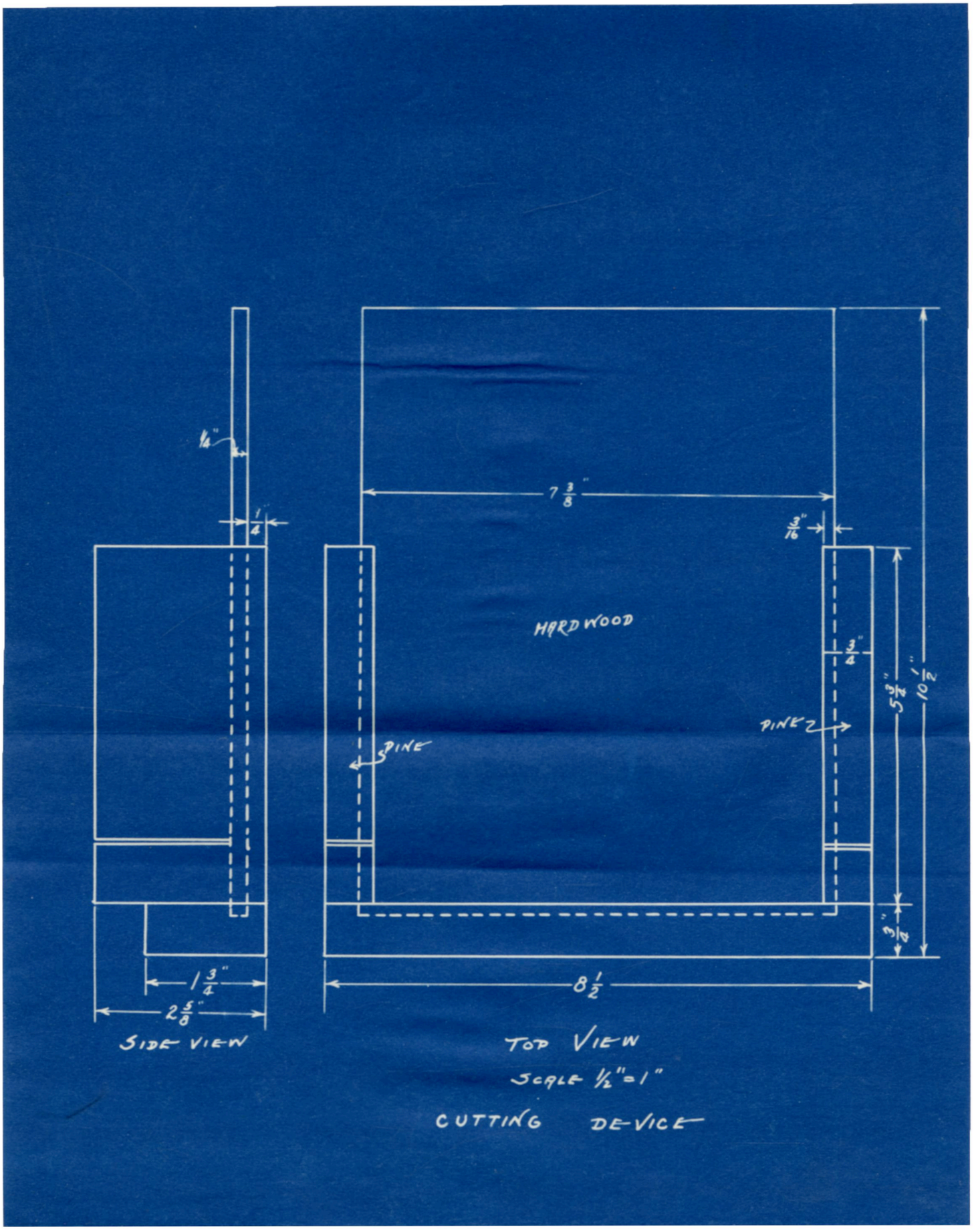
The center slice of each cake was laid on a sheet of paper and carefully outlined with a soft pencil. These outlines were used as a means of comparing the contour and volume of the different cakes. In computing the volume of

*Private communication with Roland J. Clark, Chemist, Michigan Bakeries, Inc., Grand Rapids, Michigan.

Explanation of Plate I

Device for cutting uniform slices of cake

PLATE I


1/4"
1/4"
7 3/8"
3/16"
HARD WOOD
3/4"
5 3/4"
10 1/2"
PINE
PINE
3/4"
1 3/4"
2 5/8"
8 1/2"
SIDE VIEW
TOP VIEW
SCALE 1/2" = 1"
CUTTING DEVICE

the cakes the height of the slice was determined at the center and at points one-half the distance from the center to either end. An average of the three heights was taken and this result multiplied by the area of the base of the cake as measured in square centimeters to give the "volume."

One-half of each center slice was preserved by covering with a formaldehyde-glycerin-water mixture as suggested by Markley (1934). The tensile strength was tested by using an apparatus which measured the angle at which a slice of cake broke when the two ends were pulled together (Plate II). The two ends of the slice were held between metal uprights, and rested on supports in such a manner as to leave the cake free from support in the center. By means of a gear attached to a crank, the cake was moved slowly, and at as uniform speed as possible to the angle at which it broke. The angle through which the cake rotated was measured by means of a protractor, and expressed in degrees. Three slices of cake were broken, and the average breakage recorded.

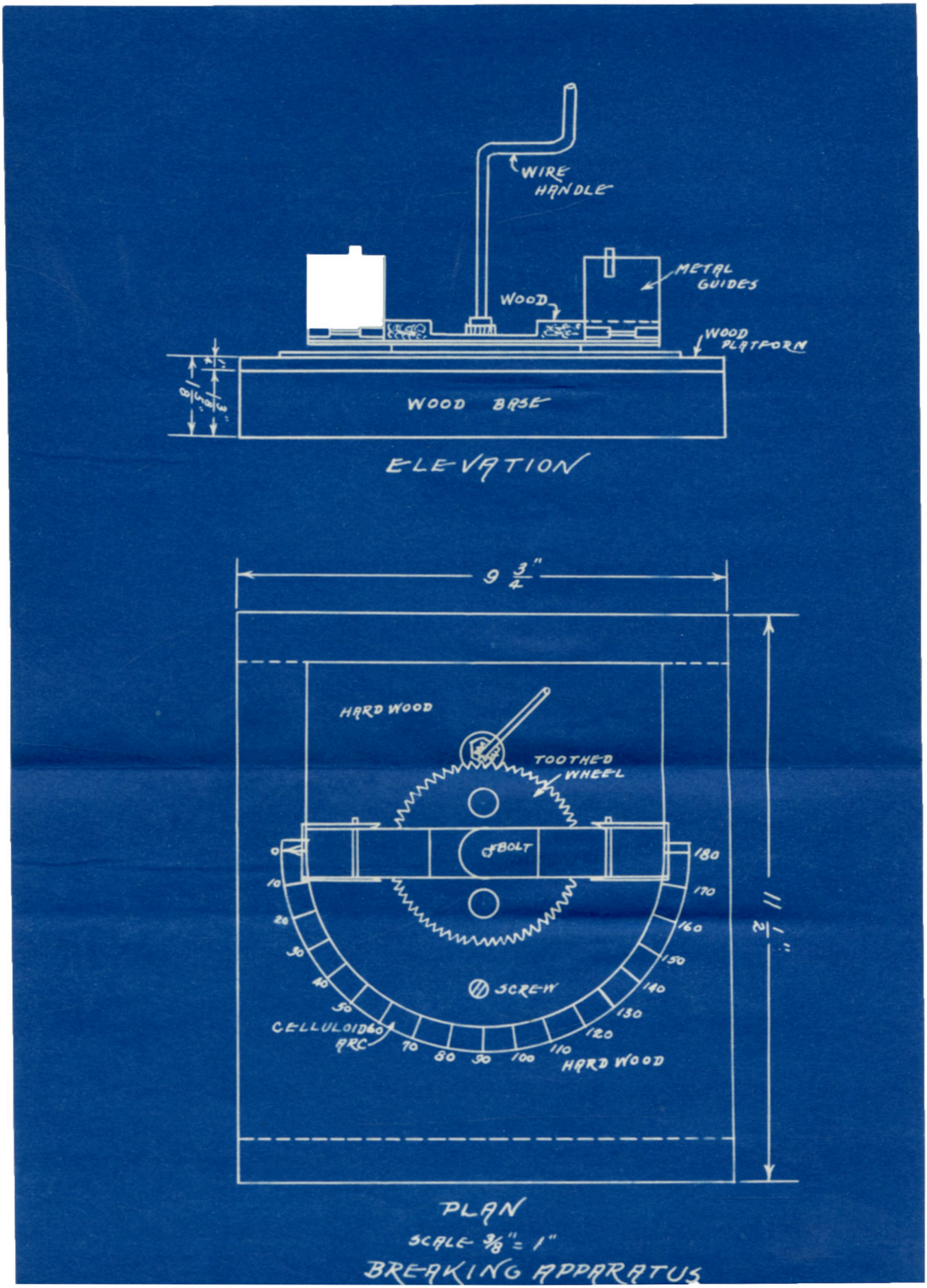
These broken slices were wrapped, numbered and given to the palatability committee to score according to Form 2.

An apparatus consisting of a modified balance and a spring balance (Plate III) was used to measure the force required to break a slice of cake one inch in thickness. A removable arm with a bar on one end was attached to the

Explanation of Plate II

Device for breaking cake

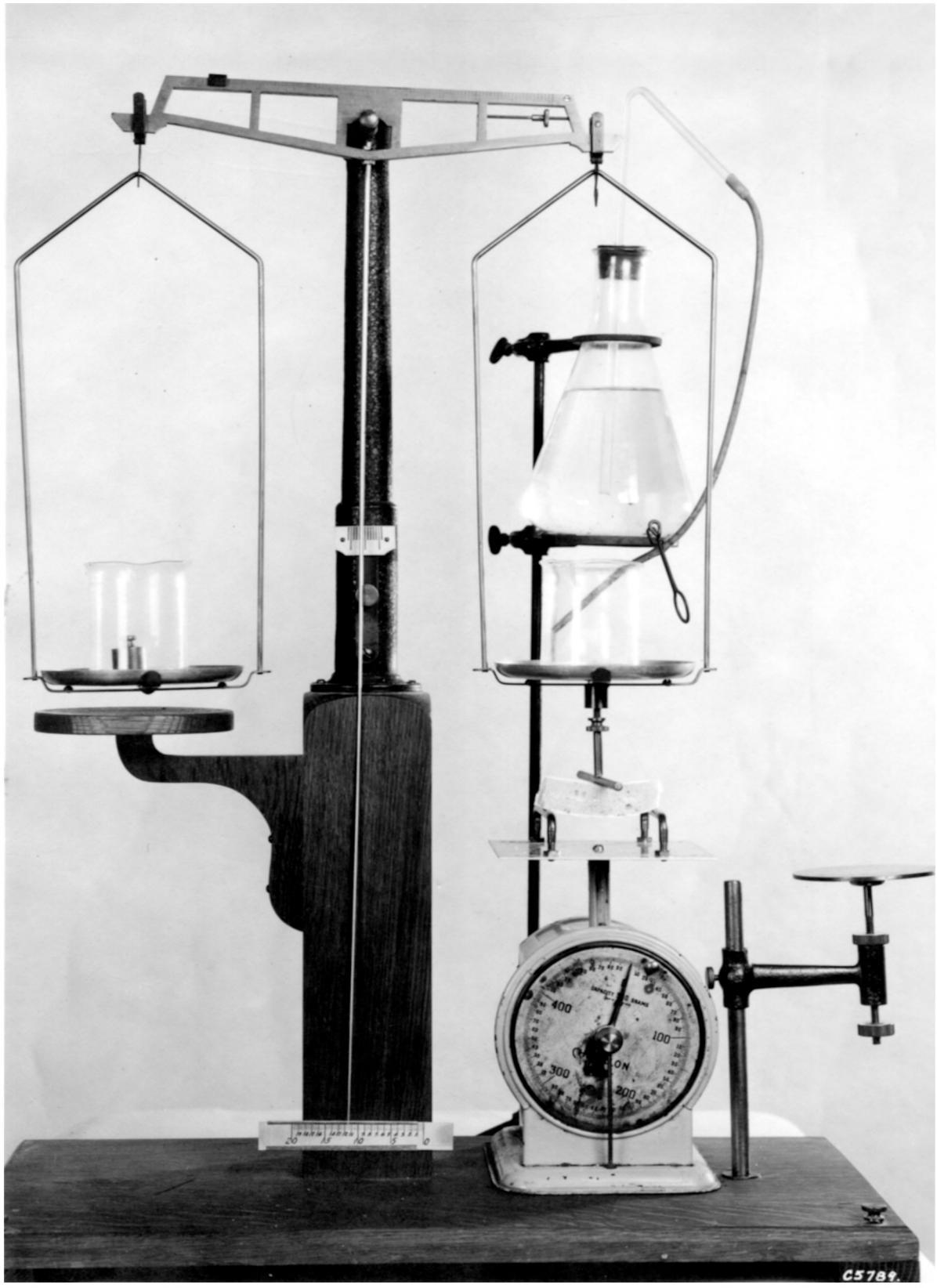
PLATE II


WIRE HANDLE
METAL GUIDES
WOOD
WOOD PLATFORM
WOOD BASE
ELEVATION
9 3/4"
HARD WOOD
TOOTHED WHEEL
BOLT
SCREW
CELLULOID ARC
HARD WOOD
0
10
20
30
40
50
70
80
90
100
110
120
130
140
150
160
170
180
11 1/2"
PLAN
SCALE 3/8" = 1"
BREAKING APPARATUS

Explanation of Plate III

Device for testing breaking and compressibility of cake

PLATE III



Form 2

SCORE CARD FOR CAKES*

Date _____

Experiment No. _____

	Perfect (No Detectable Fault)	Remarks	Sample No. 1	2	3	4
General Appearance	1. CRUST--Entire crust should be an even golden brown--Not too thick nor too thin--not blistered, sugary, or greasy.					
	2. SHAPE--Symmetrical--top should be smooth and only slightly rounded--no cracks or bumps.					
	3. COLOR OF CRUMB--Even and rich looking--Not gray or streaked.					
Texture	1. CRUMB--Should be springy and elastic--Even grain, i.e., cells small and uniform in size--Not too compact--Cell walls should be thin and fine.					
	2. TENDERNESS--Tender but not too light and feathery--Not tough or gummy.					
	3. VELVETINESS--Smooth and soft like velvet to tactile sense; (finger and palate).					
Eating quality	This includes all the qualities that make a cake agreeable or disagreeable for eating--Especially flavor, aroma, velvetiness or pleasing texture.					

Which cakes do you prefer?

1st Choice _____

2nd Choice _____

3rd Choice _____

4th Choice _____

Enter under each sample number the kind of fat you think was used.

Signature of Judge _____

*Score card taken from Cawood (1934).

bottom of the right hand pan of the balance. Beneath this was placed the spring balance which read in grams. On the weighing pan were fastened two parallel bars 3 inches apart to support the cake. The balance was adjusted so that the bar on the balance pan rested on the center of the slice. The face of the balance was adjustable. There were two hands, also moveable, one of which remained stationary when the weight was removed. The following procedure was used to determine the weight necessary to break a slice: The cake was placed on the parallel bars and the face and hands of the spring balance adjusted to zero. A 250 cc. beaker plus a 100 gram weight was placed on the left hand pan of the balance and a 250 cc. beaker on the right hand side. Water was siphoned through a rubber tube from the flask above the beaker on the right hand pan at the rate of approximately 150 cc. per minute. When the water running into the beaker was of sufficient weight to break the slice, one hand returned to zero, and the other remained stationary so the weight in grams could be read. Three slices were broken, the grams recorded, and an average taken. The broken slices were used for testing the compressibility.

The compressibility was determined by modifying the apparatus described above. The arm with the cross bar was replaced by a metal plunger one and one-fourth inches in diameter. The spring balance was removed and an adjustable

platform placed beneath the plunger. A portion of the slice used to determine the weight required for breaking was placed on the platform. Any abnormality such as excessively large holes or tunnels directly under the plunger was avoided. A weight equal to that of the plunger plus 200 grams was placed on the left hand pan. Two hundred grams and an additional 10 grams to hold the plunger in place were placed on the right hand pan. The scale which read in millimeters and the platform were adjusted so that the pointer rested at zero. A 2 minute period was allowed for the determination. At the beginning of this period a 50 gram weight was removed, at the end of 30 seconds another 50 gram weight and at the end of one minute a 100 gram weight. At the end of the 2 minute period the reading was taken directly from the scale. Three tests were made on each cake and an average recorded.

The melting point, iodine number, surface tension and rancidity as Oleic acid were determined on the three types of lard used; home-rendered, texturated, and bulk. The determination of phosphate was also attempted but too small an amount was present for quantitative determination.

A standard recipe for plain cake known to give a good product was used. The method of mixing varied only in the time of creaming. The ingredients and proportions used were:

Fat	70 grams
Sugar	200 grams
Eggs	
whites	60 grams
yolks	36 grams
Milk	158 grams
Flour	175 grams
Baking powder	8 grams
Salt	½ tsp.
Vanilla	1 tsp.

After weighing, add 50 grams of sugar to unbeaten egg whites, and cream remaining with fat.

Add well beaten yolks and vanilla to milk.

The following method of mixing was used:

Cream fat with sugar for desired time (2, 5, 7, 9, 15, 20, 25 minutes) (low speed).

Remove bowl, and beat egg whites with sugar for one minute (low speed), and for 2 minutes (high speed).

Replace bowl containing fat and sugar mixture and add one tablespoon flour. Beat 25 seconds (low speed).

Add one tablespoon milk and beat 25 seconds (low speed).

Scrape down sides of bowl with rubber scraper.

Add 1/2 remaining flour and beat 25 seconds (low speed).

Add 1/2 remaining milk and beat 25 seconds (low speed).

Scrape sides and bottom of bowl carefully.

Add remaining flour and beat 25 seconds (low speed).

Add remaining milk and beat 25 seconds (low speed).

Scrape down sides and bottom of bowl carefully.

Add beaten whites and beat 10 seconds (low speed).

Scrape down sides.

Beat batter 45 seconds (low speed).

Remove enough of the batter to determine the specific gravity. Pour remainder into weighed cake pan. Cut through batter with a spatula 6 times to remove air holes and to distribute batter evenly.

Bake 25 minutes at 350°F.

DISCUSSION AND RESULTS

All experimental work was done in the controlled heat and humidity room so that temperature and moisture, important variables in experimental baking, could be kept as

nearly constant as possible. However, even with this precaution, the temperature of the room varied during the experimental period from 21°C. to 27°C., and the relative humidity varied from 58 to 80. The temperature of the fat and sugar mixture ran from one-half to one degree higher than the room temperature, according to the length of time of creaming. As might be expected, the longer time of creaming increased the temperature, probably due to friction between the bowl and the mixture. The temperature of the batter was, in nearly every case, comparable with room temperature.

Since there were no baking facilities in the room where weighing, mixing and storing were done, it was necessary to bake the cakes in the Experimental Laboratory on the floor above. This delayed placing the cake in the oven. When the time required to go from the regulated room to the laboratory where baking was done was noted, less than one minute was consumed. This, according to experiments in which batters were allowed to stand before baking, would do no harm to the cake.

The loss of weight while baking, probably due largely to evaporation, was quite constant, varying only from 35 to 45 grams. At no time was there such a large loss as to be unaccountable.

The finished cakes were, almost without exception, sym-

metrical in shape, slightly rounded, and without cracks or lumps on the top. The type of crust varied with the fat used. The hydrogenated fats, Clix and Crisco, produced a crust that was well-browned and not thick, blistered or sugary. Butter also produced a satisfactory crust, but unlike the crust produced by hydrogenated fats, it was somewhat shiny in appearance. In the second series when the temperature was a little higher in the room where the cakes were stored, the crust of the butter cake tended to be slightly sticky. The remainder of the fats, the lards particularly, produced cakes with sticky crusts, which at times were almost objectionable.

The color of the crumb of the cakes was, for the most part, good. Crisco, at the longer creaming time, seemed to take on a grayish cast, probably from the metal mixing bowl. This grayish color was evidenced in the finished cake. With the same method of mixing, and the same ingredients used, except the fat, there seemed little reason why the color of one cake should have been more attractive than that of another.

The cakes made with oleomargarine showed hard spots throughout. These disappeared somewhat with longer creaming time, but for the 2, 5, 7, and 9 minute periods, they were very noticeable and gave a decided unevenness which was evident to both the fingers and the tongue. This un-

evenness was not noticed in cakes made with other fats.

Photographs were made of cakes with short, medium and long creaming periods. From these photographs, (Plates IV to IX), it will be noticed that there is no great difference in the cakes for different creaming periods in regard to shape or cell structure. The grain of the "2-minute cakes" appears slightly less uniform and the cell walls thicker than those of the cakes made by creaming the 9 and 25 minute periods. There is a perceptible difference between the volume of the cakes creamed for the different periods, especially of those containing Clix, home-rendered lard and oleomargarine. The "25-minute cakes" have a decidedly heavy layer at the bottom.

The holes appearing in a few of the cakes are probably due to air enclosed when the batter was transferred from the bowl to the pan. There was no evidence in the baked cake of uneven mixing. From the standpoint of characteristics which can be photographed, none of the cakes were really undesirable.

The samples of cake preserved in the formaldehyde-glycerin mixture proved valuable as a means of comparing the entire series at one time. The shape, size and grain of the sample were well-preserved, and to a lesser extent the texture. Cakes made with one fat and one time of creaming were similar, indicating quite consistent results.

Explanation of Plates IV to VI, inclusive

Plate IV -- 2 minutes creaming time
Plate V -- 9 minutes creaming time
Plate VI -- 25 minutes creaming time

A -- Clix

B -- Butter

C -- Lard, Home-rendered

D -- Crisco

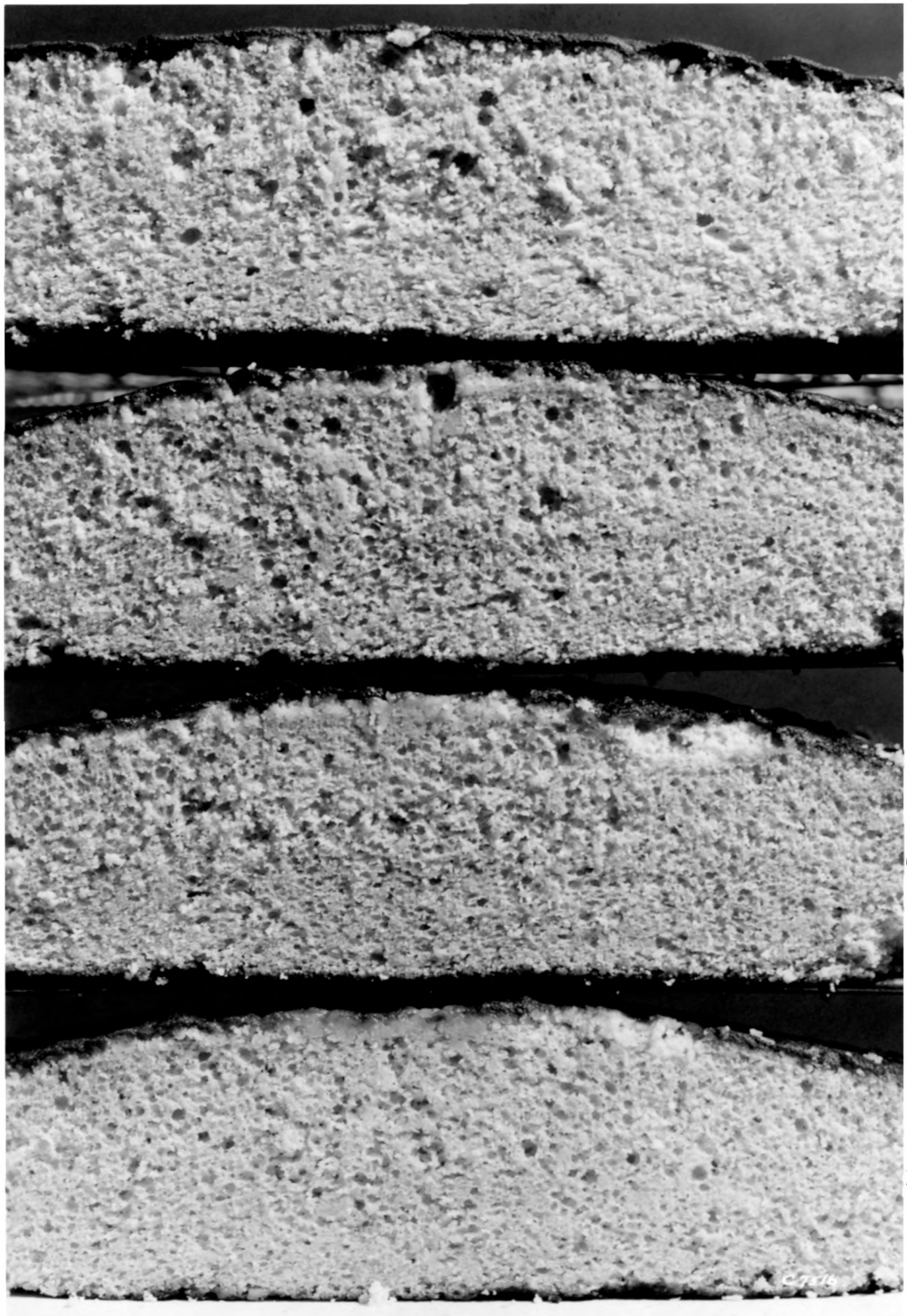

A
B
C
D

PLATE V

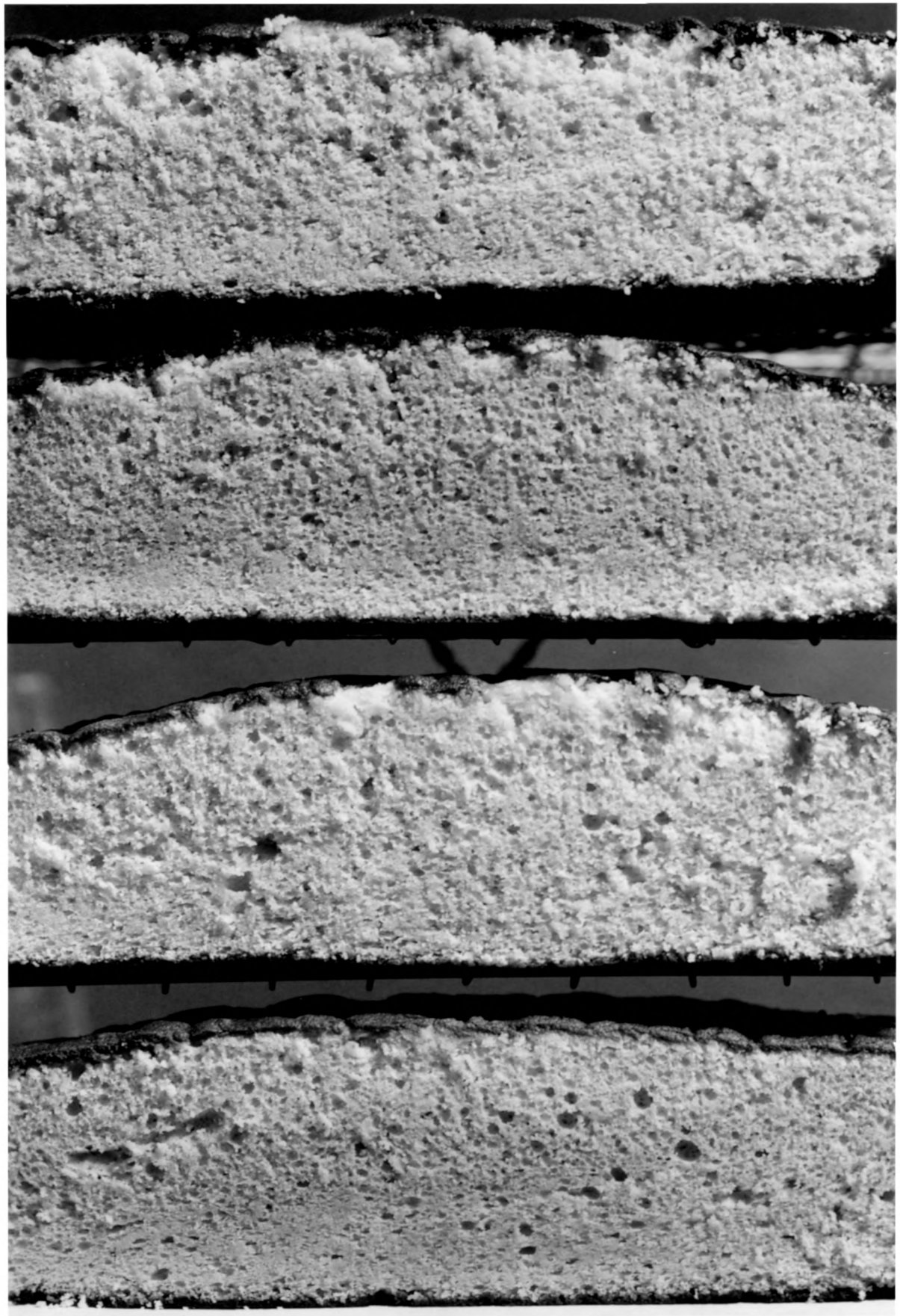
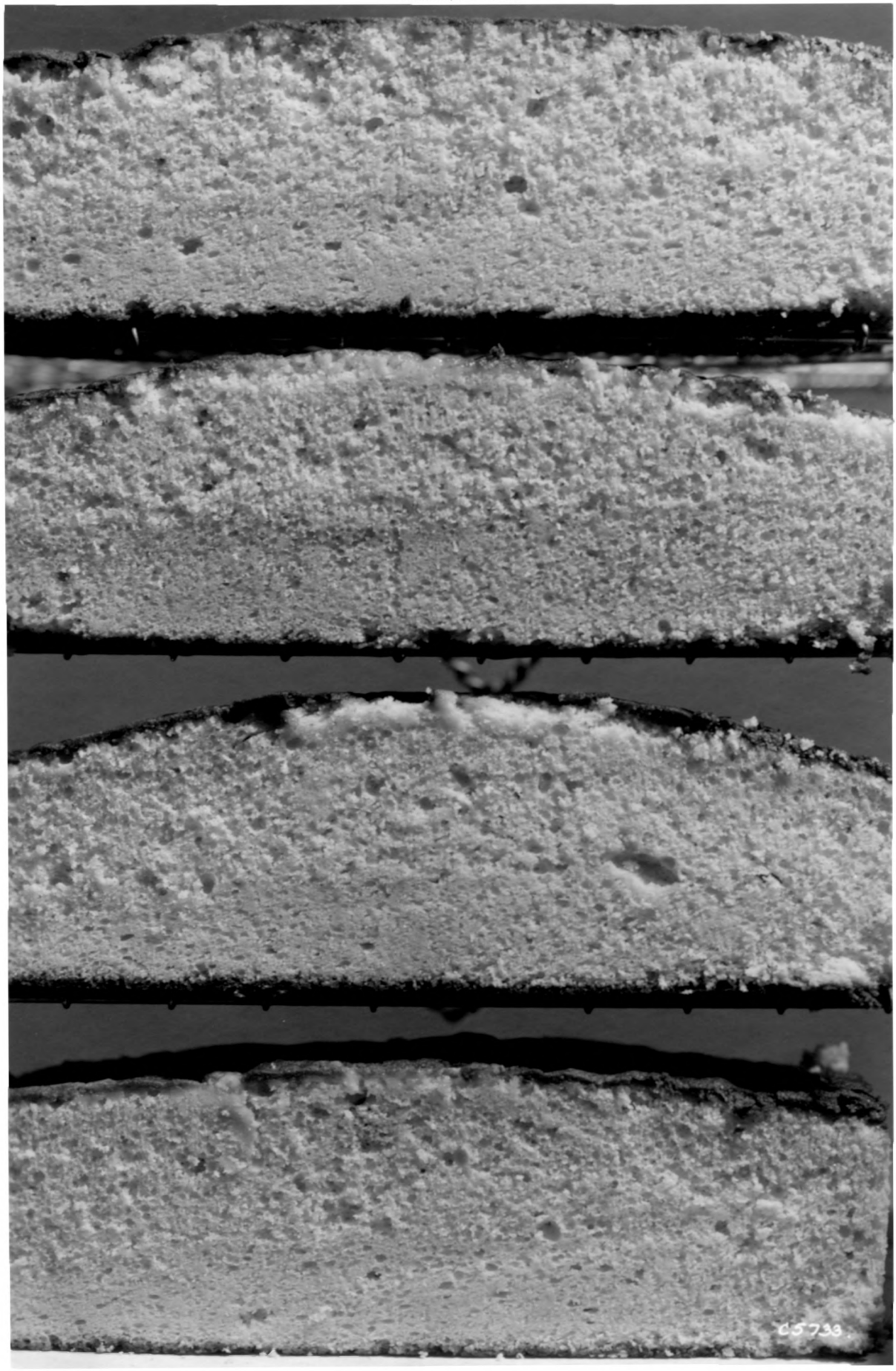


PLATE VI



Explanation of Plates VII to IX, inclusive

Plate VII -- 2 minutes creaming time
Plate VIII -- 9 minutes creaming time
Plate IX -- 25 minutes creaming time

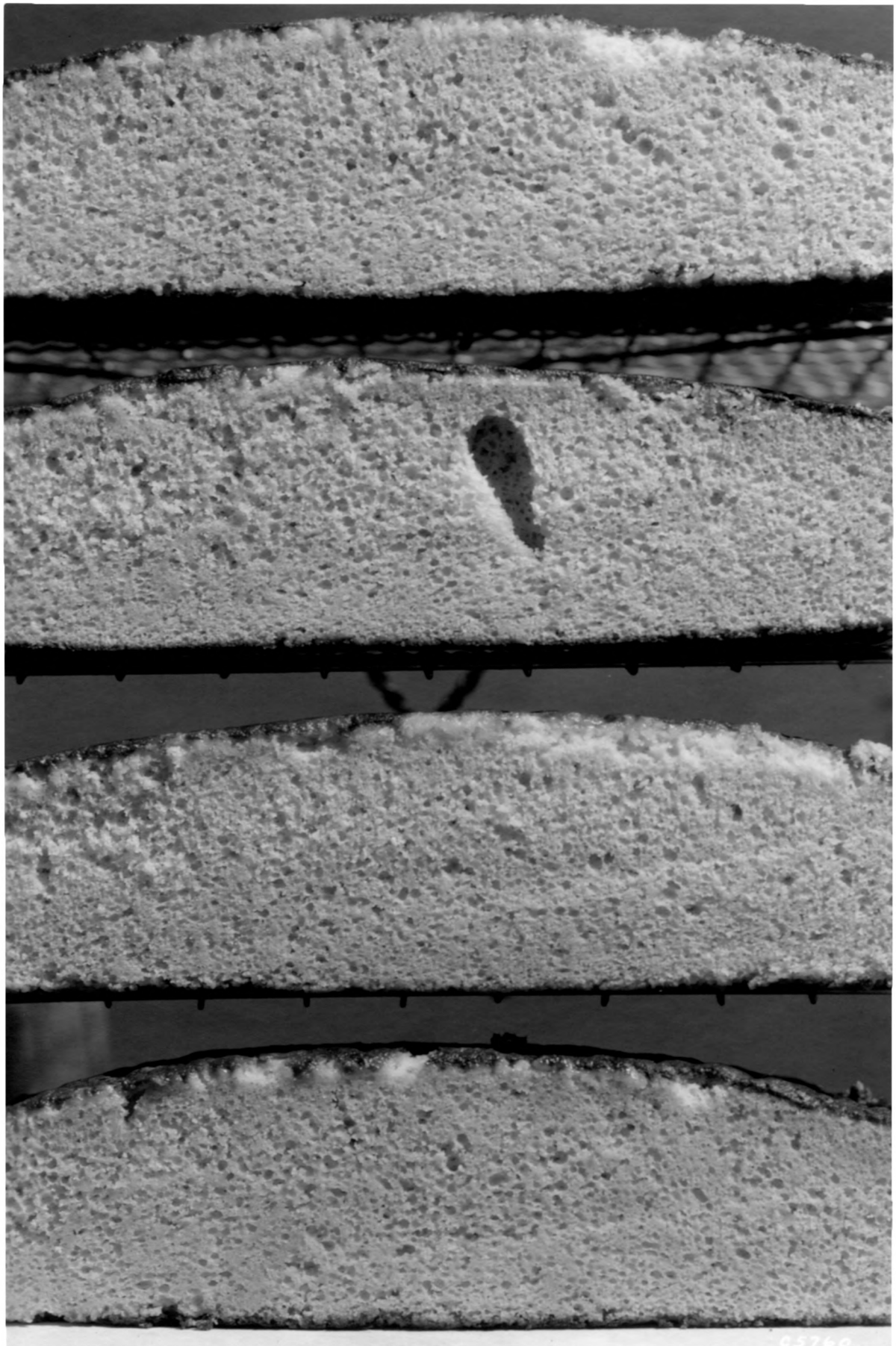
A -- Lard, Texturated

B -- Butter

C -- Lard, Bulk

D -- Oleomargarine

PLATE VII



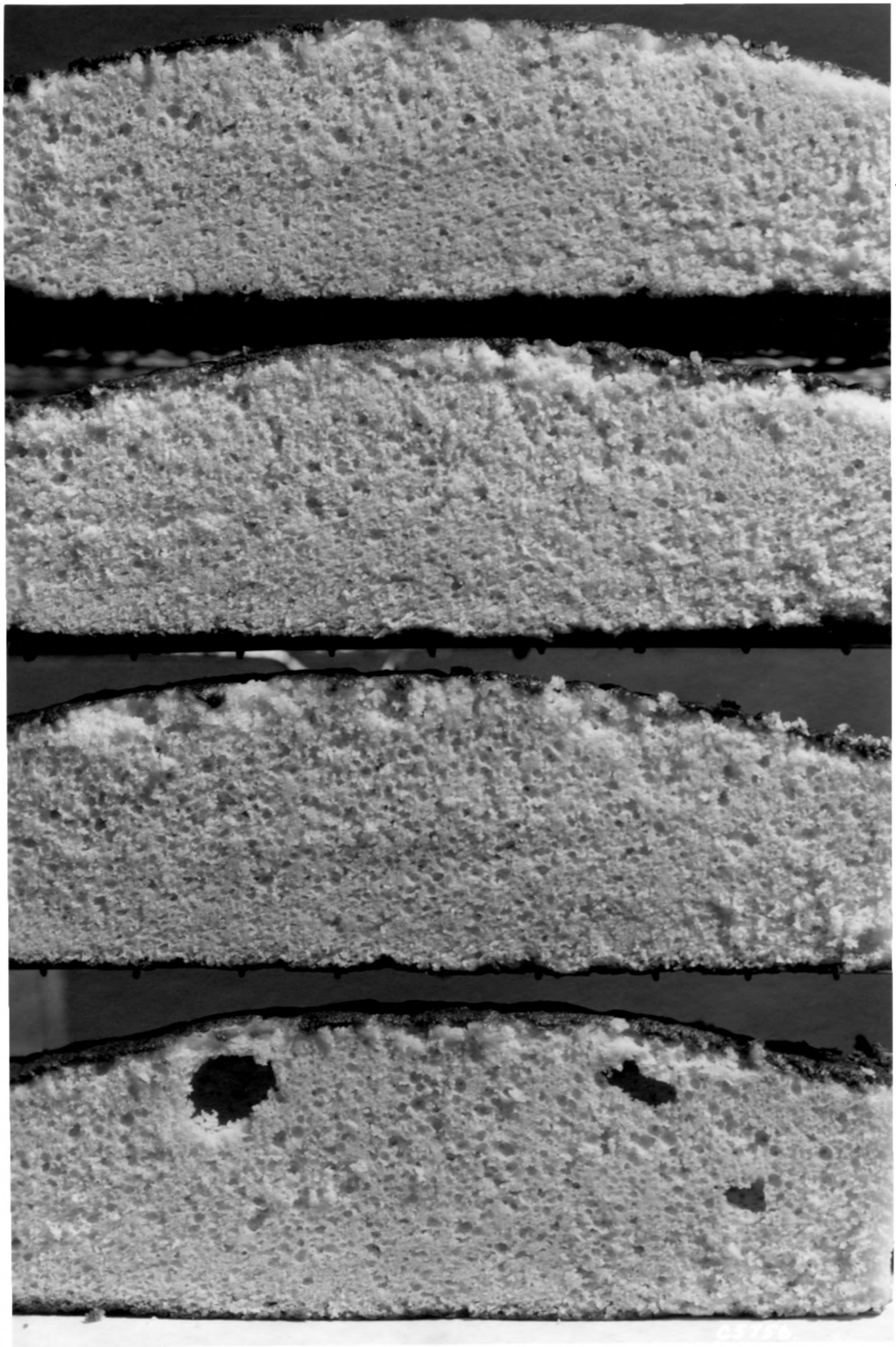
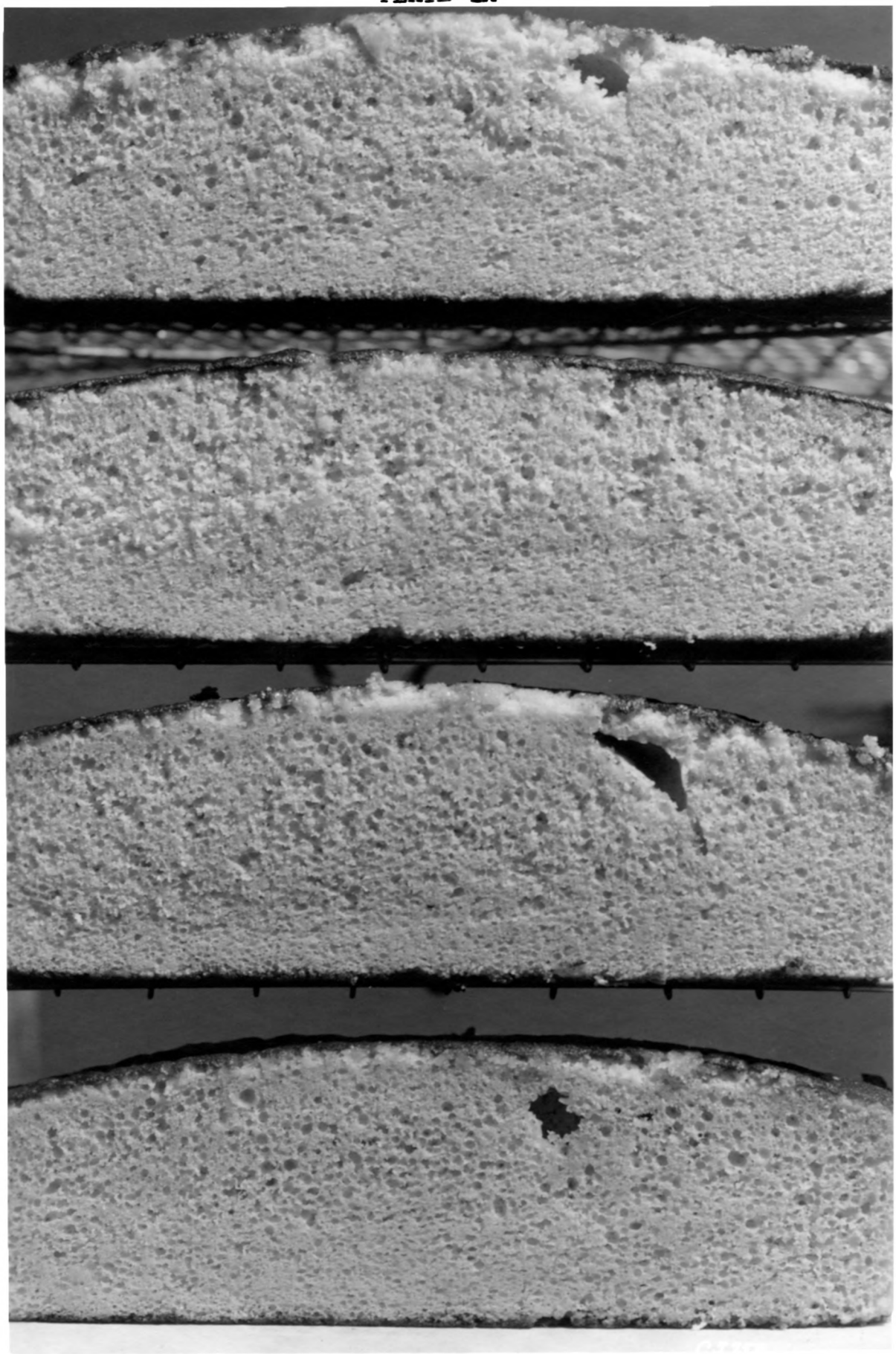

A
B
C
D

PLATE IX



Regardless of the fat used, the volume of the fat and sugar mixture was small when the weight or specific gravity was large. The volume was perceptibly larger when the specific gravity was small. The mixtures of high specific gravity were not light and fluffy as it was thought creamed mixtures should be, but were heavy and compact. This was particularly true of the mixtures containing bulk lard which were oily and heavy with long creaming. The mixtures of low specific gravity were light and fluffy indicating the incorporation of a considerable quantity of air. This was taken to mean a fat with high creaming properties.

The mixture containing butter (second series Table 1) had the highest specific gravity of all the mixtures creamed for two minutes. That containing oleomargarine was highest of all mixtures creamed 5, 9, 15 and 20 minutes. The mixture with Crisco was highest when creamed 7 minutes, and the one with bulk lard for 25 minutes.

The mixtures of home-rendered lard and sugar had the lowest specific gravity at 2, 5 and 7 minutes, and those of Clix and sugar at 9, 15, 20 and 25 minutes.

Home-rendered lard which was rather dark in color, became almost a pure white with creaming. On the other hand some fats, particularly Crisco, took on a grayish cast with long creaming, apparently due, at least in part to the metal bowl in which mixing was done.

Table 1. Summary of Data for Cakes Made with Different Fats.

Fat	Time of creaming	Temperature			Relative humidity	Specific gravity		Rate of flow of batter	Cake volume	Tensile strength		Compressibility
		Room	Creamed mixture	Batter		Creamed mixture	Batter					
	minutes	°C.	°C.	°C.				minutes and seconds	cc.	degrees	grams	mm.
Clix	2	24.2	24.7	25.2	67.2	1.024	0.767	5' 40"	1752.9	62.3	102.9	3.4
	5	23.5	24.3	24.2	65.8	.930	.767	11' 58"	1781.2	62.8	98.6	3.5
	7	23.2	24.2	23.7	65.2	.830	.784	5' 32"	1784.8	61.8	98.9	3.6
	9	24.6	24.5	24.0	62.7	.771	.741	9' 7"	1751.2	62.3	95.2	4.3
	15	24.1	24.8	24.5	65.2	.706	.743	7' 58"	1742.0	59.8	101.8	2.7
	20	23.8	24.8	24.1	65.1	.674	.740	7' 40"	1761.7	60.7	99.1	3.6
	25	24.5	25.3	24.5	63.3	.652	.717	6' 39"	1615.2	59.7	94.9	3.9
Butter	2	24.1	24.2	24.0	67.2	1.162	.830	3' 12"	1713.8	62.3	98.2	4.0
	5	23.5	24.4	24.3	65.8	.998	.774	3' 55"	1710.4	62.9	100.3	3.2
	7	23.5	24.5	24.0	65.2	1.015	.868	3' 28"	1715.5	61.5	98.9	3.9
	9	25.2	25.4	25.3	62.7	.962	.818	2' 42"	1749.6	62.7	93.6	4.1
	15	23.5	24.0	23.5	65.2	.938	.813	3' 51"	1790.6	61.8	103.9	4.0
	20	24.1	24.8	24.3	65.1	.942	.833	2' 41"	1710.5	62.3	94.9	4.1
	25	24.3	24.8	24.0	63.3	.984	.788	2' 25"	1678.8	64.4	95.9	4.5
Crisco	2	25.1	25.7	24.7	67.2	1.110	.847	2' 45"	1699.2	69.0	103.5	4.9
	5	23.1	25.1	24.0	65.8	1.099	.828	4' 48"	1710.4	62.0	92.2	3.2
	7	22.6	23.0	22.6	65.2	1.130	.820	4' 55"	1730.2	59.1	102.0	3.5
	9	23.8	24.3	23.9	62.7	.986	.759	9' 22"	1794.6	62.4	106.2	3.8
	15	23.5	24.2	23.9	65.2	.874	.754	**	1769.4	63.1	121.5	3.3
	20	24.1	24.3	23.9	65.1	.819	.731	**	1764.3	61.1	94.8	3.8
	25	24.2	25.1	24.5	63.3	.764	.685	**	1712.9	60.3	97.9	3.1
Lard, Home-rendered	2	24.5	24.5	27.8	67.2	.936	.837	1' 19"	1677.0	61.8	77.0	5.6
	5	23.3	24.3	23.9	65.8	.851	.837	1' 35"	1744.6	62.7	76.3	4.1
	7	22.2	23.1	23.1	65.2	.791	.832	1' 32"	1827.4	62.6	87.9	5.4
	9	23.8	24.3	23.9	62.7	.815	.809	2' 52"	1712.5	64.4	87.7	4.6
	15	23.4	24.6	23.6	65.2	.762	.821	3' 2"	1738.6	62.5	86.9	3.9
	20	23.5	25.1	24.0	65.1	.729	.814	2' 23"	1750.4	63.6	87.3	5.4
	25	25.0	25.5	25.0	63.3	.697	.819	2' 17"	1710.4	61.8	85.6	4.4
Butter	2	23.3	25.0	24.3	68.0	1.175	.815	2' 14"	1793.4	70.9	60.6	3.7
	5	25.7	25.5	25.2	69.5	1.028	.799	2' 40"	1759.2	67.0	88.3	2.8
	7	26.0	25.9	25.2	66.5	.977	.802	2' 19"	1728.4	66.6	87.2	3.9
	9	26.8	26.7	25.5	65.1	.981	.804	2' 30"	1748.9	68.0	98.6	3.4
	15	26.0	27.0	26.0	59.5	.955	.807	5' 19"	1744.3	68.6	84.7	5.1
	20	26.8	28.0	27.5	64.1	.972	.792	2' 6"	1724.9	65.4	84.6	4.8
	25	27.2	27.8	25.8	74.2	.974	.804	1' 48"	1740.9	70.7	89.6	5.5
Lard, Tex-turated	2	26.3	24.6	24.8	68.0	1.106	.872	56"	1701.0	66.5	87.9	3.3
	5	25.6	25.3	24.7	69.5	.970	.870	1' 1"	1712.6	65.9	84.9	2.9
	7	25.8	25.5	23.8	66.5	.959	.861	56"	1633.0	65.1	83.6	3.4
	9	26.0	26.3	25.3	65.1	.945	.870	55"	1706.7	66.3	114.1	2.8
	15	25.5	26.5	26.0	59.5	.904	.873	1' 2"	1695.3	69.2	90.6	3.4
	20	26.8	27.7	26.0	64.1	.866	.841	1' 17"	1726.0	67.8	82.1	4.3
	25	26.8	26.3	25.8	74.2	.652	.717	1' 2 "	1677.9	64.6	74.5	3.4
Lard, Bulk	2	26.3	25.7	25.2	68.0	1.117	.865	41"	1667.2	69.4	83.9	3.8
	5	26.2	25.5	24.8	69.5	.988	.827	53"	1679.3	65.3	76.2	3.4
	7	26.5	26.5	25.7	66.5	.965	.824	48"	1737.5	66.0	77.7	3.3
	9	26.8	26.6	25.5	65.1	.925	.848	40"	1755.5	68.4	86.2	3.4
	15	26.0	26.8	26.2	59.5	.903	.844	48"	1747.8	65.6	80.7	4.6
	20	26.7	27.0	26.2	64.1	.985	.819	53"	1755.7	66.8	77.4	5.1
	25	27.3	28.0	26.3	74.2	1.042	.871	40"	1755.7	66.9	95.1	3.9
Oleomar-garine	2	26.0	25.3	25.0	68.0	1.105	.855	51"	1796.7	71.8	101.9	2.9
	5	26.3	25.2	25.2	69.5	1.225	.833	41"	1623.5	68.1	99.5	2.9
	7	26.7	26.5	25.7	66.5	1.052	.825	1'	1703.3	70.5	93.4	3.3
	9	26.5	27.0	26.2	65.1	1.038	.828	58"	1724.9	71.0	111.5	2.0
	15	26.3	26.8	26.0	59.5	.987	.833	59"	1698.7	69.0	98.8	3.2
	20	26.7	27.2	26.2	64.1	1.018	.822	52"	1714.7	71.8	97.2	3.8
	25	27.8	28.5	26.8	74.2	1.031	.739	37"	1740.9	70.8	102.3	3.4

**Too thick to run through.

The batter containing Texturated Lard was highest in specific gravity no matter what the time of creaming. It varied only about 0.03 in specific gravity in the entire series.

The lowest specific gravity of the batter resulted when a hydrogenated fat was used. The batter containing Clix had the lowest specific gravity for the 2, 5, 7, 9 and 15 minute creaming periods and that containing Crisco for the 20 and 25 minute periods. Clix was consistently low in specific gravity whereas that containing Crisco became progressively less as the creaming time increased.

Apparently a close relationship exists between the specific gravity and the consistency of the batter as measured by the rate of flow. Mixtures with high specific gravity tend to flow more readily than those with a low specific gravity. Batters containing Clix with 2, 5, 7 and 9 minute creaming periods and Crisco with 15, 20 and 25 minute periods flowed most slowly.

The length of the creaming period, the specific gravity of the batter and the volume of the finished cake appeared somewhat related. With 2 minutes of creaming, when the specific gravity of the batter, on the whole, was high, the cakes tended to be small. The volume for the most part increased with the length of time of creaming until the maximum volume was reached. This maximum was reached with about

9 minutes of creaming but varied considerably with the various fats. Cakes containing one or the other of the hydrogenated fats had the largest volume for all periods of creaming except the 2 and 25 minutes. The cake containing butter, second series, was the largest for the short creaming period and that containing bulk lard for the long. This seems to indicate a tendency for a batter of low specific gravity to produce a cake of large volume.

The specific gravity of the fat and sugar mixture appears to be related to the angle through which a slice could be turned before breaking. Every time, except the cakes made by creaming the fat 2 minutes, those containing either Clix or Crisco broke at the smallest angle. The exception was home rendered lard, which for this creaming time, had the lowest specific gravity. With a five minute creaming period it also had a low specific gravity and it broke at about the same angle as the Clix and Crisco cakes. Cakes containing oleomargarine, which so often had a high specific gravity of the creamed mixture, were turned each time through the greatest angle before breaking. The tenderness as measured by the weight required to break a slice varied greatly. No consistency was noted as regards either the time of creaming, the fat used, or the specific gravity. Cakes made with butter, home-rendered lard, and bulk lard broke with the least weight. On the other hand, butter, in

one instance, required the greatest weight to break.

The compressibility, which at least to some extent measures the quality often designated as "velvetiness," appeared to be related to the specific gravity. However the effect of temperature and humidity on the compressibility was much more noticeable than on the other tests made. The variation in these last two factors may at least partially account for the results obtained. Cakes containing oleomargarine, which were each time turned through the greatest angle before breaking showed the least compressibility for 3 creaming periods and were low for the other periods. The results of the chemical analysis of the lards are as follows:

Sample of lard	M. P.	I_2 No.	Surface Tension	Rancidity as Oleic Acid
Texturated	40°	69.0	30.8	0.53
Home-rendered	45°	66.1	28.9	0.47
Bulk	44°	66.4	30.9	0.40

The difference in the Iodine number and the rancidity is probably not enough to be of importance in this work. A variation of 5°C. in the melting point might affect the consistency of the batter, but no such results were obtained. The chemist who made the surface tension determinations of the fats believed that the difference in surface tension was enough to affect the creaming capacity. A study of Table 1 shows that for each of the 7 creaming periods the

specific gravity of the creamed fat and sugar mixture was less for home-rendered lard than for either the Texturated or bulk lards. This seems to indicate a relationship between the surface tension and the creaming capacity, at least of lards.

In addition to the physical and chemical tests made, the cakes were scored by a committee of six judges including the experimental worker. This committee was composed of both faculty and students in the Division of Home Economics. The personnel of this committee was the same for the entire first series, but with the beginning of the second series it was necessary to replace two of the members. The judges were told at the beginning of the experiment the seven fats to be used, but they were not told that the experiment was divided into 2 series.

The comments of the judges regarding the cakes were for the most part favorable. However, in the second series a few cakes were decidedly objectionable as evidenced by the remarks made. Only one judge consistently refused to identify the fats. One or two of the judges seemed unable to overcome a prejudice in favor of butter for cake-making. This was shown by the fact that with few exceptions they believed the cake of their preference to be made with butter.

Table 2 shows the average scoring of the judges of the individual fats for the different periods of creaming as

Table 2. Summary of Scores of Palatability Committee.

	Time of creaming (min.)	Crust	Shape	Color	Crumb	Tenderness	Velvetiness	Eating quality	Averages
Clix	2	86.1	88.2	90.5	84.1	87.6	88.7	88.9	87.7
	5	86.4	88.3	90.5	86.3	87.8	88.4	88.5	88.3
	7	86.8	85.8	88.0	82.3	85.0	84.0	82.7	84.9
	9	88.4	88.9	89.9	85.0	86.6	86.7	89.3	87.8
	15	86.7	88.3	87.7	81.4	81.6	82.2	87.7	85.1
	20	87.3	91.3	90.9	85.2	89.1	83.9	89.8	88.2
	25	84.1	83.9	86.4	78.5	82.6	82.5	83.7	83.1
Average		86.5	87.8	89.1	83.3	85.8	85.2	87.2	86.5
Butter	2	76.1	86.0	86.0	81.1	84.5	87.2	83.5	83.5
	5	78.4	85.5	84.0	82.3	82.0	82.1	83.6	82.6
	7	80.9	86.8	88.6	86.6	88.3	86.4	83.6	85.9
	9	83.9	88.1	88.6	84.1	86.6	84.3	84.6	85.7
	15	83.2	88.1	87.4	85.9	88.8	88.7	87.1	87.0
	20	81.3	88.1	90.3	86.8	87.1	84.1	85.8	86.2
	25	79.8	87.8	86.6	84.1	88.0	84.9	84.0	85.0
Average		80.5	87.2	87.4	84.4	86.5	85.4	84.6	85.1
Crisco	2	82.0	85.0	82.4	79.9	78.9	77.4	78.6	80.6
	5	81.0	86.3	85.7	80.6	82.1	81.2	80.5	82.5
	7	82.7	89.1	89.6	84.6	86.4	85.8	85.3	86.2
	9	86.4	88.6	86.9	78.8	83.0	82.3	82.7	84.1
	15	84.2	86.1	83.1	78.6	82.9	83.5	81.3	82.8
	20	83.1	89.0	83.4	80.0	84.4	83.6	82.3	83.5
	25	82.0	89.0	85.6	81.1	83.0	83.7	83.0	83.9
Average		83.1	87.6	85.2	80.5	83.0	82.6	82.0	83.4
Lard, Home-rendered	2	76.8	87.5	87.7	85.0	87.5	88.1	86.2	85.5
	5	79.7	87.6	87.6	87.8	89.4	87.9	84.1	86.3
	7	79.5	89.6	90.5	88.9	90.3	87.9	86.3	87.6
	9	79.6	87.1	90.7	88.1	91.6	90.7	86.2	87.7
	15	80.2	86.7	89.0	86.6	91.0	88.5	85.8	86.8
	20	82.7	87.2	90.2	88.0	86.1	87.2	81.9	86.2
	25	75.0	89.2	87.5	85.5	89.1	88.4	82.4	85.3
Average		79.1	87.8	89.0	87.1	89.3	88.4	84.7	86.5
Butter	2	82.2	88.8	87.8	85.2	85.4	85.1	89.7	86.3
	5	83.8	88.7	89.2	85.4	87.2	85.1	90.4	87.1
	7	84.9	88.5	91.0	88.3	88.7	87.3	90.7	88.5
	9	81.9	90.6	92.1	87.9	90.7	89.4	92.4	89.3
	15	79.0	91.2	92.9	91.6	89.9	91.2	91.8	89.7
	20	81.8	92.2	93.3	87.6	91.1	90.1	93.3	89.9
	25	81.8	88.0	90.5	87.6	88.1	88.6	89.8	87.8
Average		82.2	89.7	91.0	87.7	88.7	88.1	91.1	88.2
Lard, Tex-turated	2	73.8	89.8	86.7	83.3	86.3	83.7	69.9	81.9
	5	74.4	88.2	85.9	83.1	84.2	83.7	73.7	81.9
	7	77.7	88.7	87.7	84.9	86.4	85.6	77.2	84.0
	9	77.2	89.3	89.3	84.5	87.7	86.7	75.0	84.3
	15	75.9	90.0	86.9	84.5	88.7	85.7	75.3	83.9
	20	74.3	85.2	86.2	85.6	84.7	85.3	77.6	82.7
	25	75.9	89.8	85.4	87.1	93.3	90.2	77.6	85.6
Average		75.6	88.7	86.9	84.7	87.3	85.8	75.2	83.5
Lard, Bulk	2	77.6	90.2	85.9	81.3	82.7	81.7	79.5	82.7
	5	76.0	88.0	88.9	86.0	89.8	88.3	84.7	86.0
	7	80.4	89.9	89.0	88.8	90.3	89.6	85.7	87.7
	9	75.7	91.3	87.1	87.6	88.6	90.3	81.7	86.0
	15	74.7	93.9	89.4	89.2	90.8	89.2	86.3	87.6
	20	77.9	87.9	89.7	86.9	88.1	88.6	83.7	86.1
	25	77.7	92.6	88.1	86.3	86.8	88.2	84.3	86.3
Average		77.2	90.5	88.3	86.6	88.2	88.0	83.7	86.1
Oleomargarine	2	75.3	90.2	84.6	77.1	77.2	79.1	82.4	80.8
	5	79.3	88.9	84.9	74.1	74.5	75.2	77.4	79.2
	7	80.9	88.1	87.9	74.5	81.9	77.5	83.9	82.1
	9	82.7	90.6	86.6	78.4	79.8	78.3	82.6	82.7
	15	77.0	90.2	87.4	78.8	81.1	81.8	81.4	82.5
	20	81.0	92.3	84.4	80.3	82.2	79.5	81.1	83.0
	25	80.6	90.2	84.1	81.3	82.7	81.6	82.7	83.3
Average		79.5	90.1	85.7	77.8	79.9	79.0	81.5	81.9

well as the total averages for each fat. The table shows considerable variation in the scoring of the crust. Those which scored low had moist, sticky crusts. This was particularly evident on the cakes made with lard. There was little variation in the scoring of the shape and the color. Cakes made with oleomargarine and Crisco had the least desirable crumb. They were also least tender and least velvety according to the scoring of the committee. Those containing other fats showed little variation.

When rated according to the score given for "eating quality," butter (second series) ranked first, then Clix, home-rendered lard, butter (first series), bulk lard, Crisco, oleomargarine and Texturated Lard.

The judges' preference for cakes in the first series showed butter and Clix to be equally desirable with home-rendered lard next and Crisco last. In the second series butter ranked first, then bulk lard, oleomargarine and Texturated Lard. There was a great deal of variation in the scoring of these points by the individual judges, but when the scores were averaged and compared, the results were quite consistent.

On the score card (Form 2), a space was provided for recording the kind of fat thought to be used. It was in this identification of the fats (Table 3) that the greatest inconsistency was shown by the judges. In the first series

Table 3. Results of Identification of Fats by Palatability Committee.

Number of times identified as*	Fats actually used							
	Clix	Butter, first series	Crisco	Lard, Home-rendered	Butter, second series	Lard, texturated	Lard, Bulk	Oleomargarine
Clix	31	16	20	14	1	6	8	10
Butter	38	55	14	19	84	--	5	8
Crisco	20	9	16	10	2	1	18	14
Lard, Home-rendered	--	12	8	10	--	15	3	1
Lard, Texturated	1	1	5	18	1	18	13	2
Lard, Bulk	2	3	7	13	1	6	25	4
Lard	18	7	18	30	--	53	10	6
Oleomargarine	11	27	22	3	5	1	19	47
Total for all types of lards	21	23	38	71	2	92	51	13

*That is, Clix was called Clix 31 times, Butter 38 times, et cetera.

where Clix, Crisco, home-rendered lard and butter were used, the fats were more difficult to identify than in the second series where Texturated Lard, bulk lard, oleomargarine and butter were used. Those in the second series had such a decided flavor that the judges were better able to identify the fat. Contrary to what might be expected, lard was not always easily detected. Home-rendered lard was called Texturated Lard and butter an equal number of times. It was also thought to be each of the other fats used. Bulk lard, too, was difficult to identify. It was guessed a number of times to be oleomargarine and Crisco. Texturated Lard had a flavor that was least liked of any, and was most easily recognized as lard. It was once called "bad lard", and three times called "unpleasant lard."

Clix, the hydrogenated lard, was the only fat identified as butter more times than as the fat it was. The second number of guesses was Clix, and the next Crisco.

Crisco was more times called Clix, oleomargarine and lard than Crisco.

The percentage identification of the fats by the judges is as follows: Texturated Lard as "lard", 98.8 per cent, as "Texturated Lard", 18 per cent; butter (first series) as, "butter" 42.3 per cent; home-rendered lard, as "lard" 71.8 per cent, and as "Crisco" 11.7 per cent; bulk lard, as "lard" 27.2 per cent; Clix, as "Clix" 25.6 per cent, and

as "butter" 31.4 per cent and oleomargarine, as "oleomargarine" 51.6 per cent.

SUMMARY AND CONCLUSIONS

This investigation was an attempt to find the effect of time of creaming of the fat and sugar mixture on the specific gravity and to note the relationship among these, the specific gravity of the batter and the quality of the finished product.

Seven fats were used in this study. The work was divided into two series. In the first Clix, a hydrogenated fat, home-rendered lard, butter and Crisco, a hydrogenated vegetable fat, were used, and in the second Armour's Texturated Lard, butter, Wilson's bulk lard, and Armour's Silver Churn Oleomargarine. Three checks were made on the first series and two on the second.

All work except the baking was done in a room with controlled heat and humidity. In spite of this the temperature and humidity varied considerably during the experimental period.

Ingredients for the series were as nearly identical as possible.

The manipulation varied only in time of creaming. The creaming time was 2, 5, 7, 9, 15, 20 and 25 minutes.

The following determinations were made: temperature, humidity, specific gravity of the creamed mixture, specific gravity of the batter, consistency of batter, volume of baked cake, compressibility, angle and weight required to break slices of cake, and quality as determined by a palatability committee.

The highest specific gravity of the fat and sugar mixture was obtained with 2 minutes of creaming.

The decrease in specific gravity of the fat and sugar mixture with increase in time of creaming varied with the different fats, being most pronounced with Crisco and Clix.

Crisco and Clix were the only fats which showed a close relationship between the specific gravity of the creamed mixture and of the batter. Other fats showed little variation in specific gravity of the batter.

The batters of low specific gravity were thick as measured by the rate of flow and produced cakes which were large in volume.

A low specific gravity of the batter resulted in cakes which broke at a small angle and had a fairly high compressibility. A high specific gravity of the batter resulted in cakes which broke at a greater angle.

On the whole, 9 and 15 minute creaming periods were desirable from the standpoint of both volume and quality of the cakes.

There were individual differences among the judges from day to day, but the averages were quite consistent. The judges' "preference" in the first series showed butter and Clix to be equally desirable, with home-rendered lard next, and Crisco last. In the second series the order of choice was butter, bulk lard, oleomargarine and Texturated Lard.

When rated according to the score given for the "eating quality" of the cakes the order varied slightly, butter from the second series ranking first, then Clix, home-rendered lard, butter from the first series, bulk lard, Crisco, oleomargarine, and Texturated Lard.

The identification of the fats by the judges varied. Butter in the first series was identified 42.3 per cent of the time, Clix 25.5 per cent, Crisco 14.5 per cent, and home-rendered lard as "lard" 71.8 per cent. In the second series butter was identified 92.2 per cent of the time, oleomargarine 51.6 per cent, Texturated Lard as "lard" 98 per cent, and bulk lard as "lard" 27.2 per cent.

As a result of this study it would seem that for the method of mixing and the creaming periods used, various fats give cakes with satisfactory external and internal characteristics. However the variation in flavor made some more desirable than others. As great a variation was found between the different types of lard, including the hydrogenated lard, as between all the fats used.

ACKNOWLEDGMENT

The investigator wishes to express her appreciation to Miss Gladys Vail of the Food Economics and Nutrition Department of Kansas State College for her interest and guidance.

LITERATURE CITED

Ahlborn, Margaret.
A comparison of the shortening power of various fats as tested by their tensile strength in a baked product. Jour. Home Econ. 18: 417-418. 1926.

Alexander, G. L.
Creaming for a definite time compared with creaming to a definite specific gravity. Cereal Chem. 8: 254-255. 1931.

Allen, Bernice.
Studies in cake making. Jour. Home Econ. 17: 337-338. 1925.

Barackman, R. A.
Report of subcommittee on methods of cake scoring. Cereal Chem. 7: 365-367. 1930.

Cawood, Jennie Fisher.
Lard. Bul. Dept. Scientific Research, Inst. Amer. Meat Packers. 71 p. 1934.

Cline, Jessie Alice.
The use of lard in cookery. Mo. Agr. Expt. Sta. Bul. 335, 26 p. 1934.

Davis, Clark E.
Shortening, its definition and measurement. Jour. Ind. and Engrg. Chem. 13: 797-799. 1921.

Denton, Minna, Baird, Ruth, Walker, Fanny, and Godfrey, Rosalie. Lards and lard substitutes in household pastry making. Jour. Home Econ. 13: 549-556. 1921.

Fisher, V. E.
Effect of temperature on the dough and its influence on the standard baking test. Cereal Chem. 7: 367. 1930.

Halliday, Evelyn J., and Noble, Isabelle.
Hows and whys of cooking. Chicago. Univ. Chicago Press, 175 p. 1928. (Ref. p. 64, 65, 67, 68).

Lewis, W. E.
Lard, from kettle to cake. Bul. Amer. Stove Co. 4, 4 p. 1934.

Lowe, Belle.
Experimental cookery. New York. Wiley & Sons, 482 p. 1932. (Ref. p. 388).

Lowe, Belle.
Use of lard in cake baking. Report, Sec. Natl. Lard Conference, 2 p. 1933.

Markley, M. C.
Method of preserving bread for permanent grain judging standards. Cereal Chem. 11: 200. 1934.

Platt, Washington, and Kratz, Phillip D.
Measuring and recording some characteristics of test sponge cakes. Cereal Chem. 10: 73-90. 1933.

Platt, Washington.
Shortening and the chemistry of baking. Amer. Food Jour. 18: 372. 1923.

Sweetman, Marion.
Food preparation. New York. Wiley & Sons, 339 p. 1932. (Ref. p. 318).