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A CRITICAL STUDY OF THE CHEMICAL AND PHYSICAL FACTORS INVOLVED IN CAKE MAKING.

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B. A comparison of the development of bread making and cake making.

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A CRITICAL STUDY OF THE CHEMICAL AND PHYSICAL FACTORS INVOLVED IN CAKE MAKING.

INTRODUCTION.

There is no specific history as to how and when the first cake was made. However, it is reasonable to suppose that it developed logically from bread making at an early date, when some clever cook found that the addition of several ingredients heretofore unused in her bread produced a loaf with a new and pleasing flavor. The origin of cake making is probably almost as ancient as that of bread making, yet the development of the two processes has been unequal and along divergent lines. At an early stage bread making was reduced to its simplest terms and was understood to be a mixture of basic ingredients made according to a formula of fairly definite proportions. This was largely due to the fact that bread making was so early commercialized and that even as far back as biblical times, bakers worked according to fixed rules to meet a demand for a standard product.

With cake making the process, instead of becoming more simplified, has become more complex. One reason for this fact is that cake making has never yet been successfully commercialized, partly because the materials necessary are more expensive and more perishable than those used in bread making, but probably because there has never existed a demand for a standard cake. Another reason can be found in the many different constituents used in cake making and the numerous possibilities of variation.

Much the same complex condition exists with cake making in the home. The average housewife believes that there are as many varieties of cake as there are recipes in her cookbook. Since the ingredients and proportions vary with each recipe, it never occurs to her that there is a possibility of reducing all these recipes to a common denominator, as it were, and of defining the limits of variation. To her mind there is something mysterious about cake making. She must follow the recipe verbatim in order to obtain a successful result, and even then she is in no wise certain as to the ultimate outcome until the cake is safely out of the oven. If, after long practice, the housewife does evolve some satisfactory rules and proportions, these are rarely handed down to the next generation, since these principles are habitual rather than verbal. The business of cake making is usually transferred to the daughter before she has had a great deal of experience in cooking, and she finds it easier to depend upon a printed recipe than upon the methods of her mother. Thus the progress made in one generation is too often lost in the next generation, and cook after cook grows up depending so literally on recipes that she never dreams of the underlying simplicity of this apparently complex art.

Investigations into the scientific principles underlying cake making are comparatively recent and few. Although the results obtained have not as yet undergone the test of time, still the scope and possibilities of the problem have been definitely established. These investigations have followed four lines: the economic phase, the method of mixing, the standardization of proportions, and the problem of baking. All of these investigations have one purpose in view, to organize and simplify the knowledge of this science so that it may be comprehended and applied practically by the average cake maker.

DISCUSSION OF INVESTIGATION ON CAKE MAKING.

The first work done on the problem of cake making was at Chicago University in 1909 when Miss Mabel Wellman[1] made a study of the methods of mixing cakes. She used weighed amounts of ingredients and kept the same proportions in all cakes made. The oven temperature was kept constant at 195°C. The methods of combining tested were as follows:

1. Cake Mixing - Mabel T. Wellman - American Journal of Home Economics, December 1909.

1. Sugar was beaten into the egg yolks, flour and baking powder added alternately with the milk, melted butter beaten in, then the well beaten egg whites added.

2. A part of the sugar was dissolved in the milk before making the cake, and other ingredients added as before.

The aim was to compare these methods of mixing with the conventional method in which the butter is creamed with the sugar rather than melted. Miss Wellman found that the batter differed in appearance from that of cakes mixed in the usual way, but after baking there was no difference either in taste or in appearance. She concluded that melted butter may be used in cake making with good results and that half the time consumed was saved by not creaming the butter and sugar.

Miss Ava B. Milam[1] made a study of cakes from the economic and dietetic standpoint at Chicago University in 1912 for her A. M. degree in the Department of Household Administration. She found that the form of sugar has a marked effect on the quality of cake produced. It is most desirable to have the sugar in the form in which it can be most easily

1. Factors Affecting the Economic and Dietetic Value of Foods. A Study of Cakes - Ava B. Milam - American Journal of Home Economics, June 1912.

and thoroughly mixed as long as it is kept in the solid state. Powdered sugar affords the most desirable form because it is finely divided. Cheaper fats, if fresh, may be substituted for butter. Of the fats used the lard substitutes seemed the most satisfactory, but oleomargarine was not tried. Her conclusions from the dietetic standpoint were that cakes made with water are of as good quality as those made with milk, and that with a standard three cups of flour recipe, one half cup of butter seemed to give a cake of a better quality than three-fourths of a cup of fat. Both substitutions lowered the food value of the cake, but this was not objectionable so long as cake was considered an accessory to the diet rather than an integral part of it.

Louis Jackson[1] made a study of the effect of albumen in baking powder on the specific volume of cup cakes. He found that the cakes made with albumenized powder had an average specific volume of 3.10, while those made with non-albumenized powder had an average of 3.11. This article was of interest because it was one of the first to give a definite method for determining the specific volume of a cake.

1. Egg Albumen in Baking Powder - H. Louis Jackson - The Journal of Industrial and Engineering Chemistry, December 1914.

Two bulletins on cake making by Katherine H. Mills were issued in 1914 by the State College of Agriculture at Cornell University. They contain a discussion of the ingredients used in cake making, some tested formulas, methods of mixing and baking, and several tables for substitution. Some of the conclusions drawn are the following:

1. When fine grained sugar is used in making cake, more air is included than when coarse grained sugar is used and the cake has a finer grain.

2. Sugar adds moisture to the cake, but too much causes the crumb to be moist and sticky and the crust sugary and gummy.

3. Eggs give lightness and help hold the various ingredients together.

4. A cake which contains much fat will crumble; an excess will cause it to be heavy.

5. As the proportion of fat is increased, there should be a corresponding increase in the amount of flour or a decrease in the amount of liquid. Also the amount of baking powder or egg should be increased with the fat.

6. If the mixing of ingredients has been very thorough, the method does not greatly influence the result obtained. Differences in results are due to variations in

the thoroughness with which the ingredients have been mixed, rather than to the order or manner of mixing.

Although these bulletins are presumably based upon scientific investigation, many of the conclusions are not substantiated by facts. These points will be discussed later in the conclusion of this thesis.

STATEMENT OF THE PROBLEM.

In this investigation we are especially interested in the study of the effect of the variations in the different proportions of the ingredients used in cake making. It has been generally accepted as a fact by teachers and students of home economics that when the specific gravity of the cake batter is too great the cake falls. With this as a starting point, we have made our investigations along the following lines:

1. The effect of the different constituents upon the specific gravity of the batter.

2. Experimental work to determine whether there is any relation between the specific gravity of the batter and the lightness, or specific volume of the cake.

3. A study of other factors which seemed to affect the lightness of the cake.

METHOD OF PROCEDURE.

In this thesis we have confined our attention to the so-called butter cakes. The necessary ingredients of these cakes are flour, liquid, fat, sugar and egg. Some form of leavening agent is usually added, though it is possible to leaven the cake by means of the air incorporated into the beaten egg white. In order to have the experiments comparable, one constituent must be kept constant in every cake. Since flour is the most basic constituent, it was taken as the constant factor. Three cups of flour were used in all of the proportions because this amount makes a cake of standard size. Since none of our utensils are standard or even uniform in size or shape, all of the dry ingredients were weighed rather than measured, and the liquids were measured in a one-hundred cubic centimeter cylinder. The following weights have been used as equivalent to the household measures by various investigators:

	(1)	(2)	(3)
1 cup of sugar	210g.	240. g.	118g.
1 cup of flour	100g.	122.2g.	
1 cup of butter	227g.	240. g.	
1 cup of milk	244g.		
1 egg yolk	20g.		
1 egg white	30g.		
1 cup of water	237g.	260. c.c.	
1 teaspoon baking powder	3g.		

Source of above weights:

1. Cake Mixing - Mabel T. Wellman - Journal of Home Economics, December 1909.
2. Some Points in the Making and Judging of Bread - Isabel Bevier - University of Illinois.
3. Cake Making - Katherine H. Mills - New York State College of Agriculture at Cornell University.

This diversity of opinion between trained investigators in regard to the weight of equal measures of the dry ingredients is the best argument we have for weighing rather than measuring them. The weights used in this investigation were taken from the figures given by Miss Wellman.

Pastry flour was used because its low gluten content makes it well adapted to cake making. Both sugar and flour were weighed in the desired amounts and put aside for mixing. The weighing was done on balances sensitive to a variation of a hundredth part of a gram. A piece of paper was placed on the left-hand side, and the balance adjusted. Then the correct number of weights was placed on the right-hand side and flour or sugar, after having been sifted once, was sifted onto the paper through a one-cup sifter. When the required amount was on the scales, the paper was removed and the flour poured upon a paper napkin, which was then pinned together and marked for future use. Sugar was weighed in the same way. The fat used was oleomargarine which was weighed as needed. The eggs and the skimmed milk were measured in a one hundred cubic centimeter cylinder. It was found that if the milk was warmed slightly there was less foam to interfere with accurate weighing. For the same reason the eggs were beaten only enough to break them up. A tartrate baking powder was used because it gives off gas slowly in the cold and less gas would thus be lost in any delay in getting the cakes into the oven. The baking powder was measured by level teaspoonfuls. No flavoring was used, since it made no change in the characteristics of the cake in which we were interested.

Utensils:

1. Quart sauce pans rather than small bowls were used for mixing because they were more easily handled.

2. A dover egg beater was used for mixing all cakes. In some instances the batter was so thin that the lumps could not be removed with a wooden spoon, other mixtures were almost too stiff for the beater, but it was found more uniform results would be obtained if each cake was mixed with the same utensil and with the same number of revolutions.

3. A small saucepan (one half pint) was used for melting the fat.

4. Ten square cake pans, size $5x5x1\frac{3}{4}$ inches, were used for baking. Two series were made at a time, as the first pans could not be ready for the second lot without delay. These pans were marked with white paint so that the cakes could be identified after removing them from the oven.

5. A Centigrade thermometer was used which was first standardized by testing in melting ice and in the steam from boiling water to establish the zero and boiling points. It registered correctly. It was inserted in the oven from the top through a small hole and was held in place by means of a spring clothespin on the outside of the oven. The temperature used was that given by Miss Wellman, 195°C.

6. Several small cylindrical bottles were used to weigh the cake batter.

7. Two large tin boxes were needed to preserve the cakes for future examination and comparison. In each of these was placed a small beaker of sulphuric acid, to provent too much moisture and consequent mold.

8. One set of balances sensitive to the variation of a hundredth part of a gram and one fine balance sensitive to the variation of a ten thousandth part of a gram were necessary for weighing.

General Method of Combining the Cakes.

The quart sauce pans were placed in a line on the table. Since the cake pans were not smooth, they were lined with greased paper and floured before being placed in order in a second line, beginning with number one. The small numbered bottles were likewise placed in order so that no mistakes could be possible. The egg and the milk were measured and poured into the saucepans. Next was added the fat which was not merely soft but entirely melted. One tablespoon of the flour was put aside to be added later with the leavening agent. Then the dry ingredients were sifted directly into the liquids, first stirred well and then beaten one hundred times with the dover egg beater. Each cake was mixed in this manner. Then a sample from each saucepan was placed in the bottle with the corresponding number, the thinner batters being poured in slowly, the thicker ones being dropped in carefully from the end of a teaspoon, to avoid air bubbles. Each bottle was filled rounding full and the excess leveled off with a spatula. The filled bottle was then weighed on a delicate balance. Into the rest of the batter were sifted the remaining tablespoon of flour and one and one half teaspoons of baking powder. The cake was then beaten twenty five times to insure thorough mixing, poured into the pan with the proper number and put into the oven.

Baking:

The temperature was kept as near 195°C as possible. It never registered below 190°C or above 205°C and then for only a few minutes. All of one series were baked at the same time. As soon as they were baked, the cakes were removed from the pans and promptly labeled with a piece of paper giving the proportions used. When entirely cool, they were put away in the tin boxes.

PRELIMINARY EXPERIMENTS.

A. Method of Mixing:

Before beginning systematic work on the problem, it was desirable to determine the best method of combining the ingredients. This method was found by the experiments cited below and was followed uniformly throughout the investigation, unless a statement to the contrary is made.

The usual method of mixing cake is to cream the butter and the sugar, add the egg yolks well beaten, then alternately the milk and the flour, and the well-beaten egg whites last. The baking powder is sifted with the flour. This is the oldest method and many people firmly believe that good cake can be made in no other way. They stress especially creaming the butter and the sugar, and beating the eggs separately and thoroughly before putting them into the cake.[1] The object aimed for is the thorough mixing of the ingredients of the cake. Some shorter methods were tried to see if one could not be found which would produce just as good a cake with uniform results and with less expenditure of time and energy.

Miss Wellman had found that by melting the butter and adding it to the flour and the liquid, it was possible to obtain a cake of practically as good texture as that produced by the more laborious task of creaming. The following methods were tried to see whether the differences in texture justified the time required:

1. The method described above, (page 13) the traditional way.

2. The liquid ingredients, milk, egg and melted fat were well mixed in a bowl and into these were sifted the dry ingredients, sugar, flour and baking powder.

1. For example, a popular cook book gives the following directions for mixing cake - Wash the butter in water (in summer use ice water) and cream until very light; add the sugar gradually and cream well together, alternate the milk and the flour, add the baking powder to the last cup of flour, beat the whites of the eggs until stiff and fold in at the very last.

3. The fat was rubbed into the flour with a fork, then the sugar was added and finally the liquid ingredients, everything being mixed at one time.

4. The sugar was dissolved in the liquid and egg mixture, and the flour stirred in, the melted butter being added last.

5. The sugar was dissolved as above, the fat rubbed into the flour and the two combined.

One-third of the following proportions was used in each of the five cakes.

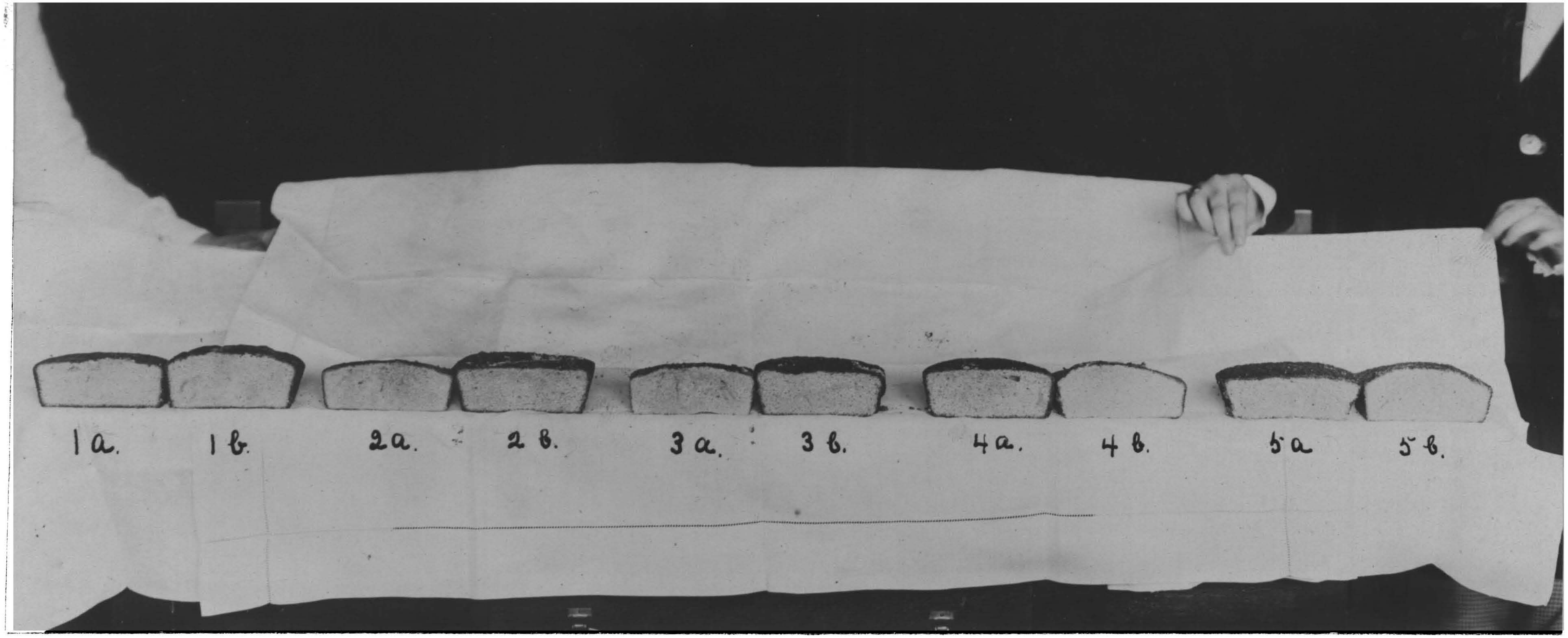
Flour, 3 cups	Liquid, 1 cup
Sugar, $1\frac{1}{2}$ cups	Eggs, 3 large
Fat, $\frac{3}{4}$ cup	Baking powder, 3 teaspoons

All of these ingredients were weighed or measured as previously described.

Except when the first method was used, the mixtures were much thinner than the usual consistency of cake batter, which was in accordance with the results reported by Miss Wellman. This was due to the fact that the fat was melted. Lumps could not be beaten out with a wooden spoon, so a dover egg beater was used, each cake being beaten the same number of times. After the cakes were baked, the one made by the traditional method proved to be the largest and of the best texture. Believing this to be due to the large amount of air incorporated in the cake by beating the eggs separately, the

ILLUSTRATION NUMBER I.

Cakes Combined by Different Methods.



1a. 1 teaspoon of baking powder.

1b. 1 teaspoon of baking powder.

2a. 1 teaspoon of baking powder.

2b. $1\frac{1}{2}$ teaspoon of baking powder.

3a. 1 teaspoon of baking powder

3b. $1\frac{1}{2}$ teaspoon of baking powder.

4a. 1 teaspoon of baking powder

4b. $1\frac{1}{2}$ teaspoon of baking powder.

5a. 1 teaspoon of baking powder

5b. $1\frac{1}{2}$ teaspoon of baking powder.

same series was repeated, an additional half teaspoon of baking powder being used in the other four cakes. All the cakes of this series were approximately the same size, and the cakes to which more baking powder had been added were noticeably larger than the same cake of the preceding series. (See Illustration No. 1)

With an idea of obtaining good texture in the least possible time, the length of time of mixing the five cakes was recorded as follows:

1. "Traditional" required 15 minutes for mixing.
2. Mixing liquid and dry ingredients, $2\frac{1}{2}$ minutes.
3. Rubbing fat into the flour, 4 minutes.
4. Dissolving sugar in the liquid, 6 minutes.
5. Dissolving sugar in the liquid and rubbing fat into the flour, 7 minutes.

There was a difference of $12\frac{1}{2}$ minutes in the time required to mix number one and number two, but very little difference in the texture of the cake, not enough to warrant the extra time required. If a little too much liquid should be added at one time in number one, or the liquid and flour not added alternately, the sugar would be dissolved and separated from the fat and number two would be the better cake as regards texture. On the other hand if care is used in mixing number two, a cake of uniformly good texture results. The cake in which the sugar was dissolved in the liquid ranked third. Those in which the fat was rubbed into the flour were coarse and heavy. (See Illustration No. 1)

Consequently, since the mixing of liquid and dry ingredients gave a cake of good size and texture when some additional baking powder was used, and since it took the least time for mixing, this method was selected for constant use in this investigation.

B. <u>Method of Determining Specific Gravity</u>:

1. Specific Gravity of the Constituents:-It has been generally accepted that the specific gravity of the cake batter has some definite relation to the lightness of the cake when baked and especially to its tendency to fall. It seemed desirable to know first of all the specific gravity of the various constituents. The following method was employed in determining this specific gravity: Four Florence flasks, of the smallest size obtainable (about 100 cubic centimeters) were marked with a glass cutter and each one weighed three times on fine balances, removing flask and weights from the pans of the balance each time. An average of these three weighings was taken as the weight of the flask.

Weight of the Flasks.

	I.	II.	III.	IV.
	20.3680grams	22.9157grams	25.627grams	22.270grams
	20.3677	22.9155	25.627	22.270
	20.3677	22.9155	25.627	22.270
Average	20.3678	22.9156	25.627	22.270

Next each flask was filled with distilled water and the excess leveled off with a spatula. Each flask was then weighed three times, emptying and filling it each time, and an average of the weights taken. The weight of each flask was subtracted from the weight of that flask filled with water and the cubic content of the flask found.

Cubic Content of Specific Gravity Flasks.

	116.9091grams	118.2719grams	127.8025grams	111.1315grams
	116.9073	118.2705	127.8020	111.1326
	116.9065	118.2719	127.8060	111.1321
Average	116.9076	118.2714	127.8035	111.1320
Wt.flask	20.3678	22.9157	25.6270	22.2700
Wt.water	96.5398	95.3557	102.1765	88.8620

Since approximately one gram of water equals one cubic centimeter, we have taken (without correction) the above weights as the volumes of the flasks. Flour and sugar were weighed, proceeding as above and using the same care, but the results showed a much greater variation, due to the difficulty of obtaining the same compactness each time.

Specific Gravity of the Flour.

64.5811	grams - weight of flask of flour
64.9797	
64.5657	
64.7088	average of the three weighings
22.9156	weight of the flask
41.7932	grams - weight of the flour
95.3557	cubic content of the flask

$\frac{41.7932}{95.3557} = .438$ the specific gravity of the flour.

Specific Gravity of Sugar.

99.2801	grams -	weight of flask of sugar
99.1182		
99.3768		
99.2401		average of the three weighings
20.3678		weight of the flask
78.8720		weight of the sugar

$\frac{78.8720}{96.5398}$ = .817 the specific gravity of the sugar.

The specific gravity of the skimmed milk and of the whole egg was taken by means of an ordinary specific gravity spindle. The average of the readings for the milk was 1.035 and for the egg 1.037.

Table of Specific Gravities of Constituents.

Reverse

Sugar	= .438	Skimmed milk	=1.035
Flour	= .817	Whole egg	=1.037

2. The Specific Gravity of the Batter:-The determination of the specific gravity of the batter itself was more difficult. At first these same flasks were used in these determinations. A batter of the following proportions was mixed: Flour 3 cups, liquid 1½ cups, fat ¼ cup, eggs 1½, and sugar varying from 1 to 2¼ cups. A flask was filled with a sample of each batter, leveling off the excess with a spatula. The baking powder was not added to the batter until after this sample was obtained, because it was found that the formation of the

carbon dioxide gas from the baking powder filled the batter with bubbles which interfered with the accuracy of the result. Subtracting the weights of the flasks from the weights of the flasks plus the batters, gave the following weight for the batters:

Sugar Varied - Other Ingredients Constant.

1 cup sugar	$1\frac{1}{2}$ cups sugar	$1\frac{3}{4}$ cups sugar	2 cups sugar	$2\frac{1}{4}$ cups sugar
108.2942	115.1545	102.0114	108.5709	111.3642
108.7547	120.5180	107.0310	115.1594	116.1322
116.1580	121.5995	105.5711	115.5008	116.1352
116.5727	123.1230	107.1650	115.4044	116.3822
110.0072	117.8380			

Accurate filling of the flasks was very difficult. Where the neck joined the rounded part, many unavoidable air bubbles were necessarily included. Several weighings were made of each batter with no very accurate results except in the case of those batters where the larger proportions of sugar were used. This was probably due to the fact that there was less variation in the amount of sugar which went into solution. Averaging the last three weights of each of these batters and calculating for the specific gravity gave the following results:

Amount of sugar	$1\frac{3}{4}$ cups	2 cups	$2\frac{1}{4}$ cups
Average weight of batter	106.5890	115.3548	116.2165
Specific gravity of batter	1.19	1.22	1.20

Since there was so much variation in these results, it was decided to substitute smaller cylindrical bottles for the larger flasks. These were much more easily filled because they had straight sides and if any large air bubbles did occur, they could be removed with a tooth pick. Moreover, they required so little batter to fill them that the rest of the mixture could have the leavening agent added and be baked, leaving the bottles to be weighed later. The smaller amount of batter used also made the percentage of error due to the incorporation of air less, so the bottles were used exclusively in all later experiments. They were marked and weighed just as the flasks were, and an average of the three weighings was taken as the weight of the bottles. In none of these weighings did the figures vary more than in the third place of the decimal.

Weights of the Bottles.

I.	13,4405	grams.
II.	13.2140	grams.
III.	14.6009	grams.
IV.	13.5005	grams.

Cubic Content of the Specific Gravity Bottles.

I.	20.6521
II.	20.4019
III.	17.8065
IV.	19.8312

C. <u>Method of Determining the Specific Volume of the Cake</u>:

An important factor in the success of a cake is its lightness. The specific volume, or the volume per unit of weight, was determined by the method described in an article on "Egg Albumen in Baking Powders" by Louis Jackson,[1] making some slight modifications. The basis of the method was to determine the volume of seed which the cake would replace. The method was substantially as follows:

A tin box was obtained which was large enough to hold the cake and have some space left over. This box was weighed three times, and an average of the three weights taken as the weight of the box, 275.8 grams. Clover seed were used because they were small and inexpensive. The box was filled lightly with seed and leveled off with a large spatula, the blade of which reached across the box. The seed and box were weighed and the box emptied; this operation was repeated twice, making three weighings with an average of 2071.5 grams. Subtracting the weight of the box (275.8 grams) from the weight of the box full of seed, gave the weight of seed the box held as 1795.7 grams. The volume of the box was also found by filling it with water, 2265 cubic centimeters. Then this box of water was weighed to see how nearly the weight in grams and the num-

1. Egg Albumen in Baking Powder - H. Louis Jackson - The Journal of Industrial and Engineering Chemistry, December 1914.

ber of cubic centimeters checked. The weight in grams of the water the box held was 2264.2. The weight of seed in grams that the box held divided by the cubic contents of the box in cubic centimeters gave the number of grams of seed in one cubic centimeter, .79.

On this basis, the specific volume of the cake was obtained as follows: A generous layer of seed was put into the box, and the cake to be measured placed on this. The remaining space was filled with seed, care being taken not to press down or shake down either cake or seed. The box thus filled was weighed, emptied and filled in the same manner three times, and an average of the three weighings taken. From the weight thus obtained was subtracted the weight of the cake and box which had been taken previously because the seed would stick to the cake in many cases, making the weights incorrect. This gave the weight of the seed in the box with the cake. Subtracting this weight from the weight of seed the box held, the weight of the seed replaced by the cake was obtained. This weight divided by the weight of one cubic centimeter of seed, gave the volume of the cake. The volume of the cake divided by its weight (found by subtracting the weight of the box), gave the specific volume of the cake in question. For example,

1740.5 grams - weights of box, seed and cake
1742.0
1744.2
1742.2 1/3 grams - average of the three weighings
591.3 grams - weight of box and cake
1150.9 1/3 grams - weight of seed in box with cake

1795.7 grams - weight of box full of seed
1150.9 1/3
664.7 2/3 grams - weight of seed replaced by cake

$\frac{664.7\ 2/3}{.79 \text{ (weight of 1 c.c. of seed)}} = 816.16$ grams, the volume of the cake

591.3
275.8 - weight of box
315.5 - weight of the cake

$\frac{816.16}{315.5} = 2.58$ the specific volume of the cake or the number of cubic centimeters for one gram of cake.

EXPERIMENTAL WORK.

A. Specific Gravity of the Batter.

After the three preliminary experiments previously described had been worked out and the methods of procedure determined, work was begun directly on the problem under consideration. The first question to be investigated was the specific gravity of the batter. This problem consisted of three parts which were as follows:

1. The effect of each constituent on the specific gravity of the batter.

2. Influence of variation in proportion of the different constituents on the specific gravity of the batter.

3. The influence of method of combining on the specific gravity of the batter.

1. The Effect of Each Constituent on the Specific Gravity of the Batter:-In investigating the effect of each of the ingredients on the specific gravity, the following experiments were carried out. The first point to be tested was the effect upon the specific gravity when the sugar was in complete solution. In order to be certain that all the sugar was dissolved, the milk and the sugar were heated over water. These solutions were allowed to cool before being measured or weighed, so that the results would be more accurate. Each solution was then measured in a graduated cylinder to see the relation between the total and combined volumes. The specific gravity of the solution was then taken according to the method given on page 17. The results were as follows:

how much? what?

Series I.

Measure of sugar in c.c.	Measure of liquid (milk)	Combined measure	Wt. of solution	Specific gravity
122.5c.c.	118.5c.c.	195c.c.	127.8185g.	1.25
122.5	98 2/3	175	121.9774	1.27
122.5	79 c.c.	151	126.8937	1.31
122.5	59¼ c.c.	132	120.0700	1.35

Series II.

Measure of sugar in c.c.	Measure of liquid (milk)	Combined measure	Wt. of solution	Specific gravity
122.5c.c.	118.5c.c.	191c.c.	39.2325g.	1.24
122.5	98 2/3	180	39.2004	1.26
122.5	79	152	37.8953	1.30
122.5	59¼	115	39.5154	1.36

Conclusions:-When solids go into solution, the combined measure is less than the sum of the measures of the original ingredients. As the liquid is decreased, the specific gravity of the sugar solutions is increased.

The next step was to note the effect upon the weight and the specific gravity of the mixture after the addition of each ingredient. After the specific gravity of the sugar solution had been obtained, the sample was emptied back into the mixing bowl and the amount of flour to be used was added. This was thoroughly mixed with the solution and a sample of this mixture weighed as before. This process was repeated after the egg had been added and again after the melted fat had been added, the same bottle being used each time. Finally, the specific gravity of the finished batter was determined. Proportions used were, flour three cups, fat one-fourth cup, sugar one and three-fourths cups, eggs one and one-half, liquid varying from three-fourths to one and one-half cups.

Series I.

Liquid	Wt. of solutions	After adding flour	After adding egg	After adding fat	Sp. Gr. Batter
$1\frac{1}{2}$c.	127.8185	125.5540	124.6030	124.2000	1.215
$1\frac{1}{4}$	121.9794	116.2544	115.5214	114.9051	1.215
1	126.8937	116.7392	114.1127	112.7877	1.16
$\frac{3}{4}$	120.0700	108.5165	106.6000	104.8700	1.18

Series II.

$1\frac{1}{2}$c.	39.2325	39.3143	39.4400	38.9409	1.23
$1\frac{1}{4}$	39.2004	38.9136	38.7500	38.1315	1.206
1	37.8953	36.9438	36.4314	36.0015	1.207
$\frac{3}{4}$	39.5154	38.1960	37.5379	37.1450	1.19

The sugar and milk solution weighed more than an equal quantity of any of the other mixtures. The addition of flour, egg, and fat decreased the weight of equal amounts, or the specific gravity, of the sample of batter in every case. As the liquid was decreased, there was a decrease in the specific gravity of the batter from 1.215 to 1.18 in one series, and from 1.23 to 1.19 in the second series. This decrease is what would be expected when we look at the specific gravities of the various constituents of the cake. While the specific gravity of the sugar solutions increase with the smaller proportions of liquid (see table, p. 24), the total amount is so much smaller that the lighter weight flour, egg, and fat more than compensate for this difference, and we have the final specific gravity of the batter in reverse order to the specific gravity of the sugar solution.

In order to determine the effect of having the sugar in solution, the above series was repeated by the usual method, combining the liquid and the dry ingredients, with the following results:

Liquid	Sp. Gr. of Batter.	% of liquid in terms of sugar.
$1\frac{1}{2}$ cups	1.11	85%
$1\frac{1}{4}$ cups	1.14	71%
1 cup	1.19	57%
$\frac{3}{4}$ cup	1.20	42%

The results here are exactly the reverse of those in the above experiment. As the liquid is decreased from one and one-half cups to three-fourths cup, there is an increase in the specific gravity from 1.11 to 1.20. The explanation of this lies in the fact that a large proportion of the sugar does not go into solution. We have as a result the ingredients acting independently rather than as a solution. In this case, decreasing the liquid which has a specific gravity lower than that of the resultant batter will naturally increase the specific gravity. The extent to which this influence is shown will depend upon the proportion of sugar which goes into solution. This proportion was found to vary with sugars of varying degrees of fineness. When a sugar of finer grain was used the following results were obtained instead of those above.

Sugar $1\frac{3}{4}$c.

$1\frac{1}{2}$c. liquid=1.215
$1\frac{1}{4}$c. liquid=1.217
1 c. liquid=1.22
$\frac{3}{4}$ c. liquid=1.23

2. Influence of Variation in Proportion of the Different Constituents on the Specific Gravity of the Batter.

(a) Effect of Decreasing the Liquid.

(1) Proportions[1]--flour 3 cups, fat $\frac{3}{4}$ cup, eggs $1\frac{1}{2}$, liquid varying from $\frac{3}{4}$ cup to $1\frac{1}{2}$ cups.

I.
Using $1\frac{3}{4}$ Cups of Sugar.[2]

Liquid	Sp. Gr. of Batter.	% of liquid in terms of sugar.
$1\frac{1}{2}$ cups	1.11 (2)	85%
$1\frac{1}{4}$ cups	1.14	71%
1 cup	1.19	57%
$\frac{3}{4}$ cup	1.20	42%

II.
Using 2 Cups of Sugar.

Liquid	Sp. Gr. of Batter.	% of liquid in terms of sugar.
$1\frac{1}{2}$ cups	1.14	70.5 %
$1\frac{1}{4}$ cups	1.17	62.5 %
1 cup	1.20	50 %
$\frac{3}{4}$ cup	1.22	37 %

III.
Using $2\frac{1}{4}$ Cups of Sugar.
(See Illustration No. 2)

Liquid	Sp. Gr. of Batter	% of liquid in terms of sugar.
$1\frac{1}{2}$ cups	1.21	66%
$1\frac{1}{4}$ cups	1.22	51%
1 cup	1.23	44%
$\frac{3}{4}$ cup	1.26	33%

1. Note - One-third of the proportions given were used in all experiments.

2. Data for these tables was taken from tabular record of experimental work appended.

Difference in specific gravities between $\frac{3}{4}$ and $1\frac{1}{2}$ cups of liquid.

With $1\frac{3}{4}$ cups sugar = 9
" 2 " " = 8
" $2\frac{1}{4}$ " " = 5

Decreasing the liquid increases specific gravity of the batter. The more sugar there is in proportion to liquid, when liquid and dry ingredients are combined, the less it goes into solution, and only that which goes into solution increases the specific gravity.

(2) Proportions--flour 3 cups, sugar $1\frac{3}{4}$ cups, eggs $1\frac{1}{2}$, liquid varying from $\frac{3}{4}$ to $1\frac{1}{2}$ cups.

I.
Using $\frac{1}{2}$ Cup of Fat.

Liquid	Sp. Gr. of Batter	% of liquid in terms of sugar.
$1\frac{1}{2}$ cups	1.16	85%
$1\frac{1}{4}$ cups	1.18	71%
1 cup	1.16	57%
$\frac{3}{4}$ cup	1.19	42%

II.
Using $\frac{3}{4}$ Cup of Fat.

Liquid	Sp. Gr. of Batter	% of liquid in terms of sugar
$1\frac{1}{2}$ cups	1.14	85%
$1\frac{1}{4}$ cups	1.12	71%
1 cup	1.18	57%
$\frac{3}{4}$ cup	1.16	42%

III.
Using 1 Cup of Fat.

Liquid	Sp. Gr. of Batter.	% of liquid in terms of sugar.
$1\frac{1}{2}$ cups	1.13	85%
$1\frac{1}{4}$ cups	1.15	71%
1 cup	1.16	57%
$\frac{3}{4}$ cup	1.14	42%

Difference in specific gravities between $\frac{3}{4}$ and $1\frac{1}{2}$ cups of liquid.

With $\frac{1}{2}$ cup fat= 3
" $\frac{3}{4}$ " " = 6
" 1 " " = 3

The results seem to be less regular here than in other cases. Probably the large amount of fat prevents the sugar from going into solution so readily. The extent to which this takes place depends upon the mixing rather than the absolute amount of fat used. With the larger fat content the specific gravity is not increased so much as the liquid is decreased.

(3) Proportions--flour 3 cups, sugar $1\frac{3}{4}$ cups, fat $\frac{1}{4}$ cup, liquid varying from $\frac{3}{4}$ to $1\frac{1}{2}$ cups.

I.
Using $1\frac{1}{2}$ Eggs.

Liquid	Sp. Gr. of Batter.	% of liquid in terms of sugar.
$1\frac{1}{2}$ cups	1.11	85%
$1\frac{1}{4}$ cups	1.14	71%
1 cup	1.19	57%
$\frac{3}{4}$ cup	1.20	42%

I.
Using 3 Eggs.

Liquid	Sp. Gr. of Batter.	% of liquid in terms of sugar.
$1\frac{1}{2}$ cups	1.12	85%
$1\frac{1}{4}$ cups	1.08	71%
1 cup	1.10	57%
$\frac{3}{4}$ cup	1.16	42%

II.
Using 4 Eggs.

Liquid	Sp. Gr. of Batter.	% of liquid in terms of sugar.
$1\frac{1}{2}$ cups	1.15	85%
$1\frac{1}{4}$ cup	1.11	71%
1 cup	1.13	57%
$\frac{3}{4}$ cup	1.17	42%

Difference in specific gravities between $\frac{3}{4}$ and $1\frac{1}{2}$ cups of liquid.

With $1\frac{1}{2}$ eggs = 9
" 3 " = 8
" 4 " = 6

Conclusion - Decreasing the liquid where a small amount of egg is used increases specific gravity. With larger amounts of egg, the specific gravity is still increased but to a less degree and in irregular sequence. This is probably due to a variable amount of air incorporated with the larger proportions of egg.

ILLUSTRATION NUMBER II.

Effect of Increasing Sugar.

	Top Row - 2 cups of sugar used.		Bottom Row -- 2¼ cups of sugar used.	
	(4)	(3)	(2)	(1)
Amt. of Liquid.	¾c.	1c.	1¼c.	1½c.

(b) Increasing the sugar.

(1) Proportions--3 cups of flour, $\frac{1}{4}$ cup of fat, $1\frac{1}{2}$ eggs, $1\frac{1}{2}$ cups of liquid.

I.
Using $1\frac{1}{2}$ Cups of Liquid.

Sugar	Sp. Gr. of Batter.	% of liquid in terms of sugar.
1 cup	1.17	150%
$1\frac{1}{2}$ cups	1.18	100%
$1\frac{3}{4}$ cups	1.20	85%
2 cups	1.21	75%
$2\frac{1}{4}$ cups	1.22	66%

II.
Using $1\frac{1}{4}$ Cups of Liquid.

Sugar	Sp. Gr. of Batter.	% of liquid in terms of sugar.
$1\frac{3}{4}$ cups	1.14	71.0 %
2 cups	1.17	62.5 %
$2\frac{1}{4}$ cups	1.22	51.0 %

III.
Using 1 Cups of Liquid.

Sugar	Sp. Gr. of Batter.	% of liquid in terms of sugar.
$1\frac{3}{4}$ cups	1.19	57%
2 cups	1.20	50%
$2\frac{1}{4}$ cups	1.23	44%

IV.
Using $\frac{3}{4}$ Cup of Liquid.

Sugar	Sp. Gr. of Batter.	% of liquid in terms of sugar.
$1\frac{3}{4}$ cups	1.20	42%
2 cups	1.22	37%
$2\frac{1}{4}$ cups	1.26	33%

Working out the liquid in per cent of sugar when other factors are constant, those containing a regular per cent of sugar gave fairly regular specific gravities.

Using the Same Method
of Combining.

150% = 1.17	
100% = 1.18	
85% = 1.20	85% = 1.20
70% = 1.21	70.5% = 1.14
66% = 1.22	
57% = 1.19	
51% = 1.22	
50% = 1.20	
44% = 1.23	
42% = 1.20	
37% = 1.22	
33% = 1.26	

Conclusion - As the per cent of liquid in terms of sugar decreases, the specific gravity increases.

(c) Increasing egg.

(1) Proportions--flour 3 cups, fat $\frac{1}{4}$ cup, sugar $1\frac{3}{4}$ cups, egg varying from $1\frac{1}{2}$ to 4.

I.
Using $1\frac{1}{2}$ Cups Liquid.

Eggs $1\frac{1}{2}$=1.11
Eggs 3 =1.12
Eggs 4 =1.15

II.
Using $1\frac{1}{4}$ Cup Liquid.

Eggs $1\frac{1}{2}$=1.14
Eggs 3 =1.08
Eggs 4 =1.11

III.
Using 1 Cup Liquid.

Eggs $1\frac{1}{2}$=1.19
Eggs 3 =1.10
Eggs 4 =1.13

IV.
Using $\frac{3}{4}$ Cup Liquid.
Eggs $1\frac{1}{2}$=1.20
Eggs 3 =1.16
Eggs 4 =1.17

Difference in specific gravities between $1\frac{1}{2}$ and 4.

With $1\frac{1}{2}$ cups liquid plus 4
With $1\frac{1}{4}$ cups liquid minus 6
With 1 cup liquid minus 9
With $\frac{3}{4}$ cup liquid minus 4

(2) Proportions--flour 3 cups, fat $\frac{1}{2}$ cup, sugar $1\frac{3}{4}$ cups, eggs varying from $1\frac{1}{2}$ to 4.

I.
Using $1\frac{1}{2}$ Cups of Liquid.

$1\frac{1}{2}$ eggs=1.16
2 eggs=1.16
3 eggs=1.10
4 eggs=1.16

II.
Using $1\frac{1}{4}$ Cups of Liquid.

$1\frac{1}{2}$ eggs=1.18
2 eggs=1.15
3 eggs=1.14
4 eggs=1.13

III.
Using $\frac{3}{4}$ Cup of Liquid.

$1\frac{1}{2}$ eggs=1.19
2 eggs=1.17
3 eggs=1.15
4 eggs=1.18

Difference in specific gravities.

$1\frac{1}{2}$ cups minus 6
$1\frac{1}{4}$ cups minus 5
$\frac{3}{4}$ cup minus 4

(3) Proportions--flour 3 cups, fat $\frac{3}{4}$ cup, sugar $1\frac{3}{4}$.

I.
Using $1\frac{1}{2}$ Cups Liquid.

$1\frac{1}{2}$ eggs=1.14
2 eggs=1.14
3 eggs=1.13
4 eggs=1.15

II.
Using $1\frac{1}{4}$ Cups Liquid.

$1\frac{1}{2}$ eggs=1.12
2 eggs=1.14
3 eggs=1.14
4 eggs=1.17

III.
Using $\frac{3}{4}$ Cup Liquid.

$1\frac{1}{2}$ eggs=1.16
2 eggs=1.18
3 eggs=1.15
4 eggs=1.16

Differences in specific gravities.

$1\frac{1}{2}$ cups liquid plus 2
$1\frac{1}{4}$ cups liquid plus 5
$\frac{3}{4}$ cup liquid plus 3

In general the specific gravity ~~de~~increases as the egg is increased up to 3 eggs. From that point on, it decreases with the addition of egg.

(d) Increasing fat.

(1) Proportions--flour 3 cups, sugar $1\frac{3}{4}$ cups, eggs $1\frac{1}{2}$, liquid $1\frac{1}{2}$ cups.

I.
Using $1\frac{1}{2}$ Cups Liquid.

$\frac{1}{4}$ cup fat	=1.11
$\frac{1}{2}$ cup fat	=1.16
$\frac{3}{4}$ cup fat	=1.14
1 cup fat	=1.13

II.
Using $1\frac{1}{4}$ Cups Liquid.

$\frac{1}{4}$ cup fat	=1.14
$\frac{1}{2}$ cup fat	=1.18
$\frac{3}{4}$ cup fat	=1.12
1 cup fat	=1.15

III.
Using 1 Cup Liquid.

$\frac{1}{4}$ cup fat	=1.19
$\frac{1}{2}$ cup fat	=1.16
$\frac{3}{4}$ cup fat	=1.18
1 cup fat	=1.16

IV.
Using $\frac{3}{4}$ Cup Liquid.

$\frac{1}{4}$ cup fat	=1.20
$\frac{1}{2}$ cup fat	=1.19
$\frac{3}{4}$ cup fat	=1.16
1 cup fat	=1.14

Differences in specific gravities.

$1\frac{1}{2}$ cups liquid	=5
$1\frac{1}{4}$ cups liquid	=6
1 cup liquid	=3
$\frac{3}{4}$ cup liquid	=6

(2) Proportions--flour 3 cups, eggs 2, sugar $1\frac{3}{4}$ cups, liquid $1\frac{1}{2}$ cups.

I.
Using $1\frac{1}{2}$ Cups Liquid.

$\frac{1}{2}$ cup fat=1.16
$\frac{3}{4}$ cup fat=1.14
1 cup fat=1.15

II.
Using $1\frac{1}{4}$ Cups Liquid.

$\frac{1}{2}$ cup fat=1.15
$\frac{3}{4}$ cup fat=1.14
1 cup fat=1.14

III.
Using $\frac{3}{4}$ Cup Liquid.

$\frac{1}{2}$ cup fat=1.17
$\frac{3}{4}$ cup fat=1.18
1 cup fat=1.17

Differences in specific gravities.

$1\frac{1}{2}$ cup liquid=2
$1\frac{1}{4}$ cup liquid=1
$\frac{3}{4}$ cup liquid=1

With smaller amounts of liquid, fat decreases the specific gravity. With larger amounts of liquid, fat does not change the specific gravity or may even increase it.

3. Influence of Method of Combining on the Specific Gravity of the Batter:-In the course of the experiment an investigation was made to see if the method of combining the ingredients had any effect on the specific gravity of the batter.

The same proportions were used as in the previous experiment on the method of combining (page 15). They were as follows:

Flour 3 cups	Liquid 1 cup
Sugar $1\frac{3}{4}$ cups	Eggs 3 large
Fat $\frac{3}{4}$ cup	Baking powder

The methods of combining used were as follows:

(a) The butter and the sugar were creamed, the well-beaten egg yolks were added, then alternately the milk and the flour, and the well-beaten egg whites last. The baking powder was sifted with the flour.

(b) The liquid ingredients, milk, egg yolk and melted fat, were well mixed and into these were sifted the dry ingredients, sugar, flour and baking powder. The beaten white was folded in last.

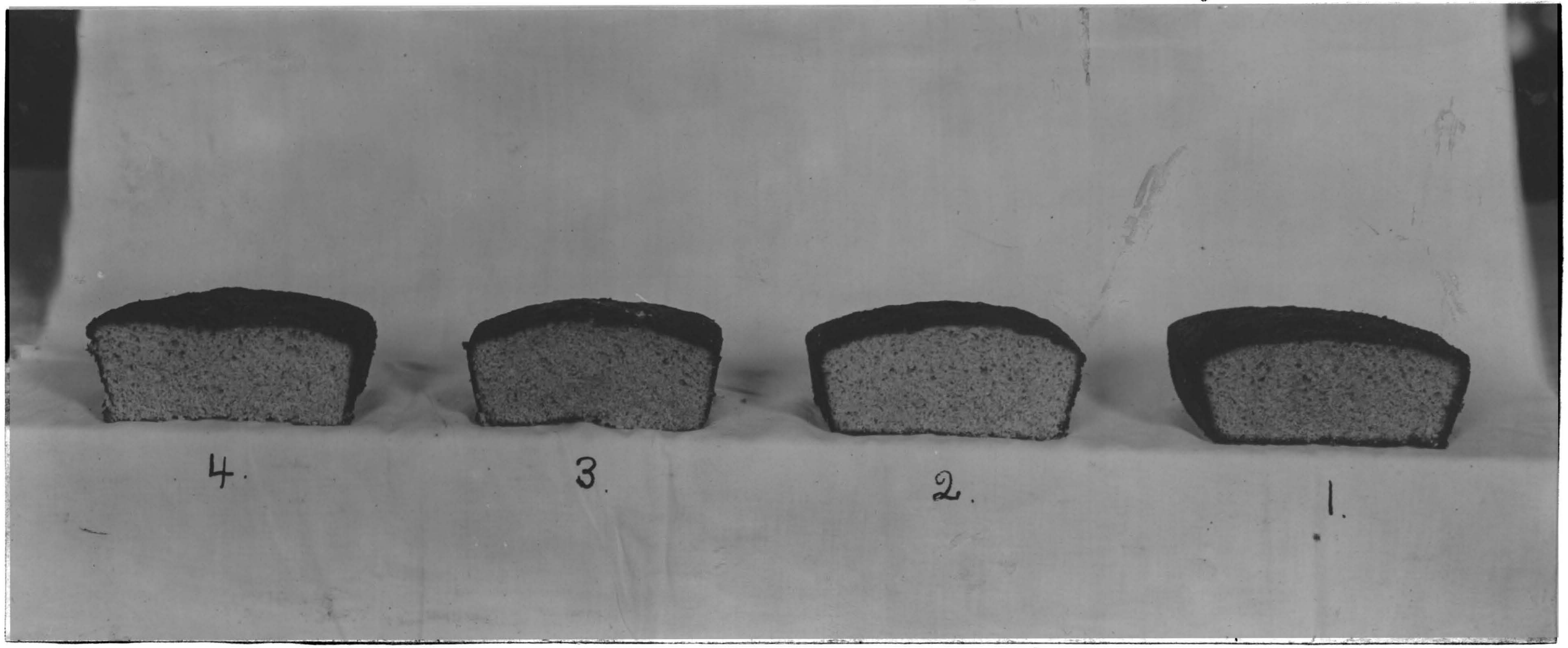
(c) This method was the same method as number two except that the egg was not separated. The whole egg was mixed with the liquid ingredients and then the dry ingredients added.

(d) The sugar was dissolved in the liquid, melted fat and egg mixture, and the flour and baking powder stirred in.

Two cakes were made by each method with the following results:

ILLUSTRATION NUMBER III.

Effect of Method of Combining on Specific Gravity.



1. Traditional
   1 teaspoon of baking powder.

2. Liquid and dry plus beaten egg white.
   1 teaspoon of baking powder.

3. Liquid and dry.
   $1\frac{1}{2}$ teaspoon of baking powder.

4. Sugar dissolved in liquid.
   $1\frac{1}{2}$ teaspoon of baking powder.

Method of Combining	Specific Gravity of Batter I.	II.
1. Traditional	.98	.98
2. Liquid and dry ingredients plus beaten egg white	.99	.99
3. Liquid and dry ingredients	1.15	1.14
4. Sugar dissolved in liquid	1.18	1.17

The method of combining affected decidedly the specific gravity of the batter. The batters to which beaten egg white was added had, as would be expected, the lightest specific gravity. The one where the liquid and the dry ingredients were combined ranked third, while that in which the sugar was dissolved in the liquid had the greatest specific gravity. This was due to the fact that more sugar went into solution in number 4 than in number 3, and the sugar in solution increased the specific gravity.

In cakes number 1 and number 2, only one teaspoon of baking powder was used. In cakes 3 and 4, one and one-half teaspoons of baking powder were used. It had been found in a preliminary experiment on method of combining (page 16) that cakes made by these methods required more baking powder, if they were to be as large as the one mixed by the traditional method. All these cakes were approximately the same size, showing that the air incorporated in one beaten egg white was equal in leavening capacity to one-half teaspoon of baking powder. The fact that cake number 2 was as large as cake number 1 proved definitely that creaming the butter and sugar does not incorporate any air. As to texture and appearance, the cakes ranked as follows:

Number 2, best texture and appearance.
Number 3, second.
Number 1, third - coarser texture than the above.
Number 4, coarsest as to texture and somewhat heavy.

Number 2 required more time for mixing than number 3, since the egg white was beaten alone, but this made it possible to lessen the amount of baking powder used. Since scientific opinion places all baking powder somewhat in disrepute, this point is worthy of consideration. Taking all factors into account, it was concluded that for household purposes, number 2 was the best method of combining cake.

B. Specific Volume.

The experiments upon specific volume were made to determine the effect of varying proportions upon the lightness of the cake. Three cups of flour and one and three-fourths cups of sugar were used throughout the series. The fat was increased from one-fourth to one cup, the eggs were increased from one and a half to four, and the liquid was decreased from one and a half to three-fourths cup. The following tables are records of the work done.

Interpretation of Work Done.

Cakes made with $\frac{1}{4}$ cup of fat, $1\frac{1}{2}$ eggs and liquid decreased from $1\frac{1}{2}$ to $\frac{3}{4}$ cup.

Sp. Gr. of Batter	Wt. of Cake	Size of Cake c.c.	Sp. Vol.	Comments.
1.11	279.6	609.24	2.18	Best cake.
1.14	267.9	628.68	2.~~27~~ 32	
1.19	260.2	615.55	2.36	
1.20	255.2	470.50	1.84	

Fat increased to 1/3 cup - other ingredients not changed.

1.18	325.1	591.18	1.81	
1.17	310.6	616.45	1.98	
	282.4	438.01	2.00	
1.19	266.2	597.55	2.16	

Fat increased to $\frac{1}{2}$ cup - other ingredients not changed.

1.16	300.8	555.19	1.83	All heavy
1.18	299.9	581.18	1.9~~7~~3	
	282.7	572.48	2.00	
1.19	267.7	378.86	1.41	

Fat increased to $\frac{3}{4}$ cup - other ingredients not changed.

1.14	312.9	584.00	1.86	All heavy and very tender.
1.12	314.0	584.20	1.86	
	293.6	550.54	1.87	
1.16	295.0	533.67	1.80	

Fat increased to 1 cup - other ingredients unchanged.

1.13	340.9	561.26	~~1.06~~ 1.64	All extremely heavy.
1.15	388.7	553.54	1.42	
	330.3	592.82	~~1.79~~ 1.83	
1.14	327.4	536.37	1.60	

Conclusions - From the tables above, it was found that with 1½ eggs, more than 1/3 cup of fat could not be used successfully. As the cakes increased in size, there came a point where the cell walls were no longer able to bear the strain and the cake fell. This point came sooner in cakes made with 1/3 cup of fat than where ¼ cup of fat was used. The specific volume seemed to increase with specific gravity until the point was reached where the cells were no longer able to bear the strain. The cakes made with ½ cup, ¾ cup, and 1 cup of fat and only 1½ eggs were uniformly heavy. The specific volume increased as before with the specific gravity up to the breaking point of the cell, which was in every case the cake made with 1 cup of liquid. This would seem to indicate that with ½ to 1 cup of fat, 1 cup of liquid gives the cake with the highest specific volume.

Using 2 eggs - increasing fat from ½ - 1 cup, liquid decreased from 1½ to ¾ cup.

½ Cup of Fat.

Sp. Gr. of Batter	Wt. of Cake	Size of Cake c.c.	Sp. Vol.	Comments.
1.16	320.8	662.61	2.06	
1.15	313.7	715.02	2.24	
	304.6	602.70	1.97	- Best cake.
1.17	230.4	585.86	2.03	

$\frac{3}{4}$ Cup of Fat.

Sp. Gr. of Batter	Wt. of Cake	Size of Cake c.c.	Sp. Vol.	Comments.
1.14	338.1	613.9	1.86	
1.14	315.7	591.5	2.10	
	324.5	590.3	2.31	- Best cake.
1.18	304.7	570.5	2.15	

1 Cup of Fat.

Sp. Gr. of Batter	Wt. of Cake	Size of Cake c.c.	Sp. Vol.	Comments.
1.15	357.9	686.03	1.63	
1.14	343.7	705.40	2.05	
	345.1	784.21	2.24	- Best cake.
1.17	338.3	707.89	2.08	

Conclusion - The cakes made with 2 eggs and $\frac{1}{2}$ cup or more of fat had uniformly a larger specific volume than when $1\frac{1}{2}$ eggs were used. This series as before seems to show that with these amounts of fat and 2 eggs, 1 cup of liquid is best.

Using 3 eggs - increasing the fat from $\frac{1}{2}$ - 1 cup. Liquid decreased from $1\frac{1}{2}$ to $\frac{3}{4}$ cup.

$\frac{1}{2}$ Cup of Fat.

Sp. Gr. of Batter	Wt. of Cake	Size of Cake c.c.	Sp. Vol.	Comments.
1.10	341.4	680.63	1.99	
1.14	328.2	672.94	2.02	
1.13	314.6	718.73	~~3.20~~ 2.28	- Best cake.
1.15	294.3	660.63	~~2.52~~ 2.24	

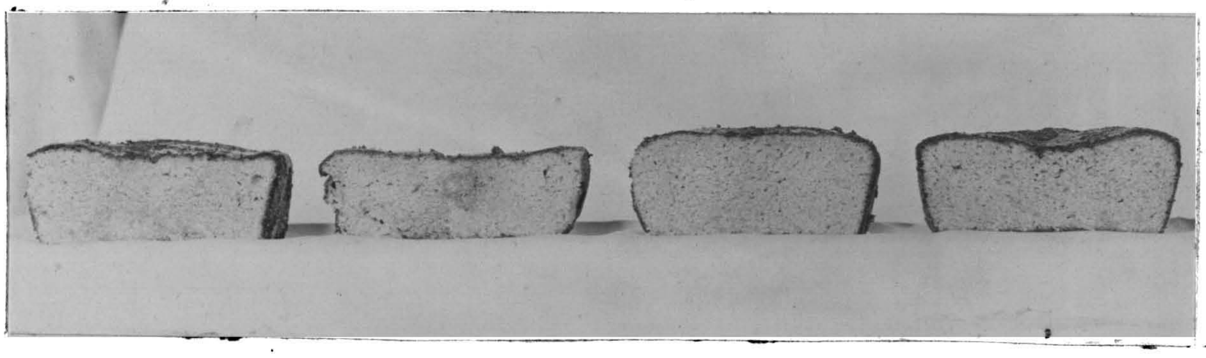
314.6) 718.73 (2.28
6292
8953
6292
26610
25168

$\frac{3}{4}$ Cup of Fat. - Illustration. No. 4.

Sp. Gr. of Batter	Wt. of Cake	Size of Cake c.c.	Sp. Vol.	Comments.
1.13	336.7	612.5	1.97	
1.14	337.0	612.8	2.18	
1.15	315.2	591.0	2.42	- Best cake.
1.15	310.0	585.5	~~2.51~~ 2.38	

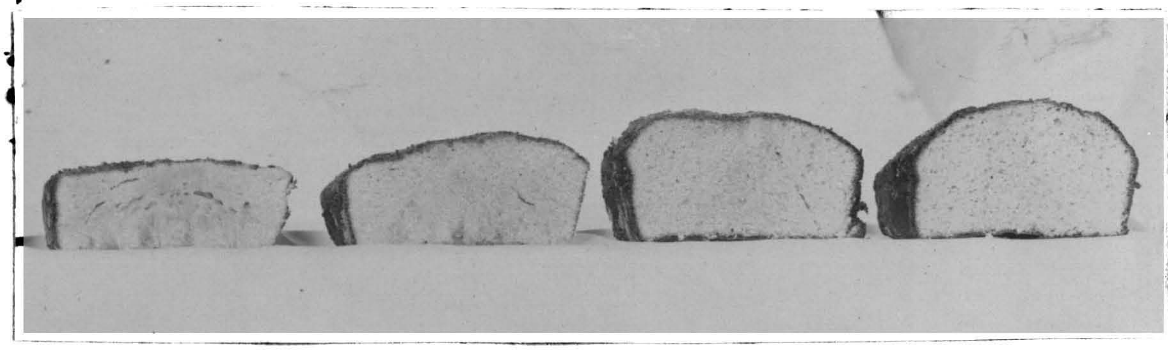
ILLUSTRATION NUMBER IV.
EFFECT ON SIZE OF CAKE WHEN
EGG AND FAT ARE INCREASED.

3 Eggs and $\frac{3}{4}$c. Fat.



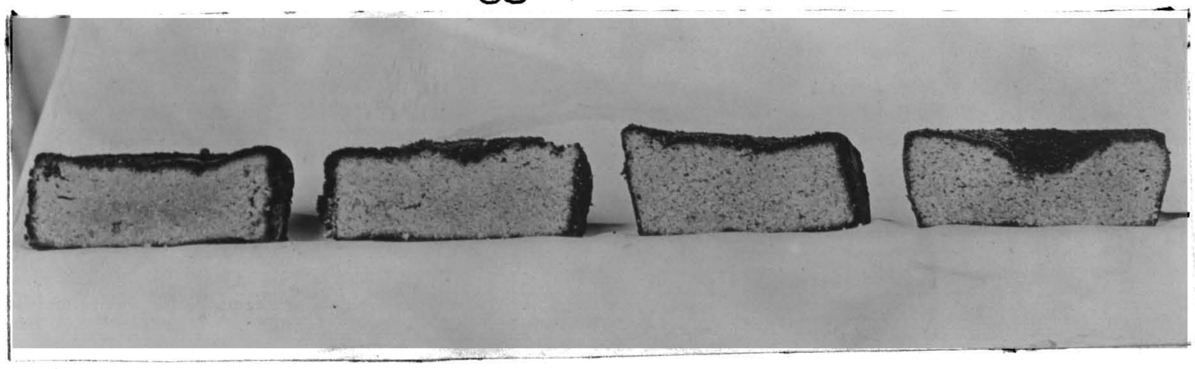
Liquid - $1\frac{1}{2}$c. $1\frac{1}{4}$c. 1c. $\frac{3}{4}$c.

4 Eggs and $\frac{3}{4}$c. Fat.



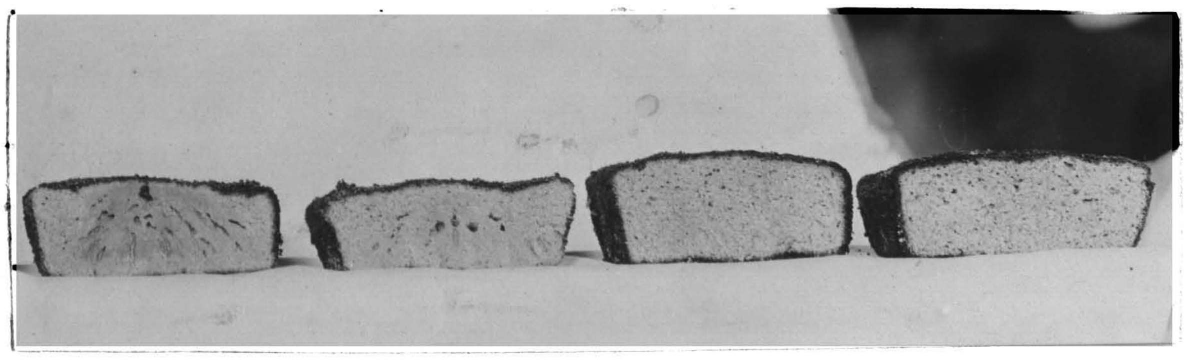
Liquid - $1\frac{1}{2}$c. $1\frac{1}{4}$c. 1c. $\frac{3}{4}$c.

3 Eggs and 1c. Fat.



Liquid - $1\frac{1}{2}$c. $1\frac{1}{4}$c. 1c. $\frac{3}{4}$c.

4 Eggs and 1c. Fat.



Liquid - $1\frac{1}{2}$c. $1\frac{1}{4}$c. 1c. $\frac{3}{4}$c.

1 Cup of Fat. - Illustration. No. 4.

Sp. Gr. of Batter	Wt. of Cake	Size of Cake c.c.	Sp. Vol.	Comments.
	367.2	643.0	1.86	
	361.4	637.2	1.88	
	355.7	631.5	1.97	- Best cake.
	342.3	618.7	1.86	

Conclusion - The specific volume of these cakes was uniformly larger. As the fat was increased ? ~~decreased~~ there was a decrease in specific volume. With 3 eggs, $\frac{3}{4}$ cup of fat seemed to be the largest amount that could be used successfully. In this series 1 cup of liquid gave the best results.

Using 4 eggs - increasing the fat from $\frac{1}{4}$ to 1 cup. Liquid decreased from $1\frac{1}{2}$ to $\frac{3}{4}$ cup.

$\frac{1}{4}$ Cup of Fat.

Sp. Gr. of Batter	Wt. of Cake	Size of Cake c.c.	Sp. Vol.	Comments.
1.15	344.5	626.02	1.81	
1.11	328.7	710.96	2.16	
1.13	320.4	810.16	2.52	Very little difference.
1.17	284.4	762.53	2.67	

$\frac{1}{2}$ Cup of Fat.

1.16	367.5	643.29	1.75	
1.13	356.7	733.40	2.06	
	323.2	821.05	~~2.46~~ 2.53	- Best cake
1.18	310.7	811.52	2.61	

$\frac{3}{4}$ Cup of Fat.

1.14	338.1	628.48	1.86	Illustration No. 4.
1.14	315.7	664.47	2.10	
	324.5	751.34	2.31	- Best cake.
1.18	304.7	655.74	2.15	

Tabulation given in as 2 egg

1 Cup of Fat.

1.15	357.9	686.03	1.63	Illustration No. 4. Same
1.14	343.7	705.40	2.05	
	345.1	784.21	2.24	- Best cake.
1.17	338.3	707.89	2.08	

Conclusion - In all this series the cakes made with 1 cup of liquid were the best ones. Too much liquid gave low specific volume, probably due to the effect on the cell wall. Too little liquid caused coarse texture, and where a large amount of fat was used, a slight falling of the cake.

Fat kept constant - eggs increased - liquid decreased.

Fat ¼ Cup.

Liquid	1½ eggs	2 eggs	3 eggs	4 eggs	
1½c.	2.18		~~2.46~~ 1.48	1.81	not agree with former
1¼c.	2.~~27~~ 32		2.32	2.05	
1 c.	2.36		2.72	2.52	
¾ c.	1.84		2.63	~~6~~ 2.67	

½ Cup of Fat.

Liquid	1½ eggs	2 eggs	3 eggs	4 eggs
1½c.	1.83	2.06	1.99	1.75
1¼c.	1.9~~7~~3	2.24	2.0~~2~~5	2.05
1 c.	2.00	1.97	2.2~~0~~8	~~3.46~~ 2.53
¾ c.	1.41	2.03	~~3.52~~ 2.24	2.61

¾ Cup of Fat.

Liquid	1½ eggs	2 eggs	3 eggs	4 eggs
1½c.	1.86	1.86	1.97	1.7~~8~~5
1¼c.	1.86	2.10	2.18	2.08
1 c.	1.87	2.31	2.42	2.37
¾ c.	1.80	2.15	~~2.51~~ 2.38	2.45

1 Cup of Fat.

Liquid	1½ eggs	2 eggs	3 eggs	4 eggs
1½c.	1.~~13~~ 64	1.~~63~~ 91	1.86	1.76
1¼c.	1.42	2.05	1.8~~7~~8	1.77
1 c.	1.83	2.2~~4~~7	1.97	~~2.32~~ 2.03
¾ c.	1.60	2.0~~8~~9	1.86	2.25

Conclusions - Egg--In most cases, the specific volume was increased with the number of eggs used up to 3, even when the fat was increased and the liquid decreased as far as 1 cup. When a small amount of liquid was used, the specific volume increased with the eggs. Liquid--The specific volume increased as the liquid decreased from $1\frac{1}{2}$ to 1 cup, even though the fat was increased, but with smaller amounts of liquid it decreased. Where a large amount of egg was used with the smaller amounts of fat, the specific volume continued to increase, even when $\frac{3}{4}$ cup of liquid was used.

2. Relation of Specific Gravity and the Falling of the Cake:-From the tables above, it was found that all cakes with a specific gravity higher than 1.18 fell, and in every case these proved to be cakes where too little liquid or too little egg was used in proportion to the amount of sugar. The specific gravities of all the good cakes varied between 1.08 and 1.18; however, not all the cakes with specific gravities of 1.10, 1.13 and 1.14 were heavy.

There are two factors which cause the cakes to fall. One is the specific gravity and the other is the strength and elasticity of the cell walls. This elasticity is increased by flour and egg, but decreased by fat and sugar. Since the relative proportion of flour is increased when the liquid is decreased, this also increases the elasticity of the cell. As has been seen, the specific gravity is affected most by sugar in solution. If cakes with a specific gravity below 1.18 fall, it can usually be explained on the basis of small proportions of flour or egg, or too much sugar, fat, or liquid. If the result is due to too much liquid, the cake is small, flat and soggy. If sugar is the cause, the cakes tend to fall in the center, have a coarse grain and a brittle, sticky crust. The fat is not held in well in such a cake and it feels greasy on the outside. When too much fat has been used in proportion to the other ingredients, the cake is small and will not hold together.

The limits of proportions were found to be as follows:

Flour	Liquid	Sugar	Fat	Eggs
3 c.	$\frac{3}{4}$-1$\frac{1}{2}$ c.	1-2 c.	$\frac{1}{4}$-1 c.	1$\frac{1}{2}$-5

In using these proportions, five general rules must be observed.

(a) As the sugar is increased, the total liquid must not be less than 72% of the sugar.

(b) As the sugar is increased, the eggs must be increased. Increased sugar means increased weight to be held up. The eggs strengthen the cell walls and maintain the elasticity of the cake.

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(c) As the fat is increased, the liquid must be decreased.

(d) As the fat is increased, the egg must be increased. Fat tends to weaken the cell walls and the increased egg will overcome this tendency.

(e) As the eggs are increased, the liquid must be decreased. Eggs supply some liquid. For example, in pound cake, a large amount of fat and eggs is used, and no liquid at all.

3. Effect of Baking on Specific Volume:-In order to see whether mixing or baking was the most important factor, two cakes were mixed separately using equal weights of the following proportions: flour 3 cups, fat $\frac{1}{2}$ cup, liquid 1 cup, eggs 3, sugar $1\frac{3}{4}$ cups. The specific gravity of this batter was 1.13. These cakes were baked at the same time and after cooling, they were measured for specific volume. The following figures were obtained:

	(a)	(b)
Weight of cake, seed and box	1740.5	1769.1
	1742.0	1770.1
	1744.2	1771.0
Average of three weighings	1742.2	1771.0
Weight of box and cake	591.3	587.3
Weight of seed in box with cake	1150.9	1183.7
Weight of box full of seed	1795.7	1795.7
	1150.9	1183.7
Weight of seed replaced	644.7	611.9
Weight of one c.c. of seed	$\frac{644.7}{.79} = 816.16$	$\frac{611.9}{.79} = 774.64$

$$\frac{\text{Volume of the cake}}{\text{Weight of the cake}} \quad \frac{816.16}{315.5} = 2.58 \text{ Sp. Vol.} \quad (a)$$

$$\frac{\text{Volume of the cake}}{\text{Weight of the cake}} \quad \frac{774.64}{311.5} = 2.48 \text{ Sp. Vol.} \quad (b)$$

Comparing these specific volumes with that of another cake using the same proportions but made previously, we found a greater difference. The specific volume of the other cake was 2.20, making a difference of .38 and .28 grams, respectively,

As a second experiment, enough batter for two cakes was mixed in one bowl. This insured the same proportions and method of combining. The specific gravity of this batter was 1.15. Then a weighed quantity of batter was put into each cake pan, and baked at the same time. The proportions used were: flour 3 cups, fat $\frac{3}{4}$ cup, sugar $1\frac{3}{4}$ cups, liquid 1 cup, eggs 3. The following figures were obtained:

Weight of seed, box and cake	1772.0	1774.3
	1778.2	1773.8
	1778.5	1780.3
Average of three weighings	1776.2	1779.0
Weight of box and cake	627.8	624.0
Weight of seed in box with cake	1148.4	1150.3
Weight of box full of seed	1795.7	1795.7
	1148.4	1150.3
Weight of seed replaced	647.2	645.4

Weight of 1cc of seed $\frac{647.2}{.79} = 819.32$

Weight of 1cc of seed $\frac{645.4}{.79} = 816.96$

$\frac{\text{Volume of the cake}}{\text{Weight of the cake}} \quad \frac{519.32}{352.00} = 2.32$ Sp. Vol. (a)

$\frac{\text{Volume of the cake}}{\text{Weight of the cake}} \quad \frac{816.96}{348.20} = 2.34$ Sp. Vol. (b)

The difference in the specific volume of these two cakes was only .02 grams. The specific volumes were likewise compared with that of another cake previously made in which the same proportions had been used. This specific volume was 2.17 making a difference of .15 and .17 grams.

In these experiments, the difference in the specific volume due to slight variations in mixing was, in the first instance, .10 grams and in the second, only .02 grams. Such a small difference proved that the slight variations in the same method of mixing affected the specific volume very little. When compared with the specific volume of a cake of another baking, the difference was much more, .38 grams and .28 grams in one case and .15 grams and .17 grams in the other. This greater difference was probably due to unavoidable variations in the temperature at which the cake was baked, either above or below the constant oven temperature.

CONCLUSIONS

A. Methods of Combining.

1. The traditional method is objectional in that it requires too much time and energy to accomplish the desired result. The second step, addition of milk, frequently counter-

acts all the good effects of the careful creaming of butter and sugar. Contrary to general opinion, no air is incorporated by creaming the butter and sugar.

2. Mixing the liquid and dry ingredients requires the least amount of time but it is necessary to add more baking powder. This is not needed when the egg white is beaten separately and added last. This method proved to be the most satisfactory in every way.

3. When the sugar is dissolved in the liquid, the cake is coarse in texture and heavy.

4. The process of rubbing the fat into the flour cannot be used successfully in cake making because it gives a streaked and heavy cake. This is due in part to the poor mixing of the fat when combined in this way and in part to the soaking up of fat by the flour.

B. Specific Gravity.

1. The specific gravity of the batter is increased by increasing the sugar or decreasing the liquid. Excess egg will also cause the same effect.

2. Specific gravity is decreased by decreasing the sugar, increasing the liquid, fat, or eggs up to three.

3. The method of combining the ingredients affects the specific gravity of the batter in two ways.

(a) Effect on solution of sugar.

(b) Incorporation of air. (Less important because it can be overcome by the addition of baking powder.)

4. When the sugar is dissolved in the liquid, the batter is heavier than when liquid and dry ingredients are combined, because only the sugar which goes into solution affects the specific gravity.

5. When additional air is added in the beaten egg white, the specific gravity of the batter is lighter.

C. Specific Volume.

1. Fat can only be increased as eggs are increased without lowering the specific volume of the cake.

2. Changes in egg and fat cause greater variations than changes in egg and liquid.

3. Not all changes in specific volume can be accounted for by the variations in ingredients. The temperature at which the cake is baked was shown to have some effect upon the size and lightness of the cake.

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INCREASING FAT.

Using $\frac{1}{4}$ Cup of Fat and $1\frac{1}{2}$ Eggs.

Liquid.	Sp. Gr. Batter	Wt. of Cake.	Wt. of Box & Cake.	Weight of Box, Seed and Cake.	Weight Seed in Box With C	Wt. of Seed Replaced	Volume of Cake	Sp. Vol. of Cake	Comments.
$1\frac{1}{2}$c.	1.11	279.6	555.4	1868.2 1869.1 1872.1 Av 1869.8	1314.4	481.3	609.24	2.18	Fairly good grain and lightness
$1\frac{1}{4}$c.	1.14	267.9	543.7	1845.2 1842.2 1841.2 Av 1842.8	1299.1	496.6	628.68	2.27 2.34	A smaller cake,-heavier and coarser.
1 c.	1.19	260.2	536.0	1845.6 1845.0 1845.6 Av 1845.4	1309.4	486.3	615.55	2.36	Still heavier and coarser. Slight depression in center.
$\frac{3}{4}$ c.	1.20	255.2	531.0	1954.6 1956.6 1955.5 Av 1955.5	1424.0	371.7	470.50	1.84	Fell. Had a sugary crust.

II.

Using 1/3 Cup of Fat and $1\frac{1}{2}$ Eggs.

Liquid.	Sp. Gr. Batter	Wt. of Cake.	Wt. of Box & Cake.	Weight of Box, Seed and Cake.	Weight Seed in Box With C	Wt. of Seed Replaced	Volume of Cake	Sp. Vol. of Cake	Comments.
$1\frac{1}{2}$c.	1.18	325.1	600.9	1929.6 1929.0 1930.1 Av 1929.5	1328.6	467.0	591.18	1.81	Best grain of series.
$1\frac{1}{4}$c.	1.17	310.6	586.4	1894.7 1891.7 1899.0 Av 1895.1	1308.7	487.0	616.45	1.98	Slight depression - heavy.
1 c.		282.4	558.2	1908.6 1908.8 1904.1 Av 1907.1	1348.9	446.7	565.53	2.00	Greater depression.
$\frac{3}{4}$ c.	1.19	266.2	542.0	1882.0 1884.5 1880.5 Av 1882.3	1340.3	455.4	576.45	2.16	Greatest depression.

III.

Using $\frac{1}{2}$ Cup of Fat and $1\frac{1}{2}$ Eggs.

Liquid.	Sp. Gr. Batter	Wt. of Cake.	Wt. of Box & Cake.	Weight of Box, Seed and Cake.	Weight Seed in Box With C	Wt. of Seed Replaced	Volume of Cake	Sp. Vol. of Cake	Comments.
$1\frac{1}{2}$c.	1.16	300.8	576.0	1930.3 1937.6 1933.0 Av 1933.6	1357.0	438.6	555.19	1.83	A heavy cake.
$1\frac{1}{4}$c.	1.18	299.9	575.7	1913.0 1909.3 1914.5 Av 1912.2	1336.5	459.1	581.18	1.97 34	Slight depression, very heavy.
1 c.		282.7	558.5	1903.5 1905.3 1897.0 Av 1901.9	1343.4	452.2	572.48	2.00	Greater depression.
$\frac{3}{4}$ c.	1.19	267.7	543.5	1939.4 1935.0 1945.3 Av 1939.9	1496.4	299.3	378.86	1.41	Greatest depression.

IV. (Continued)

INCREASING FAT.

Using $\frac{3}{4}$ Cup of Fat and $1\frac{1}{2}$ Eggs.

Liquid.	Sp. Gr Batter	Wt. of Cake.	Wt. of Box & Cake.	Weight of Box, Seed and Cake.	Weight Seed in Box With C	Wt. of Seed Replaced	Volume of Cake	Sp. Vol. of Cake	Comments.
$1\frac{1}{2}$c.	1.14	312.9	598.7	1923.3	1334.1	461.6	584.21	1.86	Not so heavy as last series.
				1921.3					
				1927.0				✓	
				Av 1923.8					
$1\frac{1}{4}$c.	1.12	314.0	598.8	1923.9	1334.1	461.5	584.20	1.86	Fell apart - too much fat.
				1927.4				✓	
				1920.5					
				Av 1923.9					
1 c.		293.6	579.4	1939.7	1360.9	434.9	550.54	1.87	Fell apart - slight depression.
				1941.9				✓	
				1939.6					
				Av 1940.3					
$\frac{3}{4}$ c.	1.16	295.0	570.8	1943.0	1374.1	421.6	533.67	1.80	Greater depression - grain very
				1945.0				✓	bad.
				1946.7					
				Av 1944.9					

V.

Using 1 Cup of Fat and $1\frac{1}{2}$ Eggs.

Liquid.	Sp. Gr Batter	Wt. of Cake.	Wt. of Box & Cake.	Weight of Box, Seed and Cake.	Weight Seed in Box With C	Wt. of Seed Replaced	Volume of Cake	Sp. Vol. of Cake	Comments.
$1\frac{1}{2}$c.	1.13	340.9	616.7	1967.0	1352.3	443.4	561.26	1.06	Broke - heavy and coarse.
				1969.5				1.64	
				1970.5					
				Av 1969.0					
$1\frac{1}{4}$c.	1.15	388.7	614.5	1973.9	1358.4	437.3	553.54	1.42	Broke.
				1972.4					
				1972.4				✓	
				Av 1972.9					
1 c.		330.3	606.1	1924.4	1317.3	478.3	605.48	1.79	Pretty good - light.
				1922.4					
				1923.6				1.83	
				Av 1923.4					
$\frac{3}{4}$ c.	1.14	327.4	603.2	1977.0	1371.9	423.7	536.37	1.60	Fell but not as much as with $\frac{3}{4}$
				1971.2				1.64	cup of fat.
				1977.3					
				Av 1975.1					

I.

VARYING FAT AND EGGS.

Using $\frac{1}{4}$ Cup of Fat and 3 Eggs.

Liquid.	Sp. Gr Batter	Wt. of Cake.	Wt. of Box & Cake.	Weight of Box, Seed and Cake.	Weight Seed in Box With C	Wt. of Seed Replaced	Volume of Cake	Sp. Vol. of Cake	Comments.
$1\frac{1}{2}$c.	1.12	317.2	593.0	1903.0	1413.0	372.7	471.77	1.48	Somewhat heavy. Pasty but
				1905.0					with more grain than 4 eggs
				1910.0				✓	and $1\frac{1}{2}$ cups liquid.
				Av 1906.0					
$1\frac{1}{4}$c.	1.08	305.6	581.4	1816.8	1234.5	561.1	710.27	2.32	Larger cake, good grain, good
				1814.0					proportions.
				1817.0					
				Av 1815.9					
1 c.	1.10	275.7	551.5	1750.0	1202.9	592.7	750.29	2.72	Largest and best cake of the
				1758.0					series.
				1755.4					
				Av 1754.4					
$\frac{3}{4}$ c.	1.16	265.9	541.7	1774.0	1233.8	561.8	711.18	2.63	Larger than number 2 but not
				1777.0				✓	such good texture.
				1775.7					
				Av 1775.5					

II. (Continued)

Using 1/3 Cup of Fat and $1\frac{1}{2}$ Eggs.

Liquid.	Sp. Gr. Batter.	Wt. of Cake.	Wt. of Box & Cake.	Weight of Box, Seed and Cake.	Weight Seed in Box With C.	Wt. of Seed Replaced.	Volume of Cake	Sp. Vol. of Cake.	Comments.
$1\frac{1}{2}$c.	1.15	344.5	620.3	1958.3	1301.1	494.5	626.02	1.81	Very pasty and soggy.
				1954.0					
				1952.0					
				Av 1954.4					
$1\frac{1}{4}$c.	1.11	328.7	604.5	1839.0	1234.0	561.6	710.96	2.16	Much better than the above cake
				1836.1					but not so large as when 3 eggs
				1840.5					were used.
				Av 1838.5					
1 c.	1.13	320.4	596.2	1741.3	1155.6	640.0	810.16	2.52	Fairly good but not so good as
				1745.9					when 3 eggs were used.
				1742.2					
				Av 1751.8					
$\frac{3}{4}$ c.	1.17	284.4	560.2	1755.3	1193.3	602.4	762.53	2.67	Fairly good. A better cake
				1752.2					than when 3 eggs were used.
				1753.0					
				Av 1753.5					

III.

Using $\frac{1}{2}$ Cup of Fat and 2 Eggs.

Liquid.	Sp. Gr. Batter.	Wt. of Cake.	Wt. of Box & Cake.	Weight of Box, Seed and Cake.	Weight Seed in Box With C.	Wt. of Seed Replaced.	Volume of Cake	Sp. Vol. of Cake.	Comments.
$1\frac{1}{2}$c.	1.16	320.8	596.6	1869.5	1272.2	523.4	662.61	2.06	Somewhat heavy and coarse but
				1866.6					better than 3 eggs.
				1870.4					
				Av 1868.8					
$1\frac{1}{4}$c.	1.15	313.7	589.5	1822.6	1230.8	564.8	715.02	2.24	Pretty good cake but not so
				1820.4				7	large as 3rd.
				1821.0					
				Av 1821.3					
1 c.		304.6	580.4	1899.0	1319.5	476.1	602.70	1.97	Third - large cake best of
				1903.0					series.
				1897.9					
				Av 1899.9					
$\frac{3}{4}$ c.	1.17	280.4	556.2	1901.0	1332.8	451.8	571.93	2.03	Fell. Coarse grain.
				1897.0					
				1902.3					
				Av 1900.0					

IV.

Using $\frac{1}{2}$ Cup of Fat and 3 Eggs.

Liquid.	Sp. Gr. Batter.	Wt. of Cake.	Wt. of Box & Cake.	Weight of Box, Seed and Cake.	Weight Seed in Box With C.	Wt. of Seed Replaced.	Volume of Cake	Sp. Vol. of Cake.	Comments.
$1\frac{1}{2}$c.	1.10	341.4	617.2	1875.5	1258.0	537.7	680.63	1.99	A heavy cake.
				1876.4					
				1873.7					
				Av 1875.2					
$1\frac{1}{4}$c.	1.14	328.2	604.0	1867.7	1264.0	531.6	672.94	2.02	Texture coarse.
				1867.3				5	
				1869.2					
				Av 1868.0					
1 c.	1.13	314.6	590.4	1817.7	1227.9	567.8	718.73	2.20	Best one of series.
				1818.7				8	
				1818.5					
				Av 1818.3					
$\frac{3}{4}$ c.	1.15	294.3	573.1	1846.4	1273.8	521.9	660.63	2.52	Coarse grain.
				1846.5				.24	
				1847.9					
				Av 1846.9					

Using $\frac{1}{2}$ Cup of Fat and 4 Eggs.

Liquid.	Sp. Gr. Batter	Wt. of Cake.	Wt. of Box & Cake.	Weight of Box, Seed and Cake.	Weight Seed in Box With C	Wt. of Seed Replaced	Volume of Cake	Sp. Vol. of Cake	Comments.
$1\frac{1}{2}$c.	1.16	367.5	642.3	1928.9 1930.0 1930.5 Av 1929.8	1287.5	508.2	643.29	1.75	Very pasty - with open streaks - heavy.
$1\frac{1}{4}$c.	1.13	356.7	632.5	1846.0 1849.2 1851.3 Av 1848.8	1216.3	579.4	733.40	2.06	Larger cake - has more grain but still resembles one above.
1 c.		323.2	609.0	1755.0 1759.0 1754.2 Av 1756.0	1147.0	648.6	821.05	2.46 2.53	Good cake. Best one of series.
$\frac{3}{4}$ c.	1.18	310.7	586.5	1735.8 1743.2 1744.3 Av 1741.1	1154.6	641.1	811.52	2.61	Not so large - coarser grain - didn't fall.

VI.

Using $\frac{3}{4}$ Cup of Fat and 2 Eggs.

Liquid.	Sp. Gr. Batter	Wt. of Cake.	Wt. of Box & Cake.	Weight of Box, Seed and Cake.	Weight Seed in Box With C	Wt. of Seed Replaced	Volume of Cake	Sp. Vol. of Cake	Comments.
$1\frac{1}{2}$c.	1.14	338.1	613.9	1912.7 1914.5 1912.1 Av 1913.1	1299.2	496.5	628.48	1.86	Rather flat and heavy.
$1\frac{1}{4}$c.	1.14	315.7	591.5	1862.8 1862.1 1861.9 Av 1862.2	1270.7	524.9	664.47	2.10	Good cake - fine texture.
1 c.		324.5	590.3	1790.1 1794.7 1792.5 Av 1792.4	1202.1	593.5	751.34	2.31	Good cake - best one. Better than 1 cup of fat and 2 eggs.
$\frac{3}{4}$ c.	1.18	304.7	570.5	1847.5 1847.2 1849.8 Av 1848.1	1277.6	518.0	655.74	2.15	Fell - rather coarse grain.

VII.

Using $\frac{3}{4}$ Cup of Fat and 3 Eggs.

Liquid.	Sp. Gr. Batter	Wt. of Cake.	Wt. of Box & Cake.	Weight of Box, Seed and Cake.	Weight Seed in Box With C	Wt. of Seed Replaced	Volume of Cake	Sp. Vol. of Cake	Comments.
$1\frac{1}{2}$c.	1.13	336.7	612.5	1890.0 1887.8 1890.3 Av 1889.3	1276.8	518.8	656.75	1.97	A heavy cake.
$1\frac{1}{4}$c.	1.14	337.0	612.8	1826.9 1828.0 1828.0 Av 1827.6	1214.8	580.8	735.27	2.18	Slightly streaked.
1 c.	1.156	315.2	591.0	1781.4 1781.2 1784.1 Av 1782.2	1191.2	604.4	765.14	2.42	Good cake.
$\frac{3}{4}$ c.	1.155	310.0	585.5	1796.5 1799.7 1797.9 Av 1798.0	1212.2	583.5	738.60	2.51 2.38	Coarse grain - very slight fall

Using $\frac{3}{4}$ Cup of Fat and 4 Eggs.

Liquid.	Sp. Gr. Batter.	Wt. of Cake.	Wt. of Box & Cake.	Weight of Box, Seed and Cake.	Weight Seed in Box With C	Wt. of Seed Replaced:	Volume of Cake	Sp. Vol. of Cake	Comments.
$1\frac{1}{2}$c.	1.15	383.6	659.4	1920.5	1263.8	531.8	673.24	1.78	Very soggy - coarse grain.
				1927.8				5	
				1921.4					
				Av 1923.2					
$1\frac{1}{4}$c.	1.17	364.4	640.2	1831.2	1195.7	599.9	759.45	2.08	Somewhat better - slight elevation.
				1837.2					
				1839.4					
				Av 1835.9					
1 c.		344.8	620.6	1765.0	1148.1	647.5	819.70	2.37	Good cake - greater elevation.
				1767.4					
				1773.8					
				Av 1768.7					
$\frac{3}{4}$ c.	1.16	341.8	617.6	1751.7	1132.6	663.1	839.36	2.45	Good cake - greatest elevation.
				1745.0					
				1744.5					
				Av 1747.2					

IX.

Using 1 Cup of Fat and 2 Eggs.

$1\frac{1}{2}$c.	1.15	357.9	633.7	1888.3	1253.7	541.9	686.03	1.63	Coarse grained and heavy cake.
				1887.2					
				1886.8				1.91	
				Av 1887.4					
$1\frac{3}{4}$c.	1.14	343.7	619.5	1857.3	1238.4	557.2	705.40	2.05	Larger - but rather coarse grain.
				1858.0					
				1858.5					
				Av 1857.9					
1 c.		345.1	620.9	1795.5	1176.1	619.5	784.21	2.24	Best one of series.
				1797.5				7	
				1798.2					
				Av 1797.0					
$\frac{3}{4}$ c.	1.17	338.3	614.1	1851.2	1236.4	559.2	707.89	2.08	Fell somewhat - coarse grain.
				1850.8				9	
				1849.7					
				Av 1850.5					

X.

Using 1 Cup of Fat and 3 Eggs.

$1\frac{1}{2}$c.		367.2	643.0	1897.0	1252.9	541.7	685.77	1.86	Very heavy.
				1895.4					
				1895.4					
				Av 1895.9					
$1\frac{1}{4}$c.		361.4	637.2	1895.9	1258.1	537.6	680.50	1.88	Still heavy.
				1892.6					
				1897.4					
				Av 1895.3					
1 c.		355.7	631.5	1871.0	1240.1	555.6	703.29	1.97	Slightly better.
				1873.0					
				1870.8					
				Av 1871.6					
$\frac{3}{4}$ c.		342.3	618.1	1903.8	1285.3	510.3	696.02	1.86	Coarse grain - fell.
				1902.2					
				1904.3					
				Av 1903.4					

XI. (Continued)

Using 1 Cup of Fat and 4 Eggs.

Liquid.	Sp. Gr. Batter	Wt. of Cake.	Wt. of Box & Cake.	Weight of Box, Seed and Cake.	Weight Seed in Box With C	Wt. of Seed Replaced	Volume of Cake	Sp. Vol. of Cake	Comments.
1½ c.		283.2	559.0	1962.0	1400.6	395.1	500.12	1.76	Very pasty with open streaks.
				1961.5					Heavy.
				1955.3					
				Av 1959.6					
1¼ c.		373.6	649.4	1919.3	1273.0	522.7	661.64	1.77	Slightly better but still heavy.
				1924.3					
				1923.6					
				Av 1922.4					
1 c.		349.2	625.0	1855.0	1233.7	562.0	711.39	2.32	Heavy - poor grain.
				1860.3				2.03	
				1860.8					
				Av 1858.7					
¾ c.		336.1	611.9	1808.5	1196.9	598.8	757.97	2.25	Best one - did not fall but not a very good cake.
				1808.8					
				1809.1					
				Av 1808.8					

UNIVERSITY OF MISSOURI
COLUMBIA

DEPARTMENT OF PHYSICS

May 27, 1916.

Dean Walter Miller,

Academic Hall.

Dear sir:-

I have carefully gone over the Thesis of Miss Sebastain. I approve the same under the condition that the corrections suggested by Miss Stanley and some more I have indicated in the margin are made. Also on page 11 she tells how the thermometer was calibrated. I presume that she tested the boiling point not by putting the thermometer in boiling water but in steam coming off from boiling water and that correction was made for atmospheric pressure. If this was not done it would be better not to state anything about thermometer calibrations.

Also on pages 18 to 20 Miss Sebastain gives readings of weighings. The weighings in many cases are made to four decimal-places when no two readings agree in the first decimal-place. In such cases only two decimals should be recorded. It is considered bad form scientifically to record such close readings which do not agree with each other.

After these corrections have bean made, I consider the thesis acceptible for the Master's degree. It shows that she has done a great deal of work on the subject.

I am

very truly yours

H. C. Rentschler

UNIVERSITY OF MISSOURI
COLUMBIA

DEPARTMENT OF PHYSICS

May 29, 1916.

Dean Walter Miller,

Academic Hall.

Dear sir:-

I have seen Miss Sebastain's Thesis since she saw Miss Stanley. I approve the thesis for the degree. The necessary corrections have been made.

I am very truly yours

H. C. Reutschler.

UNIVERSITY OF MISSOURI
COLUMBIA

DEPARTMENT OF HOME ECONOMICS

May 24, 1916.

Professor Walter Miller,
Dean of the Graduate School,
University of Missouri,
Academic Hall.

Dear Mr. Miller:

I approve the inclosed thesis, submitted by Miss Mattie Rea Sebastian as a partial fulfillment of her requirements for the degree of Master of Arts, on condition that the outline be gotten in a little better form as indicated, and that the conclusions from the experiment cited on page 51 be written up a little more clearly. Both of these changes can be made very easily, I am sure.

Very truly yours,

Louise Stanley.

LS/R

Chairman Department Home Economics.

UNIVERSITY OF MISSOURI
COLUMBIA

DEPARTMENT OF HOME ECONOMICS

May 24, 1916.

Professor Walter Miller,
Dean of the Graduate School,
University of Missouri,
Academic Hall.

Dear Mr. Miller:

The inclosed thesis came to me today shortly before one o'clock. I have gone over it very hurriedly and have indicated in the margin with a pencil such corrections as seem advisable. I am sending it on to you, rather than back to Miss Sebastian for correction, because I realize that the time is very short and I understand that Miss Sebastian is ill. Today was the first time I had seen the thesis all together and in final shape, so my judgment on the organization has been somewhat hastily made.

Very truly yours,
Louise Stanley.
Chairman Department Home Economics.

LS/R