A COMPARISON OF ANGEL FOOD CAKES MADE FROM FRESH AND FROZEN EGG WHITES

by

ELSIE LEE MILLER

B.S., Kansas State College of Agriculture and Applied Science, 1934

A THESIS

submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE

Department of Food Economics and Nutrition

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1942

TABLE OF CONTENTS

INTRODUCTION

Increased production of frozen eggs for human consumption during the past few years indicates a growing interest in their use. In a recent book, Prescott and Proctor (1937) predicted many now living will see the day when housewives will buy frozen eggs for many culinary uses. Frozen eggs are a satisfactory substitute for fresh or cold storage eggs in most mixtures; therefore, many large commercial bakeries, cafeterias, and other food service institutions are using them in food preparation.

Packers and users of frozen eggs are interested to know the comparative quality of angel food cakes made from fresh and frozen egg whites. Angel food cakes of greater volume and more uniform quality are thought to be produced when frozen egg whites are used.

The purpose of this study was (1) to compare the whipping quality of certain types of egg whites; (2) to determine the best temperature for beating these egg whites; (3) to compare the quality of angel food cakes made from fresh and frozen whites; and (4) to determine the best baking temperature for cakes made from the different egg whites.

METHOD

The work was divided into two series. In the first, a study was made of the effect of different beginning beating

temperatures on the quality of angel food cakes. In the second, the effect of different baking temperatures on angel food cakes was determined.

Sixty angel food cakes were made in the first series. The four beginning beating temperatures used were as follows: 40° F. (4.5° C.), 50° F. (10° C.), 60° F. (15.5° C.), and 70° F. (21° C.). Five cakes whipped at each of the beginning beating temperatures were made from each of three kinds of egg whites. In order that the results might be carefully checked, six cakes were baked each day, two from each of the three types of whites. All cakes of the first series were baked at 350° F. (177° C.) for 40 minutes.

In the second series, 75 cakes were baked. Five different baking temperatures were used: 350° F. (177° C.), 375° F. (183° C.), 400° F. (205° C.), 425° F. (218° C.), and 450° F. (232° C.). Cakes were made from three types of egg whites every day that cakes were baked. Five cakes were made from each of the three types of whites and baked at the five baking temperatures.

Ingredients for each series were as nearly identical as possible. Softasilk cake four, finely granulated sugar, cream of tartar, salt, and vanilla sufficient for an entire series were stored in the experimental laboratory. The only ingredient varied throughout the study was the egg whites. The three types of egg whites used were: No. 1 fresh, Regular frozen and Special frozen whites.

The Perry Packing Company of Manhattan supplied No. 1 fresh eggs, from their regular stock, for the first series of

the study. Consort Regular and Consort Special frozen whites were supplied by the Seymour Packing Company of Philadelphia through their plant in Topeka, Kansas. The frozen eggs were selected from stock which had been in the freezer for at least eight weeks. They were completely thawed, thoroughly mixed, weighed into pound lots, and packed in waxed cartons. The cartons of eggs were refrozen and sent to the Perry Packing Plant where they were stored until needed for the study. On the day before the cakes were to be baked, the eggs were delivered to the experimental laboratory where they were placed in the refrigerator at 40° to 50° F. (4.5° to 10° C.).

Fresh eggs for the second series were purchased from the Perry Packing Company. These No. 1 fresh eggs were secured in quantities sufficient for one week, and were stored in the refrigerator. The frozen eggs were received in 15 pound cans in two different shipments from the Seymour Plant in Topeka. The large cans of frozen eggs were placed in the refrigerator for 24 hours, then removed to room temperature until sufficiently thawed to be thoroughly mixed. They were then weighed into portions sufficient for one cake, placed in cartons, and stored in the freezing unit of the refrigerator. The day before the eggs were to be used they were removed from the freezing unit and placed on the shelf of the refrigerator to thaw. The frozen eggs of the second series were used within two weeks after being refrozen.

The equipment used included: A Harvard trip balance for weighing the ingredients; a Kitchen-Aid electric mixer with

two bowls of five-quart capacity; a centigrade chemical thermometer for determining the temperature of the egg white and batter; an Eastman timer; a small aluminum cup with straight sides in which the foam and batter were weighed in order that the specific gravity of each might be computed; and medium-light-weight aluminum sponge cake pans of 4000 ml. volume for baking the cakes. The cakes of the first series were baked in a bank of ovens in the experimental laboratory. The cakes of the second series were baked in the oven designed especially for experimental work and equipped with a revolving hearth and an accurate thermostatic heat control. The oven temperatures were checked with two Taylor oven thermometers. A Torsion balance was used for weighing the foam and batter, and the cake before and after baking.

The Sara Jane Reed recipe for angel food cake as taken from the Practical Cookery (1941) was used as the basic recipe. The method of mixing angel food cake on the Kitchen-Aid electric mixer, which had been worked out in the experimental laboratory, was used for mixing the cake.

The ingredients used in the study were as follows:

Ingredients	Weights	Approximate Measure
Egg whites	425 grams	1 3/4 cups
Cream of tartar	8.2 grams	2 teaspoons
Salt	1 gram	1/4 teaspoon
Sugar	300 grams	1 1/2 cups
Flour	100 grams	1 cup
Vanilla		1 teaspoon

The procedure for the experimental work for this study was as follows:

All ingredients were weighed on a Harvard trip balance.
Two hundred grams of sugar were sifted three times.
One hundred grams of sugar and 100 grams of flour were sifted together three times.
Egg whites were weighed and brought to the desired temperature before whipping.

Steps in mixing cakes:

Place egg whites in mixing bowl, use whip attachment, and fasten on the electric mixer.
Set beater at second speed.
Beat whites until frothy (30 seconds time). Add cream of tartar and salt and continue beating for 90 seconds longer.
Weigh a cup of foam.
Add sugar 1 tablespoon at a time at intervals of 5 seconds. Total time for adding sugar, 1 minute. Continue beating for 2 minutes.
Change to low speed.
Measure and add vanilla. Scrape down sides of bowl with rubber spatula.
Add flour-sugar mixture, 1 tablespoon at intervals of 10 seconds. Total time for adding mixture, 1 1/2 minutes. Scrape down sides of bowl and continue mixing for 1 1/2 minutes.

After mixing is completed, remove bowl from mixer:

Weigh a cup of batter.
Pour batter into weighed cake pans.
Drop several times on table to expell any large bubbles.
Mark depth of batter on inside of pan.
Weigh pan and batter on torsion balance
Take temperature of batter.
Place in preheated oven and bake at specified temperature and time.

After baking:

Remove from oven, invert, and weigh.
Place cake in an inverted position until cool.
Store in a tight cupboard until the following morning.

The determinations made include the specific gravity of the foam, the specific gravity of the batter, the volume of the batter, the percentage loss of weight during baking, the area of a slice of cake, the penetrometer reading, the compressibility, elasticity, and tenderness of the cake, and the quality of the cake as determined by a palatability committee.

The specific gravity of the foam and of the batter was determined by filling and weighing an aluminum cup of a known weight, and then dividing the weight of the sample by the weight of an equal volume of water at the same temperature.

The percentage loss in weight during baking was determined by dividing the difference in weight of the batter and of the baked cake by the weight of the batter.

The approximate volume of the batter was determined by marking the depth of the batter in the pan and later measuring the amount of water required to fill the pan to the line.

To obtain comparable results when testing the baked cake it was necessary that all samples be uniform in width. This was accomplished by using a metal guage. One cut was made in the cake, the guage was slipped over the cake and a one-inch slice was cut with a knife dipped in boiling water and wiped on a damp cloth. Three such slices were used for the compressibility and elasticity tests. Three one-inch cores of cake were cut by means of a sharpened cylinder, these were used to test the tenderness or tensile strength of each cake. Six slices of cake were also cut for the judges. All samples were wrapped in waxed paper to prevent drying.

The very first slice cut from each cake was laid on a sheet of paper and carefully outlined with a pencil. These outlines were later used to compute the area of the slice of cake. When computing the area, the height of the slice was determined at the center, at the outside edges, and at points one-half the distance from the center to either side. The average of the five measurements was multiplied by the average

width to obtain the area in square centimeters.

The same slice which was used in computing the area was later preserved in a glycerine-formaldehyde-water solution as suggested by Markley (1934). These samples of cake proved valuable as a means of comparing the entire series at one time. The shape, volume, and grain of the samples were well preserved but the texture was somewhat dry.

A penetrometer was used to test the tenderness and compressibility of the cake. This device was used by Lisk (1938) in her study on yellow angel foods. It consisted of an arm attached to a platform, a movable centigrade scale, and a cone shaped piece of metal connected to the arm. The cone was attached to a metal stem. A metal pointer which moved up and down with the cone and stem indicated the degree of penetration.

When testing the cake, one slice was laid upon the platform under the cone, the center of the slice facing the arm. The cone was allowed to penetrate the cake for 15 seconds, the scale adjusted to zero, and a 20 gram weight was carefully slipped on top of the cone. The weight and the cone were allowed to penetrate for 30 seconds and the reading recorded in centimeters. Unless there was a decided uneveness in the texture of the cake, tests were made three-fourths inch from the edge of the slice. Five readings were made on each slice, two at the top, one in the middle, and two at the bottom. The average of the top readings, the middle reading, and the average of the bottom readings were recorded in the table.

A second mechanical device used to test the compressibility and the elasticity of the cakes was similar to that described by Platt and Kratz (1933) and used by Kramer (1935). This device consisted of a remodeled laboratory balance. A metal plunger was fastened beneath the right-hand pan, and an adjustible platform placed so that the plunger just rested easily upon it. The left-hand pan held a brass weight and a linked chain which exactly balanced the plunger and a 200 gram weight on the right-hand pan. A wooden drum extended over the left-hand pan so that the chain could be easily wound from the pan to the drum. A metal pointer suspended from the cross arm to a scale at the lower part of the balance indicated the degree of compressibility of the cake. The scale was marked so that when the pointer moved across 8 points the cake was compressed 1 mm.

This compressibility and elasticity test was made by placing a one-inch slice of cake on the adjustible platform at the right of the balance so that the plunger just touched the surface of the cake. The scale was adjusted so that the pointer rested at zero. The chain was carefully wound to the drum in 30 seconds, thus allowing the plunger to penetrate into the cake. The weight was allowed to remain on the slice for 30 seconds longer, and a reading recorded from the scale. This reading represented the compressibility of the cake. The chain was then wound from the drum to the pan thus releasing the weight from the sample. After 30 seconds, a second reading was taken and recorded. The difference in the two readings was recorded as the elasticity of the slice. Three samples were tested from each cake and the average recorded as the compressibility and elasticity of the cake.

The tenderness or tensile strength of the cakes was determined by another mechanical device. This device was used by Reed (1931) in a study on angel food cakes. It consisted of a ring stand, the rod of which supported a short horizontal beam from which was suspended a wooden clamp for holding one end of the sample. A similar clamp fastened to the lower end of the sample supported a very light weight copper pan. The metal rings were adjusted so that the sample could be held firmly between the fingers of the clamps. The ring stand also supported a glass container from which a flow of dustless sand could be released or checked at will. This was controlled by means of a spring which was connected with a rubber stopper by a thin wire. When not in use the wire was held taut by the spring. When pressure was applied to the spring the stopper was released and the sand poured slowly into the scale pan until the sample broke. The weight of the clamp, cake, pan, and sand represented the force necessary to break the cake. Three such samples were tested from each cake and the average recorded as the breaking force.

A palatability committee consisting of six women scored the samples of the cakes according to Form 1. The committee for the first series consisted of two members of the Department of Food Economics and Nutrition, two faculty members of the Department of Institutional Management and two high school Home Economics teachers. The second series of cakes was judged by a committee consisting of one member of the staff of Institutional Management, a dietitian in a hospital, two high school cafeteria managers, and two high school Home Economics teachers.

Form 1.

Score card for angel food cakes.

Judged by _____

Sample number Date _____

External appearance:

Shape.....10

Size.....10

Crust.....10

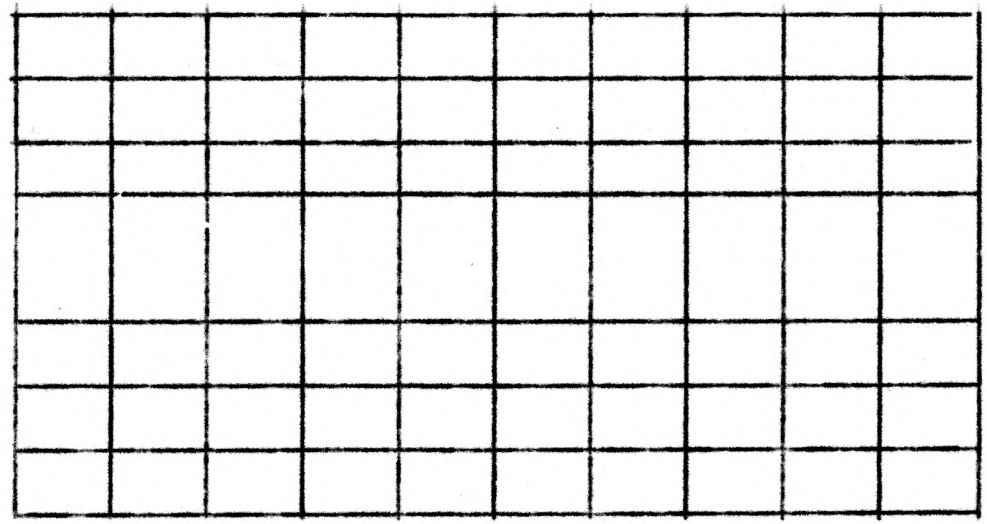
Internal appearances:

Texture.....10

Grain.....10

Color.....10

Flavor.....10



Rank all of the samples from the best to the poorest:

1st. choice No. ___ 6th. choice No. ___

2nd. choice No. ___ 7th. choice No. ___

3rd. choice No. ___ 8th. choice No. ___

4th. choice No. ___ 9th. choice No. ___

5th. choice No. ___

Comments of judge:

Directions for use of

Score card for angel food cakes

Points	Qualities	Perfect score	Rating
External Appearance			
	Shape - Symmetrical, even, and slightly rounded.	10	9-10
	Slightly uneven, somewhat rounded or sunken.		6-8
	Very uneven, peaked or sunken.		0-5
	Size - Good volume in proportion to ingredients used.	10	9-10
	Fair volume in proportion to ingredients used.		6-8
	Poor volume in proportion to ingredients used.		0-5
	Crust - Delicately browned, tender, slightly rough, slightly sticky, and of medium thickness.	10	9-10
	Medium brown, moderately tender, rough, sticky, and thick.		6-8
	Very brown, slightly tough, very rough, dry and thick crust.		0-5
Internal Appearance			
	Texture-Silky or velvety feel, very tender, moist, and resilient.	10	9-10
	Moderately moist and tender, slightly velvety in feel, rather resilient.		6-8
	Tough, dry, soggy, harsh, or crumbly.		0-5
	Grain - Fine, uniform, oval shaped cells, with thin cell walls.	10	9-10
	Fairly fine and uniform oval shaped cells, with fairly thin walls.		6-8
	Grain coarse, with many large holes or tunnels, or too fine and compact.		0-5
	Color - Very white.	10	9-10
	Fairly white.		6-8
	Gray or streaked.		0-5

Score card for angel food cakes (cont.)

Points	Qualities	Perfect score	Rating
Flavor -	Delicate and inviting, sweet and well blended, velvety feel, and pleasing odor.	10	9-10
	Reasonably delicate, sweet and blended, somewhat velvety feel, and pleasing odor.		6-8
	Flat, too sweet or unpleasant taste of certain ingredients, harsh feel, or unpleasant odor.		0-5
	Total points	70	

REVIEW OF LITERATURE

Frozen eggs have been on the market for many years, but their use in food preparation by commercial institutions is rather recent. Improved methods of freezing and storing have aided greatly in making frozen eggs available for human consumption. Sweetman (1937) stated that the frozen egg industry has grown so rapidly in recent years that it has become profitable to break high grade eggs for freezing. She also stated that the nutritive value of the eggs does not change with freezing, and experiments show frozen eggs to be a satisfactory substitute for fresh eggs in most mixtures. Frozen eggs are considered an economical means of supplying the part of the egg, whole, yolk, or white, needed by the consumer. Lowe (1940) in a recent editorial said, "That for several years, the angel

food cakes at Iowa State College have been made from frozen whites and that the cakes have been, in every respect, as good as those made from fresh whites. It has also been found that frozen whites are more economical and there is not the problem of using the left-over yolks."

Le Clerc and Bailey (1940) stated that in high grade establistments only the highest quality of eggs are used in the production of frozen eggs. During the preparation for freezing the eggs are handled under highly sanitary conditions. All of the eggs are candled, broken into individual cups, tested for odor and appearance and only those of high quality are frozen.

These authors also reported that much improvement has been made in the methods of freezing eggs. The older method of freezing at 0° F. (-17.7° C.) or below required 72-100 hours to freeze a 30-pound can, as compared with the new sharp freezing method which requires a much shorter time. In this process the homogenous emulsion of eggs is fed in a thin film to a mechanically chilled refrigerated roll which brings the liquid egg into a frozen condition in about seven seconds. The frozen mass is transferred to sterilized cans which are immediately sent to the sharp freezing room. This short time freezing prevents an increase in the bacterial count and is claimed to yield a product with a smooth uniform texture.

According to Le Clerc and Bailey (1940) special care should be taken when thawing frozen whites. The whites should be kept in the refrigerator until thawed, then thoroughly mixed to combine the solids, which concentrate in the center of the can during freezing, with the fluids.

These workers found frozen eggs to be more convenient to use, more uniform in quality, and in general better adapted to large-scale usage, and more economical to use the year round than fresh eggs. The frozen eggs retain their original quality almost indefinitely when kept frozen and the whites were much thicker in consistency than those of storage eggs.

Le Clerc and Bailey (1940) also stated that egg whites gave very little flavor but furnished a mellowness to the cake. The peculiar structure of the white furnished thin, but strong cell walls for the tiny air cells when the whites were whipped. The thin portion of the white seemed to incorporate more air in a shorter beating period and make better angel food cakes than the thicker whites. They also suggest that if superior quality angel foods are desired they should be made from the thin portions of the egg white.

Bailey (1935) found no pronounced difference in the foaming power of thawed and unfrozen egg whites, except for a tendency of the thawed whites to reach a maximum volume in a shorter beating period than the unfrozen whites. Leakage from the foam of the thawed whites was greater than that from the unfrozen whites, but the sharp changes in the leakage as a result of varying the whipping time, observed in the case of the unfrozen whites did not occur. It was also interesting to note that the optimum whipping time for the minimum leakage was usually a little less than the whipping time for maximum foaming. This effect was not always true, but its appearance in the majority of cases for the unfrozen whites or for eggs stored for a short period of time, three or four months, was thought to

justify the statement that, "If stability of the foam is desired, the egg whites should not be whipped to their maximum degree of foaming."

The result of work sponsored by Wilson and Company (1938) indicated frozen whites whipped at a temperature of 70° to 80°F. (21° to 28° C.) produced better foam than those whipped at either a higher or lower temperature. Whites whipped at a temperature below 70° F. (21° C.) had a tight grain and resulted in a cake with poor volume and a slight tendency to be tough. Cakes made from whites whipped at a temperature above 80° F. (27° C.) had slightly less volume and a harsher grain.

Much work has been done on the whipping properties of fresh whites. Lowe (1937) found egg whites produced more stable foams with longer beating. The air cells grow smaller and produce a more rigid structure than those which contain large air bubbles. However, too long a beating period will cause the foam to become dry and lose that shiny appearance. Workers in the Proctor and Gamble laboratory found that regardless of the time spent in whipping a given sugar and egg white mixture at 60° F. (15.5° C.) it never became as light as one of the same proportions beaten at the same speed and at a temperature of 110° F. (43° C.). Henry and Barbour (1933) reported thin whites had considerably better beating properties than thick whites, but that thin whites tended to lose volume more rapidly on continued beating. A greater volume of foam was produced when the hydrogen-ion concentration was reduced.

St. John and Flor (1931) found egg whites whipped best at a temperature of 65° to 70° F. (18° to 21° C.). At this

temperature there was not much separation of the liquid from the foam. Thin or watery whites produced a larger volume of foam when beaten than did the thick portions, and the foam from the thin whites had a more desirable texture than that from the thick whites. Eggs which had been in storage for a few days produced a larger volume of foam than did strictly fresh eggs. A storage period of two years apparently had little effect upon the whipping quality of the thin whites, but this was not true of the thick whites. It was observed that the thick portion beat to a greater volume after being stored from two to five weeks but decreased in volume with longer storage. St. John and Flor suggested that only the thin portion of the white should be used if the best quality of angel food cake is desired, when the eggs have been in storage for a long period of time. Stanley (1934) reported angel food cakes of greater volume and greater elasticity were produced from thick egg whites. She found thin whites produced a larger volume when beaten, but when the other ingredients were added the thin whites seemed to be less stable than the thicker whites, therefore cakes of smaller volume resulted.

In a study on the standardization of egg whites in white cake, Stokes and Track (1936) found cakes made from frozen egg whites to be remarkably uniform in grain, volume, and texture throughout the entire year, as compared with the cakes made from fresh egg whites which showed a much greater variation in quality.

Formerly much stress was laid upon the importance of low baking temperatures for angel food cakes, but more recently higher baking temperatures have been considered. Barmore (1935) showed that higher oven temperatures for baking angel food cakes did not decrease the tenderness, because the internal temperatures of the cakes change very little with greater differences in oven temperatures. He stated that the tenderness of the cake is dependent upon a number of factors such as: "The amount of expansion and the effect of the internal temperature on the rate of coagulation of the proteins and the gelatinization of the starch as well as the ratio of ingredients."

Reed (1931) was able to make angel food cakes of good quality by baking them at a temperature of 325° F. (163° C.) for 45 or 55 minutes. The longer baking period resulted in a cake of slightly smaller volume but the crust and contour of the cake were much improved with little sacrifice of tenderness.

In a recent investigation, Lowe (1937) found that better angel food cakes were produced when baked at 350° F. (177° C.) as compared with 325° F. (163° C.). These cakes had greater volume and were more tender and more moist than those cakes baked at lower temperatures. Burke and Niles (1936) found a temperature of 350° F. (177° C.) to be more satisfactory than temperatures of 300° to 325° F. (159° to 163° C.) for baking angel food cakes. These cakes were more moist and had a greater volume than those baked at lower temperatures. Higher oven temperatures caused the cakes to crack on the top and show sugar spots on the crusts, but the defects were more than compensated for by the improved texture.

Recent work in the laboratory of Wilson and Company (1938) indicated that even higher baking temperatures than those already mentioned produced better angel food cakes. Cakes made from frozen eggs, baked at 375° to 450° F. (191° to 232° C.) were all more moist and greater in volume than those cakes which were baked at lower temperatures. They reported the best results were obtained by baking cakes at 425° to 450° F. (218° to 232° C.). The writers stated that, "At this temperature a crust was formed on the top of the cake more rapidly, and this apparently allowed the escape of less of the vapor and gas formed during baking, thus giving a cake of greater volume. Formerly a cake of this size, i.e., one baked in a ten-inch pan with a three and a half inch spout, was baked at 375° F. (191° C.) for 40 minutes. When the cakes were baked at higher temperatures, 425° to 450° F. (218° to 232° C.), the baking period was reduced approximately 30 per cent. Moisture determinations taken on the finished cakes showed the cakes baked at 450° F. (232° C.) contained 32.9 per cent moisture as compared with the ones baked at 375° F. (191° C.) which contained only 30.6 per cent moisture."

Texture and volume of the finished cake are greatly dependent upon the quality of egg white used. Bailey and Le Clerc (1935) described eggs as an important ingredient of cakes when they said, "Eggs impart richness, improve the grain, texture, flavor, and general appearance of the cake. They serve to hold air and build the structure, increase the lightness, and give a moisture retaining quality, which in turn delays the crumbling

or staling of the cake." They added that bakers are able to make cakes which are more uniform in quality and have a much better texture, if frozen eggs are used throughout the entire year.

A good angel food cake should be even in grain and feathery light in texture. Platt (1931) well defined the texture of an angel food cake when he said, "Texture is an expression of elasticity, softness, pliability, smoothness, or silkiness of the crumb. It may be determined by a sense of touch or by the physical condition of the crumb, and to a minor degree by the grain. Speaking in physical terms, texture is a combination of compressibility, elasticity, and tensile strength."

DISCUSSION AND RESULTS

Three different kinds of egg whites were used in this study: No. 1 fresh, Regular frozen and Special frozen. The Regular frozen whites were a thick type of egg white and the Special, thin or more watery in consistency.

Sixty angel food cakes were made in the first series. Four beginning beating temperatures were used: 40° F. (4.5° C.), 50° F. (10° C.), 60° F. (15.5° C.), and 70° F. (21° C.). All cakes of this series were baked at 350° F. (177° C.) for 40 minutes.

The egg whites were removed from the refrigerator and brought to the desired temperature before beating. All whites were whipped for two minutes, with a whip beater, on second speed of the Kitchen-Aid electric mixer. A 60 ml. cup of foam

was weighed and this weight was used in computing the specific gravity of the foam.

A much greater difference was observed from cake to cake in the whipping quality of the fresh whites than in either type of frozen whites. Sometimes the white was much thinner in consistency, and when this was true, it whipped to a lighter, more stable foam. As a whole, it was observed that the fresh whites produced poorer foams than the frozen whites, and there was a greater amount of leakage from the fresh than from the frozen whites. Bailey (1935) reported a greater amount of leakage from frozen whites than from fresh whites, but in this study it was noted there was little leakage from the Special frozen (thin) and much less from the Regular frozen (thick) than from the fresh whites.

Regardless of the kind of egg white used, the volume of the foam was greater when the specific gravity was low. The foams of high specific gravity were poor and watery. In all instances, the Special frozen or thin whites produced the lightest foams, the Regular frozen whites second, and the fresh, the heaviest. The specific gravity, however, was much lower at 70° F. (21° C.) than at the three colder temperatures.

The results of the beginning beating temperatures of the present study are for the most part in keeping with those of previous studies. Seventy degrees F. (21° C.) was found to be the most satisfactory of the temperatures tried for whipping egg whites. St. John and Flor (1931) found the whites whipped best at 60° to 70° F. (18° to 21° C.); and workers in the Wilson and Company laboratories (1938) found the best foams were produced at whipping temperatures of 70° to 80° F. (21° to 26° C.).

It was found in the present study that cakes made from whites whipped at a temperature of 40° F. (4.5° C.) were more compact in grain and much smaller in volume than those whipped at the higher temperatures.

The temperature of the batter in most cases reached that of the room during the mixing period. On days when the temperature was high there was a greater increase in the temperature of the batter. However, it was observed that the thinner egg whites usually increased a little more in temperature than the others, probably because they incorporated more air than the thicker whites. The average increase in temperature for those cakes started at the lower temperatures was greater than for those started at the higher temperatures. Cake batters which were started from whites at 40° F. (4.5° C.) had much higher specific gravities than those which were started at 70° F. (21° C.). There was a greater difference in the specific gravities of the foam and batter of the cakes whipped at the higher beginning temperatures than at lower temperatures. It seemed that more stable foams and lighter batters were produced from whites whipped at 70° F. (21° C.) than at lower temperatures.

Table 1 shows the volume of batter to be greater at the higher beginning temperatures, but regardless of the temperature, the cakes made from the Special frozen whites always produced the greatest volume of batter. The fresh whites produced the second greatest amount and the Regular frozen the least amount of batter.

Table 1. Summary of data for angel food cake in first series.

Kind of egg white	Time of baking minutes	Temperature degrees Fahr. Oven	Egg white	Batter	Specific gravity Foam mg.	Batter mg.	Volume of batter ml.	Area of slice of cake sq.cm.	Compressibility mm.	Elasticity mm.	Tenderness gms.	Penetration Top cm.	Middle cm.	Bottom cm.	Average cm.
Fresh	40	350	40	77	.282	.310	2680	74.5	9.4	2.5	60.9	4.2	4.2	4.5	4.3
Regular				73	.314	.383	2222	71.9	8.5	2.9	82.6	3.8	4.0	3.9	3.9
Special				77	.148	.250	2615	75.3	10.1	2.2	58.2	4.9	5.0	5.1	5.0
Average				75	.248	.314	2506	73.9	9.3	2.5	67.2	4.3	4.3	4.5	4.4
Fresh	40	350	50	79	.273	.312	2650	72.8	9.5	2.7	66.2	4.3	4.2	4.2	4.2
Regular				79	.274	.356	2325	73.9	8.6	2.5	75.5	4.0	4.1	4.1	4.1
Special				79	.147	.288	2690	24.7	10.3	2.7	53.6	5.1	5.1	5.1	5.1
Average				79	.231	.319	2555	77.1	9.5	2.6	65.1	4.2	4.2	4.2	4.2
Fresh	40	350	60	77	.260	.302	2529	76.1	9.5	2.8	67.3	4.4	4.5	4.3	4.4
Regular				79	.254	.332	2505	79.4	8.4	2.9	76.1	4.0	4.1	4.0	4.0
Special				79	.135	.272	2920	85.2	9.9	2.7	59.2	4.4	4.6	4.6	4.5
Average				79	.216	.302	2651	80.2	9.3	2.8	67.5	4.3	4.2	4.3	4.3
Fresh	40	350	70	81	.237	.291	2600	78.4	8.9	3.0	61.1	4.3	4.2	4.5	4.3
Regular				82	.229	.322	2655	78.1	8.2	2.9	70.1	4.1	4.1	4.1	4.1
Special				82	.127	.279	3110	85.5	9.8	2.7	56.1	4.6	5.5	4.7	4.9
Average				82	.198	.297	2788	80.7	8.6	2.9	62.4	4.3	4.3	4.4	4.4

The volume of the finished cake was determined by computing the area of one slice from each cake. Greater area was found with the higher beginning temperatures. The volume of cakes made from the Special frozen whites in every case was the greatest. When the 20 samples of cake made from each type of egg white and preserved in the glycerin-formaldehyde solution were laid as closely together as possible and the area measured in square inches, the area of the cakes made from fresh eggs was 221 square inches, from the Regular frozen whites 208 square inches, and from the Special frozen whites 240 square inches.

There seemed to me quite a variation in the grain of the different cakes. The grain of the fresh egg cakes differed more than that of the frozen egg cakes, sometimes the grain was rather uniform and then again it contained many large holes. The grain of the cakes from Regular frozen whites was without exception uniform and quite compact. The grain was a little less compact at the higher beginning beating temperatures, but all of these cakes were much poorer in quality than those made from either the Special frozen or the fresh whites. The cakes made from Special frozen whites were more uniform from day to day than those made from the other two types of whites. The grain of all of the cakes made from Special frozen whites was irregular and a great number of large holes appeared in all of these cakes. The cell walls, however,

were much thinner than those of the fresh and Regular frozen egg cakes.

The texture of the cakes was also quite different. The texture of the fresh egg cakes ranged from a rather harsh or "bready" feel to one that might be described as "velvety." Most of the cakes from the Regular frozen whites were rather harsh in texture, a quality most often described as "bready" by the palatability committee. Cakes from the Special frozen whites were, with few exceptions, cakes with that "feathery-light" texture usually associated with an angel food cake. Many of these cakes were so "velvety" in texture that some of the judges described them as having that "melting in the mouth" quality.

The compressibility tests for the cakes in this series of the study show those cakes that were started at the higher beginning temperatures had a greater degree of compressibility. The cakes made from the Special frozen whites showed the highest degree of compressibility, those from the fresh egg whites second, and those from the Regular frozen whites were the least compressible. Some cakes with high compressibility readings were rather moist, some even a little soggy. The soggy layer was usually near the bottom of the cake and was especially noticeable on those cakes started at the lower beginning beating temperatures.

In nearly all cases, the cakes from the Regular frozen whites were found to have the highest degree of elasticity.

This was probably true because the cell walls were thicker than those of the other types of cakes. It was found also that those cakes which had the higher degree of compressibility usually had the lower degree of elasticity. The "bready" texture of those cakes made from the Regular frozen whites should perhaps account for the greater degree of elasticity. All cakes with a beginning temperature of 70° F. (21° C.) were more elastic than those whipped at the lower temperatures.

When the cakes were tested for tenderness or tensile strength, it was found that those started at 70° F. (21° C.) were the most tender. The cakes started at the lower temperatures were all a little less tender than those at the higher temperature, but the cakes made from the Special frozen whites at all beginning temperatures were more tender than the others.

The penetrometer test which was used to determine the tenderness of the cakes showed close average readings for all of the cakes. Those cakes started at the highest and lowest temperatures averaged practically the same degree of penetration. The cakes which were started at the lower temperatures were all very moist, and many had soggy layers at the bottom of the cakes. Even though these cakes gave readings showing as great a penetration as those with the higher whipping temperature, they were much inferior in quality to those started at the higher temperature. The cakes made from the Special frozen whites showed the greatest degree of penetration, fresh egg cakes second, and cakes made from the Regular frozen whites the least degree of penetration. It was interesting to note that the

average scores for these cakes showed them to be slightly more tender at the bottom than at the middle or top of the cakes.

The results of the palatability committee were not always consistent, but their average scores tell some interesting facts about the cakes. These results are shown in Table 2. The judges were told at the beginning of the study that three kinds of egg whites were to be used in the cakes, fresh and two kinds of frozen whites, and that four beginning beating temperatures would be used for whipping the whites. All cakes were to be baked at 350° F. (177° C.) for 40 minutes. The judges were asked to score the cakes according to shape, size, crust, texture, grain, color, and flavor. The average scores for all the cakes in this series showed that the judges seemed to prefer the cakes made from the Special frozen whites to those cakes made from either fresh or Regular frozen whites; the cakes from fresh eggs were placed second, and those from Regular frozen whites last. These results are very much in keeping with those of the mechanical tests made for the cakes.

The judges seemed to like those cakes whipped at the higher beginning temperature best. At this temperature, there was little difference made in the scoring of the cakes from fresh and Special frozen whites but those from the Regular frozen whites scored slightly lower than the others. When the scores for the different beginning temperatures were averaged, the total score was about the same for each but some variation was found when the individual scores were analyzed. In most instances, the cakes from the Special frozen whites were scored

Table 2. Summary of score of palatability committee for angel food cakes of first series.

Kind of egg white	Temperature before whipping degrees Fahr.	Shape	Size	Crust	Texture	Grain	Color	Flavor	Average
Fresh		49	46	45	46	53	54	52	49
Regular	40	48	41	44	48	50	54	52	48
Special		49	54	44	50	46	55	52	50
Average		49	47	44	48	50	54	52	49
Fresh		48	45	44	46	46	53	51	48
Regular	50	49	46	45	48	48	54	51	48
Special		47	49	45	48	42	53	52	48
Average		48	47	45	47	45	53	51	48
Fresh		50	47	48	48	49	54	52	50
Regular	60	47	43	47	43	44	54	51	50
Special		51	52	47	50	46	54	50	47
Average		49	47	47	47	46	54	51	49
Fresh		51	45	50	47	50	53	53	50
Regular	70	50	43	48	48	53	54	53	50
Special		51	53	50	54	48	55	52	52
Average		51	47	49	49	50	54	53	51

highest, those from the fresh whites second, and those from the Regular frozen whites scored lowest.

The scores for the crusts of the cakes indicated those with a beginning beating temperature of 70° F. (21° C.) were preferable to all others. Most of these crusts were golden brown in color and of good thickness. The crusts of those cakes with a beginning beating temperature of 40° and of 50° F. (4.5° and 10° C.) were tough, especially the crusts of the cake made from the Regular frozen whites. These latter cakes all had thicker crusts than cakes from either of the other two types of whites; this was true at the four beginning temperatures. No such consistent difference was noted in texture and grain for the scores varied widely with different beginning beating temperatures. Many of the judges objected to the large holes which appeared in cakes made from the fresh and Special frozen whites. The grain of those made from the Regular frozen whites was more even and more compact than that of the other cakes. At all beginning temperatures the cakes were white in color, but a little more so at the higher temperatures when the volume was better. The judges remarked many times that they could see very little difference in the color of the samples when they were scoring them. Flavor, too, was scored much the same for most of the cakes, the cakes started at 70° F. scored slightly higher than the others.

The results of the individual cakes were checked against a large recipe, enough for ten cakes, and these results showed better cakes were made at the beginning temperature of 70° F.

(21° C.) than at 40° F. (4.5° C.). Both the mechanical tests and judges' scores indicated a preference for those cakes with the higher beginning temperature.

With the trend toward a higher temperature and a shorter time for baking angel food cakes, the second series of this study was undertaken for the purpose of determining the best baking temperature and time for angel food cakes.

There were 75 angel food cakes baked in this series. The five baking temperatures and times tried were: 350° F. (177° C.) for 40 minutes; 375° F. (191° C.) for 35 minutes; 400° F. (204° C.) for 30 minutes; 425° F. (218° C.) for 25 minutes; and 450° F. (232° C.) for 21 minutes. The same three kinds of egg whites, as previously described, were used in this series. Five cakes were made from each of the three kinds of whites, and baked at each of the five baking temperatures. The average for the five cakes in each group in recorded in Table 3.

During the time these cakes were baked, it was observed that poorer cakes were made on days when the humidity was high. The crusts were sticky and the cakes were more or less soggy on the inside. It was also observed that all cakes had a greater tendency to pull away from the sides of the pan while cooling, or while standing over night when the humidity was high. The Special frozen egg cakes seemed to shrink from the sides of the pan much more when baked at 350° F. (177° C.) or 375° F. (191° C.) than when baked at temperatures of 400° F. (204° C.) or above.

When the cakes were removed from the pan, it was observed that all cakes baked at 350° or 375° F. (177° or 191° C.) had

Table 3. Summary of data for angel food cakes in second series.

Kind of egg white	Time of baking	Temperature degrees Fahr.			Specific gravity		Volume of batter	Area of slice of cake	Percentage loss of weight during baking	Compressibility	Elasticity	Tenderness	Penetration			
		Oven	Egg white	Batter	Foam	Batter							Top	Middle	Bottom	Average
	minutes				mg.	mg.	ml.	sq. cm.		mm.	mm.	gms.	cm.	cm.	cm.	cm.
Fresh				77	.289	.335	2355	82.3	42.7	9.0	4.0	75.5	4.2	4.2	4.5	4.3
Regular	40	350	70	70	.173	.321	2485	81.9	45.8	9.0	4.5	71.0	4.1	4.1	4.3	4.2
Special				73	.118	.297	2670	83.4	40.8	9.0	3.7	57.8	4.6	4.2	4.5	4.4
Average				73	.193	.318	2470	82.5	43.1	9.0	4.0	68.1	4.3	4.2	4.4	4.3
Fresh				75	.255	.336	2460	84.5	34.4	9.1	4.0	73.5	4.3	4.1	4.4	4.3
Regular	35	375	70	75	.215	.335	2555	79.9	40.9	9.0	3.6	82.2	4.0	4.1	4.2	4.1
Special				77	.121	.271	2725	89.1	35.3	9.0	3.9	63.0	4.2	4.2	4.3	4.2
Average				75	.197	.314	2580	84.5	36.7	9.0	3.8	72.6	4.2	4.1	4.3	4.2
Fresh				79	.269	.318	2556	86.7	32.4	9.4	3.8	68.3	4.5	4.6	4.7	4.6
Regular	30	400	70	81	.158	.324	2526	84.9	34.7	8.9	4.2	79.5	4.0	4.2	4.4	4.2
Special				81	.117	.271	2776	91.5	32.9	9.6	3.8	67.4	4.5	4.7	4.9	4.7
Average				81	.181	.304	2619	87.7	33.3	9.3	3.9	71.7	4.3	4.5	4.7	4.5
Fresh				79	.264	.315	2611	90.5	31.5	9.0	3.7	68.1	4.7	4.6	4.8	4.7
Regular	25	425	70	79	.151	.321	2550	90.9	32.8	8.7	3.5	65.9	4.4	4.3	4.8	4.5
Special				79	.111	.280	2718	91.4	34.4	9.7	3.7	56.3	4.3	4.5	5.0	4.6
Average				79	.175	.305	2628	90.9	32.9	9.1	3.6	63.4	4.5	4.5	4.9	4.6
Fresh				82	.275	.355	2632	82.5	32.1	8.1	2.5	65.5	4.1	4.5	4.6	4.3
Regular	21	450	70	82	.166	.329	2575	82.3	28.7	8.3	3.1	71.1	4.2	4.3	4.7	4.4
Special				82	.121	.282	2700	84.6	31.1	9.5	4.0	63.6	4.5	4.6	5.0	4.7
Average				82	.187	.315	2636	83.1	30.6	8.6	3.2	66.7	4.3	4.5	4.8	4.5

more crust stick to the sides and bottom of the pan than those cakes which were baked at higher temperatures. The thickness of the top crust seemed to increase as the temperature was raised, but the cakes made from the Regular frozen whites had thicker crusts and the cakes made from Special frozen whites the thinnest crusts at all baking temperatures. The crusts of the cakes made from the Regular frozen whites had rather a rubbery appearance and feel. This was especially true at the three higher temperatures.

The crusts of those cakes baked at the three higher baking temperatures cracked considerably more on the top. These cakes all seemed to rise quite normally during the first half of the baking period, but cracks appeared after the cakes had been in the oven one-third to one-half of the baking time. As the cakes increased in volume the cracks became deeper. However, during the last quarter of the baking period when the cakes finished browning and shrank slightly from the sides of the pan the cracks were less noticeable. The cakes baked at 450° F. (232° C.) did not rise evenly because as soon as they were placed in the oven the cakes seemed to bake on the outer edge, causing the cake to rise much higher in the center nearest the tube. The crusts on all of these cakes were heavy and dark brown in color. The cakes baked at 400° and 425° F. (204° and 218° C.) also cracked during baking but the contour was better than that of those baked at 450° F. The cakes baked at 375° F. (191° C.) cracked slightly during baking but the cracks were not noticeable after the cakes cooked. Those cakes baked at 350° F. (177° C.) were all more even in contour but were cracked

slightly on top. There seemed to be a close relationship between the specific gravity of the batter and the extent to which the cake cracked on top during baking. Perhaps that old saying, "A good angel food cake should crack on top," is true, at least it seemed to be in this study because the cakes which were tender and "velvety" were cracked on top.

All of the egg whites for this series of cakes were whipped at 70° F. (21° C.). It was found in this series as in the first, that there was a close relationship between the specific gravity of the foam and that of the batter, and better cakes were produced when the specific gravity was low. The cakes made from the Special frozen whites had the lowest specific gravity and a greater volume of batter than the cakes made from either the fresh or Regular frozen whites.

Some interesting results were obtained with the higher baking temperatures. The volume of the baked cake was one of the most interesting. Those cakes baked at 425° F. (218° C.) for 25 minutes had the greatest volume. The average area for the slices of cake baked at the different temperatures was as follows: 425° F. (218° C.) first with an average area of 90.9 square centimeters, 400° F. (204° C.) second with 87.7 square centimeters, 375° F. (191° C.) third with 84.5 square centimeters, 450° F. (218° C.) fourth with 83.1 square centimeters, and 350° F. (177° C.) last with 82.5 square centimeters. It might be concluded from this comparison that if volume is of greatest importance higher temperatures should be used for baking angel food cakes. When the three types of whites were compared separately, it was found that the Special frozen or

the thin whites produced the greatest volume of baked cake regardless of the baking temperature, the fresh whites produced cakes which were second, and the Regular frozen or the thick whites resulted in the poorest volume of baked cake.

The percentage loss in weight was computed for all cakes in the second series. According to the results, as given in Table 3, it is evident that there was a gradual decrease in the loss of weight as the baking temperature was increased. The average loss in weight at 350° F. (177° C.) was 43.1 per cent, while at 450° F. (232° C.) it was only 31.6 per cent. The cakes made from Regular frozen whites lost the greatest amount of weight at the three lower baking temperatures, next to the least at 425° F. (218° C.) and the least of all at 450° F. (232° C.). The percentage loss from the cakes made from the fresh and the Special frozen whites was not so consistent. The cakes made from the fresh whites lost more weight than those made from the Special frozen whites at 350° F. (177° C.) and 450° F. (232° C.) but when the cakes were baked at 375° F. (191° C.) and 425° F. (218° C.) the opposite was true.

The average loss in weight of cakes made from each kind of egg white baked at the five temperatures was: fresh, 42.7 per cent; Regular frozen, 45.8 per cent; and Special frozen, 40.8 per cent. Many of the cakes baked at 450° F. (232° C.) were so moist as to be almost "wet or soggy."

The compressibility test was to some degree an indication of the "velvetiness" of the cakes. This test showed cakes baked at 400° F. (204° C.) were most compressible; those baked at 425° F. (218° C.) the second; cakes baked at 350° and 375° F

(177° and 191° C.) the third; and those at 450° F. (232° C.) were the least compressible of all cakes. This seems to indicate that up to a certain degree higher baking temperatures give cakes which are more compressible but beyond that point they become less so. The cakes made from Special frozen whites had the greatest amount of compressibility at higher temperatures, those from the fresh whites the second, and the cakes made from Regular frozen whites the least.

The results of the elasticity test for these cakes did not seem to be related to those for the compressibility test. The cakes from the Regular frozen whites averaged higher in elasticity than those from the Special frozen whites and the cakes from the Special frozen whites slightly higher than those from the fresh whites. Cakes baked at 350° F. (177° C.) showed the greatest amount of elasticity, those at 400° F. (204° C.) second, 375° F. (191° C.) third, 425° F. (218° C.) fourth, and those baked at 450° F. (232° C.) were least elastic.

The tenderness test indicated that cakes baked at 425° F. (218° C.) were more tender than those at other temperatures. Cakes baked at 450° F. (232° C.) were slightly more tender than those baked at 400° F. (204° C.) and those baked at 350° F. (177° C.) were less tender than those at 400° F. (204° C.). Those cakes baked at 375° F. (191° C.) were the least tender of all. At each baking temperature, the cakes made from the Special frozen whites were most tender but the cakes made from fresh and Regular frozen whites were not so consistent. Cakes

made from the fresh whites were more tender at 375° F. (191° C.), 400° F. (204° C.), and 450° F. (232° C.) and the cake made from Regular frozen whites were more tender at 350° F. (177° C.) and 425° F. (204° C.).

In the penetrometer tests, the cakes baked at 400°, 425°, and 450° F. (204°, 218°, and 232° C.) gave higher readings; however, the readings for the cakes baked at 425° F. (218° C.) were slightly higher than those baked at either 400° or 450° F. (204° or 232° C.). The cakes made from the Special frozen whites gave higher readings than the other cakes, those from the fresh whites the second, and cakes made from the Regular frozen whites gave the lowest readings. These results were in keeping with those obtained with the compressibility and tenderness tests. When the readings were compared, it was observed that those taken at the bottom were greater than those at the top or center and those at the center greater than those at the top of the slice; the differences were greater in those cakes baked at higher temperatures than those which were baked at the lower temperatures.

Scores of the palatability committee were again not always consistent but their average scores seem to indicate they liked the cakes baked at 400° F. (204° C.) and 425° F. (218° C.) best, then the cakes at 350° F. (177° C.) and 375° F. (191° C.) and those baked at 450° F. (232° C.) were less preferred by the judges. These results are shown in Table 4.

A good angel food cake should be "feathery light." The crumb of the cake should be rather fine, of even grain, very tender, snowy white in color, and delicate in flavor. The crust of the cakes should be golden brown, moist, and tender.

Table 4. Summary of scores of the palatability committee for angel food cakes of the second series.

Kind of egg white	Baking time and temperature degrees Fahr.	Shape	Size	Crust	Texture	Grain	Color	Flavor	Average
Fresh	40 minutes	51	48	52	51	51	55	45	51
Regular	350°	48	47	51	51	47	53	43	50
Special		48	48	50	41	48	54	42	47
Average		49	48	51	48	49	54	43	49
Fresh	35 minutes	49	46	50	52	48	56	45	49
Regular	375°	46	46	47	51	44	54	41	47
Special		50	52	48	53	49	55	42	47
Average		48	45	48	52	47	55	43	48
Fresh	30 minutes	53	50	48	55	52	56	49	52
Regular	400°	52	49	48	53	50	56	41	50
Special		50	52	46	53	51	56	41	50
Average		52	50	47	54	51	56	44	51
Fresh	25 minutes	50	51	44	56	52	56	45	50
Regular	425°	45	51	42	55	50	56	44	50
Special		49	51	42	55	52	56	49	50
Average		48	51	43	55	51	56	46	50
Fresh	21 minutes	40	45	38	52	47	53	45	46
Regular	450°	40	45	31	50	45	52	39	41
Special		44	45	31	51	44	52	38	44
Average		41	45	33	51	45	52	41	44

Most of the judges liked cakes which compared well with the description of the ideal angel food given above, therefore they definitely disliked those cakes baked at 450° F. (232° C.). These cakes were uneven in shape, had poor volume, thick, dark crusts, and were compact and moist inside. They were also scored down in color and flavor because during baking they lost so little moisture that they were soggy and wet. A glance at the score card for these cakes would show that in every instance they were scored lower than those baked at any other temperature.

The cakes baked at 425° F. (218° C.) scored the highest in volume but next to the lowest for quality of crust. This would indicate that cakes baked at this temperature increased greatly in volume but at the same time this temperature produced thick, brown crusts which were disliked by the judges. The cakes baked at this temperature were rather uneven in grain, some large holes were found in many of the cakes, especially in those made from the Special frozen whites which increased the most in volume. These cakes were "velvety" in texture and moist to both feel and touch. This quality was well liked by all the judges. Cakes of this group received the highest scores for both color and flavor. These cakes were white in color and seemed to have a better flavor than the others probably because of the "velvety" feel in the mouth.

The cakes baked at 400° F. (204° C.) were also well liked by the palatability committee. These cakes were baked just 30 minutes and were not as brown a color, nor did they have as thick a crust as those which had been baked at the two higher

temperatures. All cakes baked at 400° F. (204° C.) cracked during baking but when the cakes were thoroughly baked and cooled the cracks were not especially noticeable. These cakes were all quite even in contour and had good volume; they also had a velvety texture, but were rather uneven in grain; however fewer large holes were found in this group than in the cakes baked at 425° F. (218° C.). These cakes were all snowy white in color and had a good flavor. As a whole the cakes of this group were rated highest and were apparently liked best by the members of the palatability committee. When the judges rated the cakes made from the three different kinds of egg whites, they preferred the cakes made from the fresh whites to those cakes made from either type of frozen white, but they rated the cakes from the thin or Special frozen whites higher than those made from the thick or Regular frozen whites.

Those cakes baked at 375° F. (191° C.) for 35 minutes were rated fourth in desirability by the palatability committee. The cakes of this group were more even in contour but were much smaller in volume than those cakes baked at 400° and 425° F. (204° and 218° C.). The grain of these cakes was more uniform and more compact than that of the cakes baked at the higher temperatures. Fewer large holes were found in this group, although there were some in the cakes made from the Special frozen whites and the fresh whites but almost none were found in the cakes made from the Regular frozen whites. These cakes made from the Regular frozen whites had a compact grain with thicker cell walls, were a little "off" color, and the flavor was not as well liked as that of the others by the palatability committee. The cakes made from the fresh eggs were again rated better than those cakes made from the frozen eggs.

Cakes baked at 350° F. (177° C.) for 40 minutes were rated as third best by the committee. In this group, the cakes made from the fresh eggs were scored a little higher than the cakes made from the Special frozen whites, the cakes made from the Regular frozen whites again were found to be less desirable products. The cakes of this group were all quite even in contour and had fairly good volume. The crusts of these cakes were light golden brown in color and were moist, this type of crust seemed to be preferred by the palatability committee. The crusts of the cakes made from the Special frozen whites were very thin and moist while those cakes made from the Regular frozen whites were all much thicker than those crusts of cakes made of the fresh whites. All the cakes of the group seemed to be drier in texture than those baked at the higher temperatures. In this group, cakes from the Special frozen whites were rated lower by the judges. Some of these cakes had soggy streaks near the bottom of the cakes and also were a little "off" color. The committee did not seem to like the flavor of these cakes as well as that of some others.

When the cakes made from the three types of egg whites were compared as to quality by the committee, it was found that the cakes made from the fresh egg whites were chosen most frequently as best regardless of temperature, those cakes made from the Special frozen whites rated a close second, but the cakes which were made from the Regular frozen whites were chosen very few times as first choice. From the results of this study, it is apparent that either the fresh or Special

frozen whites can be used satisfactorily in making angel food cakes, and that the Regular frozen or thicker whites produce cakes of much less desirable quality.

Few cakes in the entire series were really inedible, but some were much superior in quality to others. It would seem that it was possible to make edible angel food cakes from any of these egg whites if good technique was used and all other conditions favorable. With proportions used in this study, cakes of better quality were made on days when the humidity was low, or when the air was dry. It was apparent that all three types of egg whites whipped better and produced more stable foams when they were allowed to reach room temperature, 70° F. (21° C.) before whipping was begun. The foam was whipped just long enough so that it stood up in peaks, but still had a glossy or shiny appearance. The cake batter was placed in the oven as soon after mixing as possible in order that the air was retained in the batter. Some of the larger air bubbles were removed by dropping the cake several times on the table before placing it in the oven, thus making a cake with a more uniform grain.

At the present time, frozen eggs can be purchased only in large quantities, that is 15 or 30 pound cans. These amounts are much too large for family use, but as they increase in popularity undoubtedly they will appear on the market in smaller sized packages, probably in a sufficient amount to make one angel food cake. Frozen eggs can usually be purchased at a lower cost than fresh eggs because large quantities are frozen and stored when eggs are most plentiful. Frozen eggs are

available as whites, yolks, or whole eggs, and are becoming popular for use where large quantities of eggs are needed in food preparation. Much time is saved when it is not necessary to break and separate the fresh eggs.

SUMMARY

The purpose of this study was to determine the best temperature for whipping fresh and frozen whites; to determine the most satisfactory baking temperature for cakes made from these different egg whites; and to compare the quality of angel food cakes made from fresh and frozen egg whites.

The experimental work was divided into two series. In the first, a study of the effect of four beginning beating temperatures (40° F., 50° F., 60° F., and 70° F.) on the quality of angel food cakes was made and in the second, the effect of five baking temperatures (350° F., 375° F., 400° F., 425° F., and 450° F.) on angel food cakes was determined. Each temperature was checked four times.

The following determinations were made: temperature of egg whites and batter; specific gravity of foam and batter; volume of batter and baked cake; percentage loss of weight during baking; compressibility, elasticity, and tenderness of the cakes; and quality as judged by a palatability committee.

1. The thin frozen (Special) whites whipped more quickly than the thick frozen (Regular) whites, but both types of frozen whites whipped more quickly than the fresh whites.

2. All three types of egg whites were found to whip better at 70° F. (21° C.) than at other temperatures tried. Whites whipped at this temperature produced good foams which remained quite stable.

3. There was a greater amount of leakage from the foams of the fresh whites than from either type of frozen whites. There was little leakage from the foams of the thin frozen whites when whipped at a temperature of 70° F. (21° C.).

4. The foams of the thick frozen whites lost less volume than either the fresh or thin frozen whites when the sugar-flour mixture was added.

5. At all beginning beating temperatures, the thin or Special frozen whites produced the greatest volume of finished batter and baked cake. This was especially noticeable at 70° F. (21° C.). The fresh whites produced the second greatest volume and the thick or Regular frozen whites the least volume.

6. The cakes were more tender and had better texture when they were made from whites whipped at 70° F. (21° C.).

7. There was some difference in the color of the cakes baked in the first series; the cakes, made from whites whipped at 70° F. (21° C.), were more nearly white in color than those made from the same kinds of whites whipped at temperatures below 70° F. (21° C.).

8. There was no great difference in color and flavor of the cakes baked at the five baking temperatures, although the average scores of the palatability committee indicated a preference for those cakes baked at 400° F. and 425° F. (204° C. and 218° C.).

9. There was a gradual decrease in weight lost with an increase in baking temperatures. The percentage loss for those cakes baked at 350° F. (177° C.) was 43.1, and at 450° F. (232° C.) only 30.6 per cent.

10. Larger and more tender cakes were produced at baking temperatures higher than those usually recommended. A temperature of 425° F. (218° C.) produced the largest and most tender cakes.

11. Angel food cakes baked at a temperature of 450° F. (232° C.) had top crusts which were dark brown, thick, and tough. As the baking temperatures were decreased the top crusts of the cakes were lighter in color, thinner, and more tender.

12. In this study, angel food cakes of better quality were produced when they were made from whites whipped at a temperature of 70° F. (21° C.) and baked in a preheated oven at 400° F. (204° C.) or 425° F. (218° C.) for 35 or 30 minutes respectively. Thin frozen whites and fresh whites both produced cakes of high quality with similar characteristics, but those made from the thick frozen whites were less desirable.

ACKNOWLEDGEMENT

Indebtedness is acknowledged to Dr. Gladys E. Vail, Associate Professor of Food Economics and Nutrition, for inspiration and help during this study.

LITERATURE CITED

Bailey, M. Irene.
Foaming of egg whites. Indus. Engin. Chem. 27:973-976. 1935.

Bailey, L. H. and LcClerc, J. A.
Cake and cake ingredients. Cereal Chem. 12:183-185. 1935.

Barmore, M. A. .
The influence of various factors including altitude on the production of angel food cake. Cereal Chem. 13:71-82. 1935.

Burke, E. A. and Niles, K.B.
A study of seasonal variation in egg white performance. U.S. Egg & Poultry Mag. 42:542-547. 1936.

Department of Food Economics and Nutrition.
Practical cookery, ed. 19. Manhattan, Kansas. Kans. State Col. Agri. and Appl. Sci. 506 p. 1941.

Henry, W. C. and Barbour, A. D.
Beating properties of egg whites. Indus. Engin. Chem. 25:1054-1058. 1933.

Kramer, Ruth.
Creaming properties of various fats as related to the specific gravity of the batter and to the quality of plain cake. Unpublished Thesis. Kans. State Col. Agri. and Appl. Sci. 46 p. 1935.

LeClerc, J. A. and Bailey, L. H.
Fresh, frozen, and dried eggs and eggs products (Their use in baking and for other purposes). Cereal Chem. 17:279-311. 1940.

Lisk, Eva E.
Some factors affecting the quality of a yellow angel food cake. Unpublished Thesis. Kans. State Col. Agri. and Appl. Sci. 55 p. 1938.

Lowe, Belle.
Experimental cookery, second edition. Chicago. John Wiley and Sons. 600 p. 1937.

_____
Frozen eggs work well for cooking. Farm Sci. Rpt. 1 (2):9-10. 1940.

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

Platt, Washington.
Rational methods of scoring food products. Food Indus. 3:108-111. 1931.

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

Prescott, Samuel C. and Proctor, Bernard E.
Food technology. New York. McGraw Hill Book Company, Inc. 630 p. 1937.

Reed, Sara Jane.
Some factors affecting the quality of angel food cakes. Unpublished Thesis. Kans. State Col. Agri. and Appl. Sci. 60 p. 1931.

Stanley, Louise.
Bureau of home economics studies eggs and poultry. U.S. Egg & Poultry Mag. 40:15. 1934.

St. John, J. L. and Flor, I. H.
A study of whipping and coagulation of egg of varying quality. Poultry Sci. 10:71-82. 1931.

Stokes, W. E. and Track, Laura K.
Study on standardization of egg whites in A.A.C.C. white cake formula for testing soft wheat flour. Cereal Chem. 13:746-752, 1936.

Sweetman, Marion Deyoe.
Food preparation, second edition. New York. John Wiley and Sons. 250 p. 1937.

Wilson and Co., Inc. Bakery Research Laboratories.
Research work on frozen eggs as to the production of angel food and sponge cake. Chicago. Wilson and Co., Inc. (Mimeo.) 1935.