THE USE OF SOY FLOUR IN CAKES CONTAINING FAT

by

MARGARET IOLA BUCK

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INTRODUCTION

Global war has made increased demands on the food supply, resulting in certain shortages of fats and proteins. The use of soybean products in various food mixtures would help provide adequate nutrition and relieve shortages. Studies have shown the desirability of using soy flour in baked products, but the greater part of the research has been related to breads with only mention made of its use in cakes. Wider use of soy products will undoubtedly be made when they can be recommended as an ingredient in more American foods, including cakes.

The purpose of this study was to determine the effect of replacing a portion of the cake flour, eggs and fat with Vivasoy high protein soya flour in cakes containing fat.

A plain cake containing fat and whole eggs and a caramel devil's food cake were used as the basis for this study.

METHOD

The work was divided into four series. In Series I, Part I, a study was made of the effect of replacing varying amounts of cake flour with an equal measure of soy flour, Part II was a study of the effect of replacing varying amounts of cake flour with an equal measure of soy flour and the milk increased. Series II relating to eggs was divided into three parts: first, varying portions of egg were replaced with soy flour; second, a portion of egg was replaced with soy flour and the sugar reduced; third, varying portions of egg were replaced with soy flour and the milk was increased. Series III relating to fat was divided into three parts: first, varying portions of fat were replaced with soy flour; second, varying portions of fat were replaced with soy flour and the milk was increased; and third, a given amount of cake flour was replaced with soy flour and the fat reduced. In Series IV, a portion of both eggs and fat was replaced with soy flour and the milk was increased.

These four series were carried out for the plain cake and repeated for the caramel devil's food with the exception of part two of Series I, parts two and three of Series II, and part three of Series III which were omitted.

Table 1 indicates the variations used in each series and the number of cakes baked for each variation. In some cases only two cakes were baked because unsatisfactory results did not warrant repeating the problem.

Ingredients in each series were as nearly identical as possible. Swans Down cake flour, finely granulated sugar, brown sugar, soda, Calumet baking powder, salt, Schillings vanilla, Cudahy's white ribbon shortening, Vivasoy high protein soya flour and chocolate sufficient for the entire study were placed in the store room in Calvin Hall. Due to the shortage of chocolate, it was necessary to use Ambrosia unsweetened chocolate for the first ten caramel devil's food cakes and Baker's unsweetened chocolate to complete the study. Spry was used in place of Cudahy's white ribbon shortening for ten plain cakes because one member of the palatability committee repeatedly expressed a dislike for the flavor and odor of the fat in the cakes.

Fresh eggs were supplied regularly by the College Poultry Farm and Grade A pasteurized whole milk was obtained daily from the College Dairy.

The equipment used included a trip balance for weighing all ingredients except the leavening agents which were weighed on a Cenco laboratory balance; a Model D Hamilton Beach electric mixer with a bowl of four quart capacity; two centigrade chemical thermometers; three Eastman timers; and aluminum cake pans 7 3/4 inches square and 1 7/8 inches deep for baking the cakes. All cakes were baked in Lorraine gas-heated ovens equipped with thermostats and checked by Taylor oven thermometers.

All preparation and baking was done in the Experimental laboratory and certain testing procedures were done in the Research laboratory in Calvin Hall.

It was necessary to choose a formula for each of the two types of cakes that would produce an acceptable product and use ingredients in the quantity that was available.

The formula accepted as a standard for the plain cake was as follows:

Ingredients	Weights	Approximate measure
Fat	75 g	3/8 cup
Sugar	200 g	1 cup
Eggs	96 g	2
Milk	162.7 g	2/3 cup
Cake flour	168 g	1 3/4 cups
Baking powder	10.25 g	2 1/2 teaspoons
Salt	1.5 g	1/4 teaspoon
Vanilla		1 teaspoon

The formula accepted as a standard for the caramel devil's food was as follows:

Ingredients	Weights	Approximate measure
Fat	200 g	1/2 cup
Sugar (granulated)	206.25 g	1 cup, 1 1/3 teaspoons
Sugar (brown)	68.75 g	5 1/2 tablespoons
Eggs	96 g	2
Milk	244 g	1 cup
Cake flour	192 g	2 cups
Soda	4.5 g	1 teaspoon
Chocolate	56 g	2 squares
Vanilla		1 teaspoon

All ingredients were weighed on a trip balance.
Leavening agents were weighed on a Cenco laboratory balance.
Flour was sifted once before weighing.
All weighed dry ingredients were sifted together two times.
Weighed fat was allowed to stand at room temperature one hour before mixing.
Vanilla was measured and added to the milk.

Steps followed in mixing the plain cake:

Dry ingredients were placed in bowl of mixer.
Fat and 2/3 of milk were added.
Ingredients were mixed at speed 6 for 2 minutes, sides and bottom of bowl were scraped with rubber spatula as needed.
Remaining 1/3 of milk and unbeaten eggs were added.
Batter was mixed at speed 6 for 2 minutes, and bowl scraped with spatula as needed.

At the completion of mixing, bowl was removed from mixer:

Temperature of batter and of room was recorded.
600 grams of batter was poured into cake pan that had bottom lined with waxed paper, remaining portion reserved for line spread.
Cake pan of batter was dropped 3 times on table to expel any large bubbles.
Cake mixture was placed in a preheated oven and baked at 340° Fahrenheit for 45 minutes.
Line spread of batter was measured.

At completion of baking:

Cake was removed from oven and allowed to cool 10 minutes.
Spatula was used to loosen cake from sides of pan.
Cake pan was inverted on wire rack and cake allowed to fall from pan.
Waxed paper adhering to bottom of cake was removed and the cake turned to an upright position.
Cake allowed to cool 3 hours then placed on board and covered with a dish pan until the following morning.

The same procedure was followed for mixing the caramel devil's food cake with these exceptions:

Soda was mixed with the last one-third of the milk rather than with the dry ingredients.
The melted chocolate was added during the first period at the end of one and one-half minutes of mixing.
750 grams of batter were baked in each cake pan.
Cake mixture was baked at 340° Fahrenheit for 55 minutes.

Line spread as described by Grawemeyer and Pfund (1943) was an objective test used to measure batter consistency in terms of the ability of a product to spread. In determining line spread a flat plate glass was placed over a diagram of concentric circles 1/8 inch apart the smallest with a diameter of two inches. The circles were numbered consecutively at four widely separated points, number one being the first circle 1/8 inch from the two-inch center circle.

A small metal ring two inches in diameter and 3/8 inch deep was placed on the plate glass directly over the two-inch center circle. At the end of each mixing period the ring was filled with the cake batter and leveled off with a spatula. The ring was then lifted and the batter allowed to spread. At the end of two minutes the reading was taken at the four numbered points on the circle. The average of these four readings was the line-spread, it represented the number of eighth-inch units a given volume of cake batter at room temperature had spread in a period of two minutes.

Approximately 24 hours after baking the following determinations were made: height (used as an index to volume), shortness, compressibility, sand retention, water-absorbing ability and quality as determined by a palatability committee.

In order to efficiently perform these mechanical tests it was necessary to cut the cake in uniform slices. The cutting was accomplished by using a cake cutting box which consisted of a simple apparatus resembling a mitre box. The box was constructed of hardwood, closed at one end and at both sides. Each side had a kerf, one inch from the closed end into which fitted a long knife used for cutting the slices each one inch in thickness.

Four uniform slices were cut from each cake. The first slice was not used for the mechanical tests because of the crust on one side. The next three slices were used to test the height, shortness and compressibility.

The height was determined by measuring in centimeters the fourth slice at the center, at the outer edges and at points one-half the distance from the center to each outer edge. The average of the five measurements was recorded as the height of the cake.

A gram shortometer consisting of a modified spring balance and a remodeled laboratory balance as described by Kramer (1935) and Fulks (1936) was used to measure in grams the force required to break a slice of cake one inch in thickness.

The shortometer as pictured in Plate I was arranged so that on the weighing pan of the spring balance were two parallel bars three inches apart to support the cake. A third bar was suspended from the right-hand pan of the remodeled laboratory balance. This bar was adjusted to apply pressure on the cake at a point mid-way between the two parallel bars. A 250 cubic centimeter glass beaker was placed on the right hand pan into which water was siphoned at the rate of approximately 150 cubic centimeters per minute. The pressure required to break the cake was indicated by two movable hands rotating on the face of the spring balance. The three one-inch slices were tested on the shortometer and an average of these three readings was recorded as shortness of the cake.

The apparatus for testing compressibility similar to that described by Platt and Kratz (1933) and used by Miller (1942) consisted of a remodeled laboratory balance and an Eastman timer. On the right hand pan of the balance was placed a 200 g weight which was balanced by a brass weight and a chain of equal weight on the left hand pan. A metal arm was suspended from the right hand pan on the end of which was a plunger 31 mm. in diameter. The cake sample was placed on an adjustable platform just below and an additional 10 g weight placed on the pan above to hold the plunger to the surface of the cake. The chain on the left hand pan was attached to a wooden drum turned by a handle, the chain was removed slowly in a period of thirty seconds and the weight was allowed to act upon the plunger for two minutes. A pointer on the balance indicated on a millimeter scale any movement of the plunger. A reading was taken at the end of the test period, and the average reading for three samples was recorded as the compressibility of the cake.

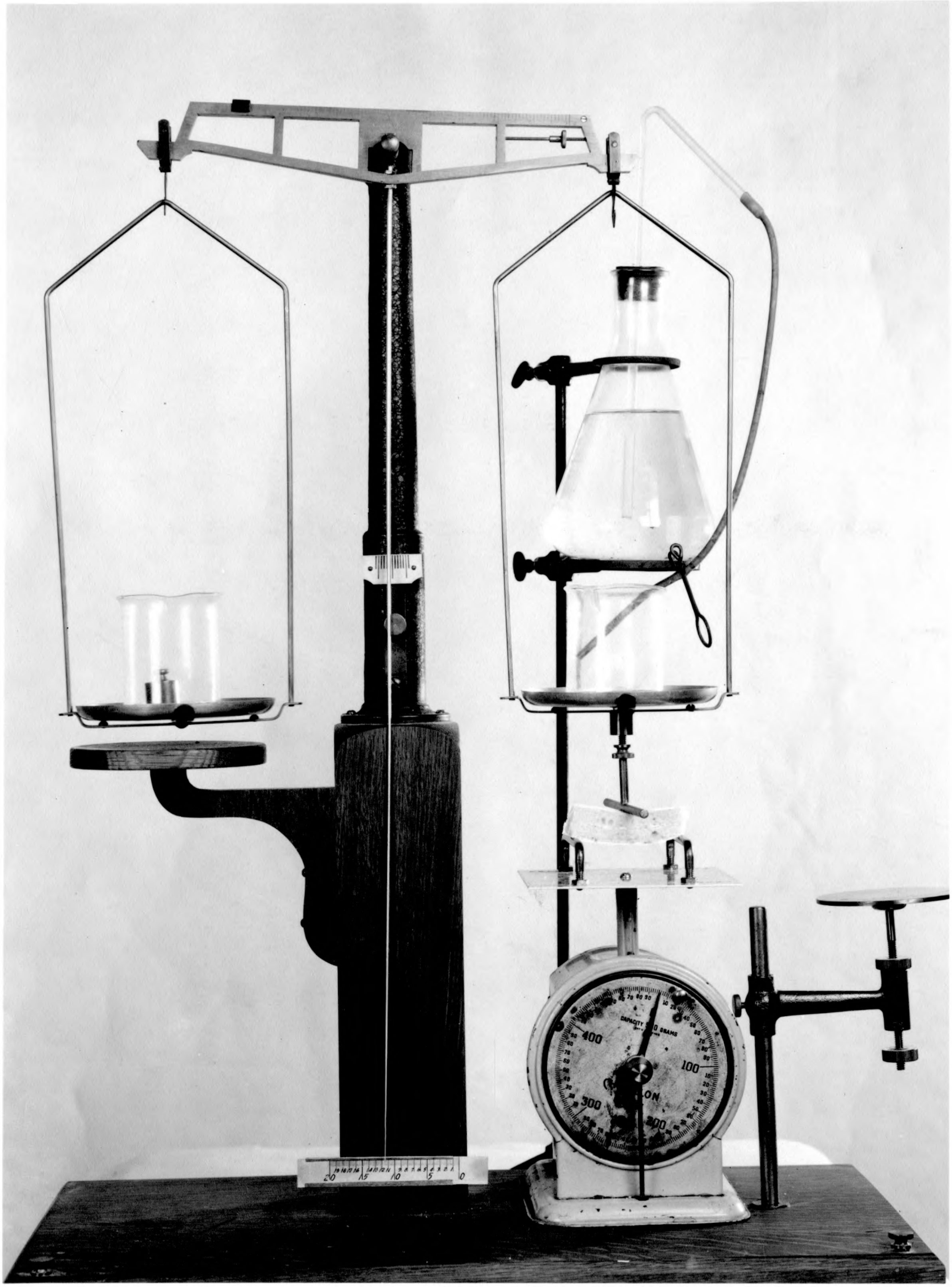
The pieces used for the compressibility tests, two of the other half pieces from the shortness test and the end piece were each wrapped in waxed paper and taken to the members of the palatability committee.

The remaining half of the center piece was preserved in a glycerine-formaldehyde-water solution as described by Markley (1934). These samples dried slightly but the shape, volume, and grain were well preserved. At the completion of

EXPLANATION OF PLATE I

Device for testing breaking and compressibility of cake.

PLATE I



the study, these samples were valuable as means of comparing cakes of one series with each other as well as those of one series with another series.

The portion of the cake that remained was used for other tests. One three-inch piece was stored in a tin cannister having two small holes in the lid and tested for compressibility the following day which was approximately 48 hours after baking. Just before testing, each piece of cake was cut into three uniform pieces of one-inch thickness using the cake cutting box.

The top crust was cut horizontally from the remaining piece and with the aid of the cake cutting box the lower crust was removed so that the test piece was one inch in thickness. The lower surface of the slab was used for the tests as the texture is more uniform near the bottom according to Swartz (1938). From this piece four rounds each one and one-half inches in diameter were cut with a biscuit cutter and carefully covered to prevent drying. The sand retention test for grain of cake and the water absorbing ability or wetability were determined as described by Swartz (1938).

The sand used was sifted through a 30-mesh sieve, thoroughly washed and dried. A weighed round of cake was then placed on a plate, a funnel 6 cm in height with a top diameter of 4.5 cm filled with 14 cc of sand which weighed 25.5 g was held one-inch above cake sample then the cork was removed and the sand allowed to pour over the cake. The piece was carefully placed on a 45° incline, sand side up, and rotated once to permit sand not in the pores to fall off. The cake sample was again weighed and the difference in weight was recorded as a measure of the coarseness of grain.

According to Swartz (1938) the eating character of cake is due to the ability of cake to become moistened with saliva in the first few minutes of chewing. This factor is termed water-absorbing ability or wetability and was determined as follows:

Thirty cubic centimeters of water weighing 30 g was placed in a Petri dish cover 9.7 cm in diameter and a depth of six millimeters. A weighed round of cake was placed in the dish of water and allowed to absorb water for five seconds. The sample was removed, inverted quickly to prevent the loss of water and weighed immediately. The difference in the weight of the cake and the cake plus water represented the water absorbing ability of the cake. Two samples were tested from each cake for sand retention and two for water absorption and the average of each recorded in the tables.

The palatability committee consisted of eight women who scored the samples of cake according to Form I. The committee consisted of three faculty members of the Department of Food Economics and Nutrition, a graduate research assistant in Food Economics and Nutrition, a graduate student in Nutrition, an office secretary, a college student, Junior in School of Home Economics and former 4-H State Champion in cake

Form I. Score Card For Cakes

Date ______________

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

Which cakes fo you prefer?

1st Choice ______________
2nd Choice ______________
3rd Choice ______________
4th Choice ______________
5th Choice ______________
6th Choice ______________

Signature of Judge ______________

Rating Scale With Abbreviations For Use in Scoring Cakes

Note: For use of investigator only.

Rating	Abbreviations	Numerical scoring expressed as percentage of perfect
Perfect	X	100
Perfect minus	X-	97
Excellent plus	E+	93
Excellent	E	90
Excellent minus	E-	87
Good plus	G+	83
Good	G	80
Good minus	G-	77
Fair plus	F+	73
Fair	F	70
Fair minus	F-	67
Poor plus	P+	63
Poor	P	60
Poor minus	P-	57
Bad plus	B+	53
Bad	B	50

Directions for Use of Score Card for Cakes

Abbreviations to be used in scoring:

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

(+ or -) may be used where fine distinctions are to be slightly better than the other but not excellent, mark one G+ and the other G-.

Note appearance of each sample and score before tasting.

Note texture and score crumb.

Taste sample and score remaining points.

Any remarks as to why certain samples were graded high or low will be particularly helpful. Remarks should be accompanied by the number of the cake about which they are made.

judging and the writer.

REVIEW OF LITERATURE

The soybean, a native of Asia, has been known for many centuries according to Horvath (1931) and Dies (1942). The first written record of the soybean was contained in a "Materia Medica" written by Emperor Shen Nung in 2838 B. C. in describing the plants of China.

The knowledge of soybeans according to Dies (1942) spread slowly and records show that in the 18th century there was some knowledge of them in Germany, Holland, France, and England. In 1804, first mention was made of them in American literature to the effect that the soybean was adapted to Pennsylvania and should be cultivated.

The countries of the Orient have long considered the soybean as a product for human consumption as Piper and Morse (1923), Gray (1936), and Dies (1942) have pointed out. Most other countries including America have until recently accepted the soybean as a feed for animals as stated by Dickson (1942) giving it little or no consideration from the standpoint of human consumption.

Horvath (1931) stated that the experience of the Chinese people was a good example that even an entirely vegetarian diet is adequate in every respect if it includes soybean products. He also stated that so far as he was aware, the soybean was the only seed which contained both the water soluble and fat soluble vitamins.

The work of Woodruff and Klass (1938) showed that vegetable soybeans had two potential uses in the United States: first, they would add further variety to the limited assortment of green vegetables on the fall markets and second, the mature beans would substantially increase the protein and calorie content of low cost diets.

Gray (1936), Isker (1942), and Sherman and Albrecht (1942) all agreed that soybeans were high in essential food materials such as vitamins, minerals, fat and complete protein but were relatively low in carbohydrate.

Piper and Morse (1923) and Gray (1936) as well as more recent workers have presented many suggestions for the use of soybeans and soybean products for table use, but most of these have been pushed aside until recently.

According to Sprague (1940) a product termed soybean flour was first made and sold in this country by processors in Decatur, Illinois. The first product termed "Health Flour" sold in 1926 was a fine powder obtained by sifting expeller process soybean oil meal.

Sprague (1940) referred to data prepared by the Department of Agriculture inferring that all finely ground soybean products have been called flour.

Horvath (1935) pointed out that the acceptance of soya flour depends on correct processing and that after correct processing it can be stored without deterioration. Horvath (1938) stated that processing has two main objectives, the elimination of the beany flavoring substances and the inactivation of the enzymes.

Edible soy flour as it is produced today is quite different from the first products as continued improvements have been made from the standpoint of palatability and color.

Payne's (1942) work showed an increased purchase of soy products in Lend-Lease from July 1941 to August 1942. Isker (1942) stated that the principal use of soybean flour by the Army at that time was in K Biscuits which were designed to provide as complete non-meat protein as possible. According to Sprague (1940), the German Press have often referred to use of "Full Soya Flour" and its high food value. It is used in the German Army's war-time diet in a product designated as "Nazi food pills".

Soy flours have already gained a permanent status in some American food products. Stanley (1942) stated that soy based soups were here to stay. The work of Jones and Divine (1942) as well as Le Clerc and Grewe (1942) showed that flour enrichment would be most successfully accomplished when such a product as soy flour was mixed with white or whole wheat flour in given proportions because it would not only add vitamins and minerals but increase the protein value.

One of the unfavorable factors in the marketing of soy products according to Horvath (1935) has been the publicity soy flour has received as a food for diabetitics. This worker believed the logical way of introducing soya flour to the American public would be to incorporate a certain percentage into existing standard food products such as breads and cakes.

Sprague (1940) and Levinson (1942) mentioned the use of soy flour in the baking of sweet goods including cakes, but no details of the work were given.

Commander-Larabee* stated that Vivasoy full fat soya flour had been used advantageously by the baking industry in a number of prepared products including cakes. Also Vivasoy high protein soya flour has had extensive use in various products produced by a number of industries including bakery goods of all kinds. According to Commander-Larabee* Vivasoy high protein soya flour has been incorporated successfully and to an advantage as an ingredient in cake and it has been used to replace a part of the cereal flour in baked goods.

Piper and Morse (1923) and Gray (1936) gave recipes using soy flour as an ingredient for such cakes as spice cake, fruit cake, and coffee cake but made no mention of the possibility of its replacing any of the given ingredients.

Bailey and Le Clerc (1935) and Lowe (1943) emphasized that each ingredient had a specific purpose in a cake mixture. Lowe (1943) stated that the liquid was a solvent for sugar, soluble salts and protein, that the proportion of liquid influenced the degree of hydration of protein and starch, and the characteristics of the finished product.

According to Bailey and Le Clerc (1935) eggs added richness and flavor to the cake mixture. Eggs also improved the general appearance and aided in delaying crumbling which is an indication of staling.

Lowe (1943) described the lecithaprotein of the egg yolk as having strong emulsifying properties and in the batter emulsified all or a major portion of the oil or melted fat.

Bailey and Le Clerc (1935) pointed out that the shortening made the cake tender, improved the grain, texture and keeping quality.

Lowe (1943) stated that sugar added flavor and when used in increasing amounts up to the optimum, it had a tendency to increase the volume and tenderness of the product to which it was added.

The framework of a baked product, which may be modified by other ingredients, was formed by the flour according to Lowe (1943).

Horvath (1931) described lecithin as an important constituent of all organs of the human body especially of the nervous tissue, the heart and the liver. He found that the percentage of lecithin in those organs increased while the subject was on a soybean diet.

According to Sprague (1940), lecithin is present in soy flour in the form of lecithin or in combination with soybean proteins. Sprague (1940) found that German literature stated that one pound of soy flour might contain as much lecithin as four to six eggs. Horvath (1931) agreed with the comparison of the lecithin content of soy flour and eggs as stated in German literature and recorded by Sprague (1940).

Sprague (1940) pointed out that the protein in soy flour is so similar to the protein of meat that neither feeding tests nor protein chemists were able to consistently distinguish between the two.

Horvath (1935) described two general methods of handling soybeans in the manufacture of soy products; namely, the Anderson expeller process and the solvent extraction process.

According to Commander-Larabee* in the production of full fat soya flour, no fat was removed from the original soybean. The cleaned, dehulled soybeans were cracked and conveyed to equipment for controlled debittering and further processing. Other soy flours and speciality products were made by one of two methods. One was the "continuous extraction process" which took the cleaned, dehulled soybeans through a series of continuous operations, cracked, heated and flaked them in order to give a maximum surface for oil extraction. The solvent was then introduced and allowed to flow in reverse direction to the travel of the soybean flakes and continued until the extraction was at the desired level. Such a process made possible soy flour that contained less than one percent fat. The extracted flakes were then further processed and finally ground. In the second method, known as the "expeller or screw press" process the prepared beans were placed in the expeller where the oil was expelled by tremendous pressure exerted in a horizontal steel barrel by a centrally revolving worm shaft.

A general analysis of Commander-Larabee's* Vivasoy high protein soya flour, made by the "continuous extraction" process, showed the following composition:

	Percent minimum	Percent maximum
Protein	51.0	53.0
Fat (ether extract)	0.5	1.0
Fiber	1.0	3.0
Moisture	6.0	8.0
Ash	5.0	6.0
Lecithin	2.0	2.5
Water absorption in bread	200-250	-
Screen analysis through #100 screen		97.0

According to Commander-Larabee* the following characteristics of Vivasoy high protein soya flour have been acknowledged:

It was a most stable soy flour in itself.
Neither it nor the products made from it were subject to deterioration even in extreme storage temperatures, due to its low fat content.
Even with its low fat content, it carried such a high percent of lecithin that it acted as a shortening extender, thus increasing the efficiency of the shortening used.

Unique control in processing retained the remarkable binding strength and the water absorption properties. The presence of this flour in baked goods in given amounts measurably extended the period prior to "staling" known as "shelf life" due to three distinct properties of the flour; namely, the water retention property which prevented moisture loss from the baked product; the anti-oxidant power of the lecithin which inhibited the development of rancidity of added shortening; and the strengthening property of the protein of the flour which caused a decrease in the rate exchange of water from the starch and gluten.

The work of Steller and Bailey (1938) on the use of soy flour in bread showed soy bread to be from four to 24 hours fresher than regular bread which had reached a particular stage in staleness.

From the foregoing review, it is evident that besides the usefulness of edible soybeans in supplementing the diet with protein, vitamins and minerals, milled products from soybeans are destined to have an increasingly important place in bakery goods.

DISCUSSION AND RESULTS

Various amounts of high protein soya flour were used in this study to replace given portions of the cake flour, eggs and fat in a plain cake and a caramel devil's food cake. Another variation was in the increase of milk in parts of several series and the reduction of sugar in one part.

The line spread of the batter was recorded (Table 1) as a check on the viscosity of the batter at the end of the last mixing period. In the plain cake there was a slight increase in line spread when a portion of the cake flour was replaced with soy flour, but the greatest line spread was recorded when a portion of the fat was replaced with small amounts of soy flour. The line spread was most nearly like that of the standard cake when one-third of the fat was replaced with a relatively large amount of soy flour. There appeared to be no correlation between line spread and the tests on the finished product.

The average of five measurements taken on the fourth slice of cake was used as the index to volume (Table 1). The

Table 1. Summary of data for plain cakes.

		Ingredients						Results										
		Cake flour g	Soy flour g	Eggs g	Fat g	Milk g	No. cakes baked	Temperature Room	Temperature Batter	Line spread 1/8 in.	Height cm	Shortness g	Compressibility mm 24 hrs.	Compressibility mm 48 hrs.	Sand retention g	Water absorption g	Palatability committee evaluation basis 100% Average score	Palatability committee evaluation basis 100% Eating quality
Standard		168	0.0	96	75	162.7	6	29.0°	25.8°	0.95	4.26	104.3	3.71	3.09	1.53	8.56	83.22	82.04
	A	162	7.2	96	75	162.7	3	28.0°	28.0°	1.25	4.02	117.53	2.46	2.63	1.55	8.95	81.69	80.41
	B	156	14.4	96	75	162.7	3	29.0°	26.0°	1.06	4.28	114.16	3.03	3.11	1.45	8.91	80.17	78.37
Series I	C	150	21.6	96	75	162.7	3	28.5°	25.5°	-1.00	4.22	114.63	3.19	2.59	1.53	9.16	81.44	79.29
Part I	D	144	28.8	96	75	162.7	5	27.6°	26.3°	-1.00	4.13	91.17	4.89	4.02	1.54	9.12	80.42	79.10
	E	138	36.0	96	75	162.7	2	30.0°	30.0°	-1.00	4.07	105.65	2.69	2.76	1.60	8.92	77.51	75.00
	F	132	43.2	96	75	162.7	4	28.7°	26.0°	-1.00	4.04	102.30	3.34	3.35	1.72	8.88	78.63	78.37
Part II		144	28.8	96	75	180.2	2	27.5°	24.0°	-1.00	3.96	102.65	2.93	3.13	1.12	9.42	79.22	77.06
Series II	A	168	7.2	72	75	162.7	3	30.0°	30.0°	-1.00	3.80	112.16	1.93	1.53	1.46	9.55	77.47	76.20
Part I	B	168	14.4	48	75	162.7	3	28.0°	28.0°	-1.00	3.78	76.85	5.04	5.55	1.33	7.28	76.84	75.45
Part II*		168	14.4	48	75	162.7	3	32.0°	29.0°	-1.00	3.78	80.88	5.66	4.10	1.26	8.96	80.31	76.50
Part III	A	168	7.2	72	75	180.2	5	29.2°	27.2°	-1.00	4.04	86.78	4.19	4.02	1.36	8.61	80.01	77.32
	B	168	14.4	72	75	197.7	3	28.3°	25.3°	-1.00	3.97	77.30	4.31	2.96	1.43	8.18	79.51	78.91
Series III	A	168	7.2	96	62.5	162.7	4	28.5°	25.5°	2.00	4.51	123.12	4.30	2.69	1.63	9.33	79.16	78.21
Part I	B	168	14.4	96	62.5	162.7	3	28.5°	27.5°	1.50	4.34	145.10	2.35	2.64	1.41	9.20	80.72	76.66
	C	168	21.6	96	37.5	162.7	2	28.0°	25.5°	3.25	4.46	186.3	2.03	2.26	1.50	7.55	80.50	76.25
Part II	A	168	14.4	96	62.5	180.2	4	28.7°	26.6°	1.43	4.30	119.82	2.93	2.33	1.37	9.50	82.34	80.46
	B	168	14.4	96	50.0	197.7	4	27.7°	24.7°	4.50	4.23	114.27	3.19	2.64	0.94	8.17	81.34	79.25
	C	168	28.8	96	50.0	197.7	3	28.6°	26.0°	3.03	4.12	167.06	2.06	2.33	1.16	8.66	79.49	76.37
	D	168	43.2	96	50.0	197.7	2	29.0°	27.5°	0.87	4.00	164.0	1.83	2.36	1.20	8.70	76.84	72.12
	E	168	21.6	96	37.5	206.45	2	28.0°	24.5°	4.87	3.87	155.65	2.13	2.53	1.30	7.17	81.01	79.37
Part III		132	43.2	96	50.0	162.7	3	26.6°	24.6°	0.91	4.50	116.43	4.33	3.15	1.25	8.70	83.72	81.91
Series IV	A	168	21.6	72	62.5	197.7	5	28.2°	26.2°	1.50	4.12	93.02	4.52	2.86	1.43	9.37	79.82	75.28
	B	168	28.8	48	50.0	197.7	4	28.0°	25.2°	1.31	3.99	113.01	2.59	2.04	1.11	8.23	82.29	81.20

* Sugar decreased from 200 grams to 187.5 grams.

volumes of the cakes were apparently affected very little by the replacing of cake flour with soy flour except when accompanied with an increase in milk which resulted in a decrease in volume (Plate II). All cakes showed a decrease in volume when a portion of the egg was replaced with soy flour even with a reduction in sugar (Plate III). The replacement of a portion of the fat with soy flour resulted in cakes with greater volume than that of the standard cake except when the milk was increased 16 percent or more (Plate IV). Cakes having both eggs and fat replaced with soy flour and the milk increased gave a product with a volume slightly less than that of the standard cake (Plate V). The volume of the cakes showed little or no relationship to the other results obtained in this study.

The shortometer tests for tenderness of the cakes (Table 1) indicated that there was a decrease in the tenderness of cakes with flour replacement up to a certain point. Larger flour replacements gave an increase in tenderness. The replacement of one-fourth of the egg toughened the cakes slightly but when the milk was increased too, the cakes were much more tender even when a larger proportion of soy flour replaced the given amount of egg. The replacement of one-half of the egg with two tablespoons of soy flour produced a cake that was even more tender than the cake in which one-fourth of the egg was replaced with two tablespoons of soy flour and the milk increased. When one-half of the egg was replaced with

PLATES II - IV, Inclusive

EXPLANATION OF PLATES II - IV, Inclusive

Plate II. Plain cakes.

Standard

Series I, Part I. Varying portions of cake flour replaced with equal measure of soy flour.

Series I, Part II. Varying portions of cake flour replaced with equal measure of soy flour and milk increased.

Plate III. Plain cakes.

Standard

Series II, Part I. Varying portions of egg replaced with soy flour.

Series II, Part II. Portion of egg replaced with soy flour and sugar reduced.

Series II, Part III. Varying portions of egg replaced with soy flour and milk increased.

Plate IV. Plain cakes.

Standard

Series III, Part I. Varying portions of fat replaced with soy flour.

Series III, Part II. Varying portions of fat replaced with soy flour and milk increased.

Series III, Part III. Portions of fat and cake flour replaced with soy flour and milk increased.

PLATE II

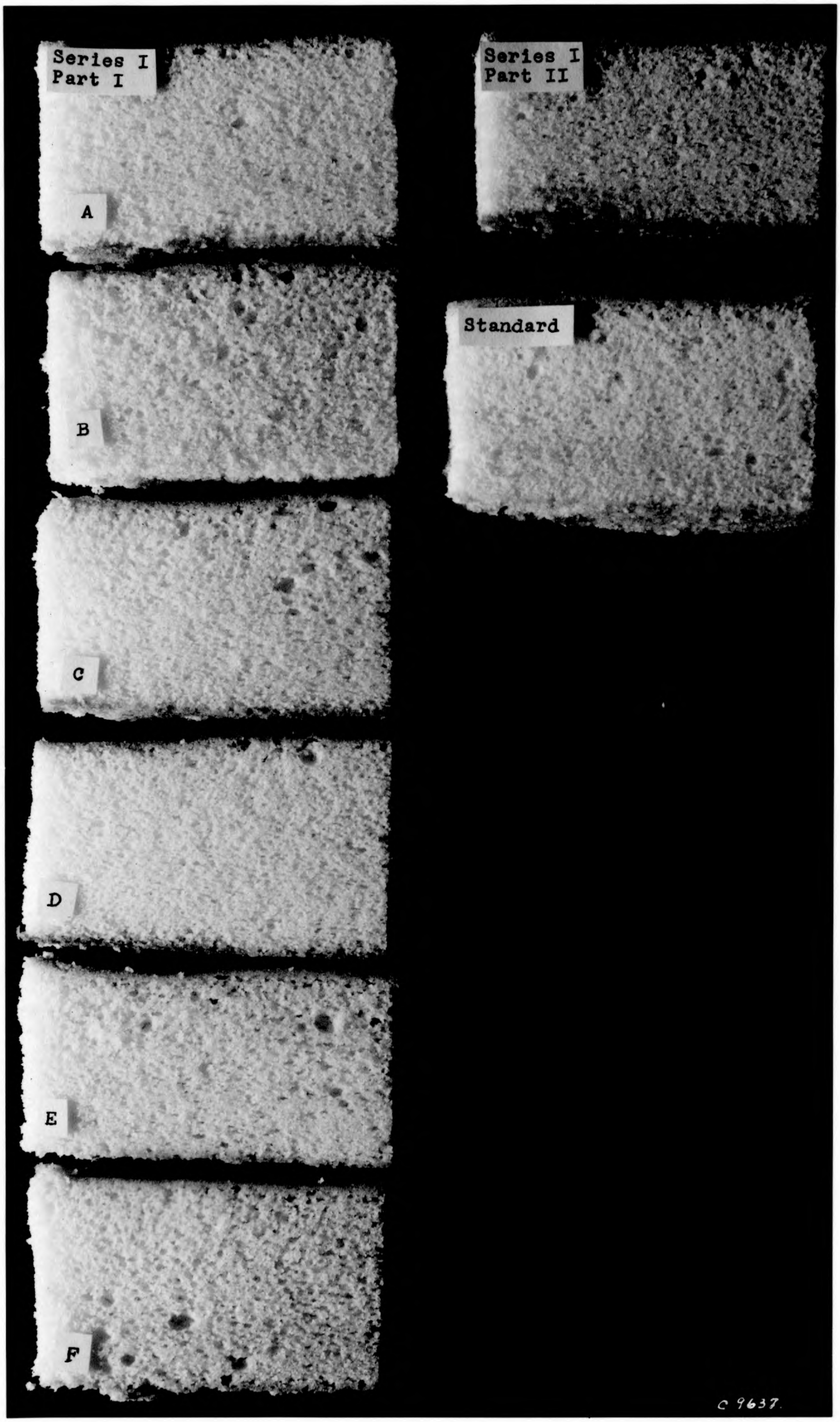


PLATE III

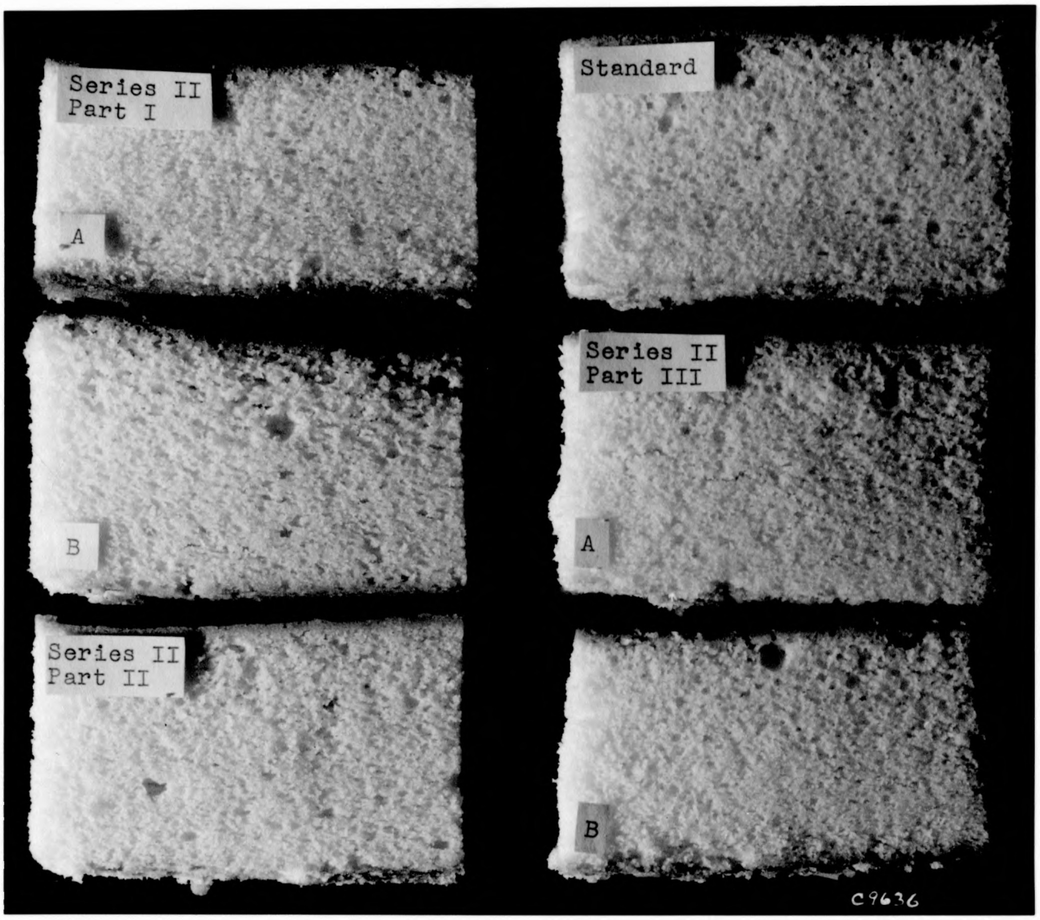
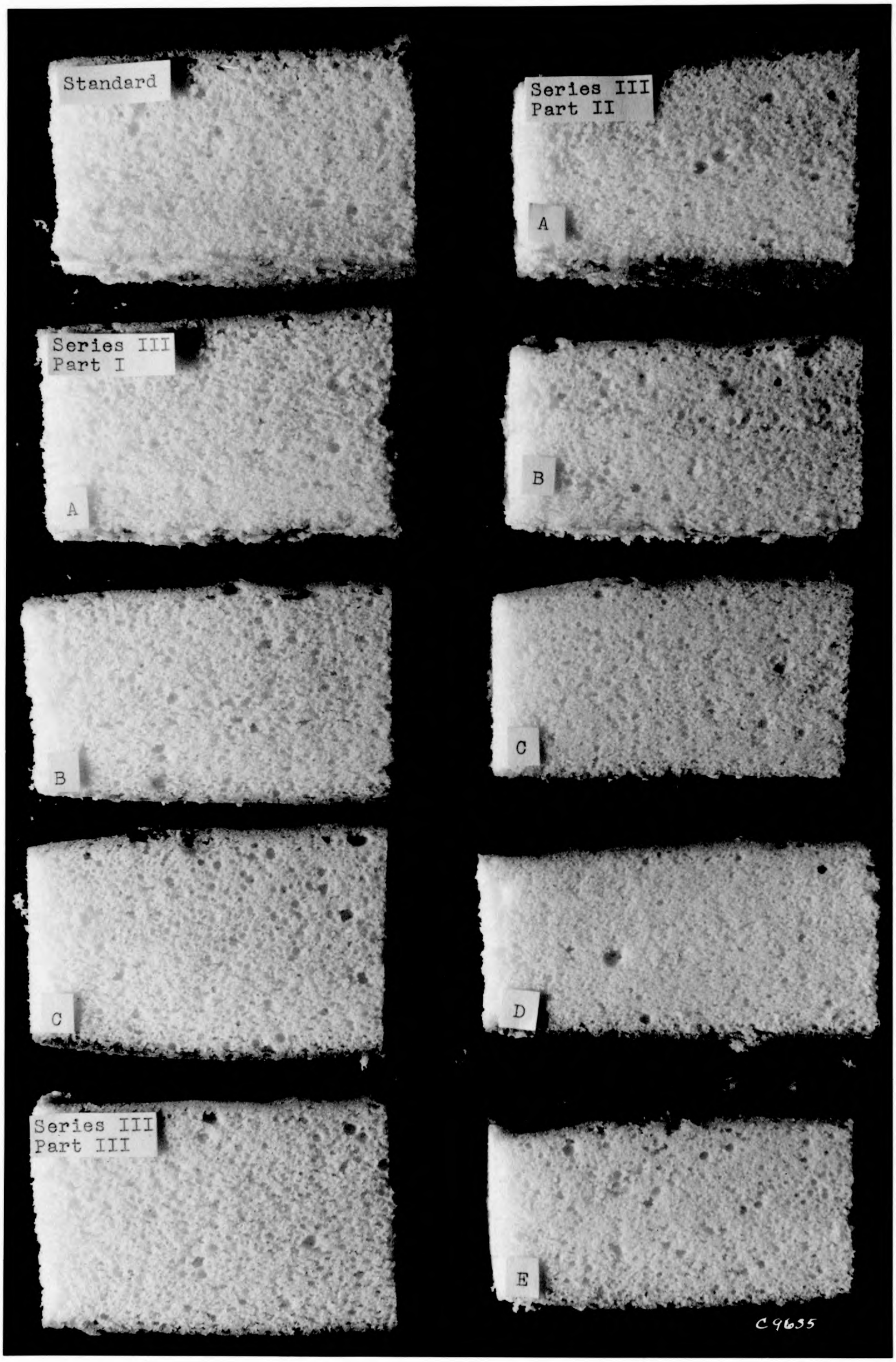

Series II
Part I
A
B
Series II
Part II
Standard
Series II
Part III
A
B
C9636

PLATE IV

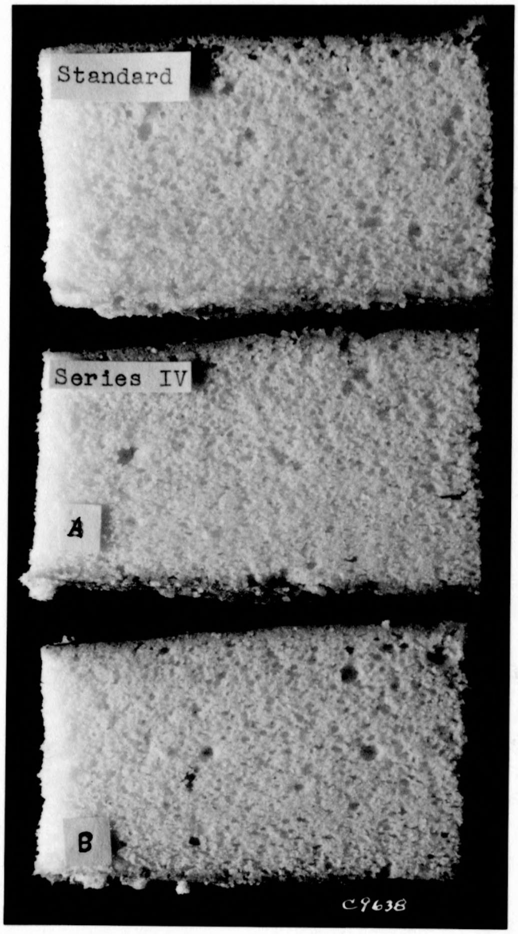

Standard
Series III
Part II
A
Series III
Part I
B
A
C
B
D
C
Series III
Part III
E
C9655

two tablespoons of soy flour and the sugar reduced one tablespoon, it made a tender cake but not as desirable as the one without the sugar reduction because it was low in the center. The replacement of a portion of the fat also toughened the cakes even with added milk. When a portion of the egg and a portion of the fat were replaced with soy flour and the milk increased, a more tender cake was obtained than with the replacement of a portion of the fat alone but not as tender as with the replacement of a portion of the eggs alone. The two cakes scored highest by the palatability committee and rated next to the standard cake in eating quality were not the ones that were most tender.

Compressibility tests (Table 1) were done approximately 24 hours after baking and again approximately 48 hours after baking in an attempt to determine the effect soy flour had on the keeping quality of cake. Flour replacements produced cakes that were low in compressibility up to a certain point, then the compressibility increased above that of the standard cake and past this point again decreased. Cakes containing low amounts of replaced flour gave higher compressibility 48 hours after baking than they did 24 hours after baking. The replacement of one-fourth of the egg produced cakes with low compressibility while the replacement of one-half of the egg gave cakes with high compressibility which further increased at the end of 48 hours. When the sugar was decreased with the

PLATE V

PLATE V



EXPLANATION OF PLATE V

Plain cakes

Standard

Series IV. Varying portions of egg and fat replaced with soy flour.

given egg replacement the compressibility was higher the first day than with the standard amount of sugar, but showed a definite decrease at the end of 48 hours. The compressibility was high at the end of 24 hours when one-sixth of the fat was replaced with small amounts of soy flour, but decreased after 48 hours. When the proportion of soy flour used to replace one-sixth of the fat was increased, the cakes had lower compressibility the first day but showed slight increase on the following day. When one-half of the fat was replaced with larger amounts of soy flour the results were comparable to those using large proportions of soy flour in replacing one-sixth of the fat. Cakes with much higher compressibility than that of the standard cake were obtained when one-fourth of the eggs and one-sixth of the fat were replaced with soy flour and the milk increased. This figure dropped to below that of the standard cake at the end of 48 hours. The replacement of one-half of the egg and one-third of the fat with soy flour accompanied by an increased amount of milk produced cakes with compressibility below that of the standard cake.

The sand retention test described by Swartz (1938) was used as a means of studying the size of pores or the grain of the cake (Table 1). A cake having a coarse grain with large pores will retain considerable sand but as Swartz (1938) pointed out, the cake with the lowest sand retention figure may not be the choice cake because it might be so compact that practically no sand would penetrate the surface of the cake. When soy flour was used to replace a portion of the cake flour there was a slight increase in sand retention over that of the standard cake, but when increased amounts of milk were used the sand retention dropped to below that of the standard cake. The cakes in which a portion of the egg was replaced with soy flour gave a sand retention figure below that of the standard cake. The series in which a portion of the fat was replaced with soy flour produced cakes with a sand retention below that of the standard cake with one exception. Sand retention below that of the standard cake also resulted when a portion of both the eggs and the fat were replaced with soy flour. It was observed that the cakes in the various series were quite similar when considering size of pores as measured by sand retention.

Swartz (1938) described the dryness of a cake as a quality that could be measured in terms of water absorbing ability or "wettability" (Table 1). The cakes that had a slightly dry feel to the touch and to the palate had higher water absorption than the ones that felt moist. The water absorption of the cakes containing soy flour was higher than that of the standard cake except in the following cases: when a portion of the egg was replaced with soy flour or when this replacement was accompanied by an increase in milk; when one-half of the fat was replaced with soy flour or when one-half or one-third of the fat was replaced each accompanied by an increase in milk; and when large portions of both the egg and fat were replaced accompanied by an increase in milk.

The members of the palatability committee often indicated a preference for the cakes containing soy flour over the standard cakes according to the score sheets. The cakes in which one-third of the fat and six tablespoons of cake flour were replaced with six tablespoons of soy flour were the choice of the palatability committee with a score of 83.72 and a rating of 81.91 for eating quality (Table 1). The second choice by the committee from the score standpoint were the standard cakes with a score of 83.22 and a rating of 82.04 for eating quality (Table 1).

The least desired cakes were the ones in which one-third of the fat was replaced with six tablespoons of soy flour and the milk increased two tablespoons. These cakes were given a score of 76.84 with a rating of 72.12 for eating quality (Table 1).

When the scores of all the cakes in a series were averaged, it was found that as a whole standard cakes were given slightly higher scores than any of the series. Cakes in Series IV in which portion of both the egg and fat were replaced scored above those in Series III in which a portion of the fat only was replaced. Cakes in Series I in which a portion of cake flour was replaced were scored above the least desired cakes of Series II in which a portion of the egg was replaced (Table 1).

In Series II, the cakes in which there was a sugar reduction or an increased amount of milk used with the given egg replacement were preferred to those cakes in which a portion of the egg was replaced with soy flour and no other variation made (Table 1).

In Series III, the cakes in which the fat replacement was accompanied by an increase in milk were preferred to those in which there was no increase in milk. However, the cakes in which a portion of the cake flour and a portion of the fat were replaced with soy flour were the preferred cakes in this series.

The results with the caramel devil's food cakes were similar to those of the plain cake in many respects.

The cake batter was rather viscous and the line spread in all series was similar (Table 2).

The minimum flour replacement gave cakes with greater volume than that of the standard while increased flour replacements gradually decreased the volume until 28.8 g were used when the cakes were low in the center (Plate VI). Egg replacements gave decreased volumes while fat replacements gave increased volumes (Plate VI). When portions of both eggs and fat were replaced with soy flour the volume (Plate VII) was increased (Table 2).

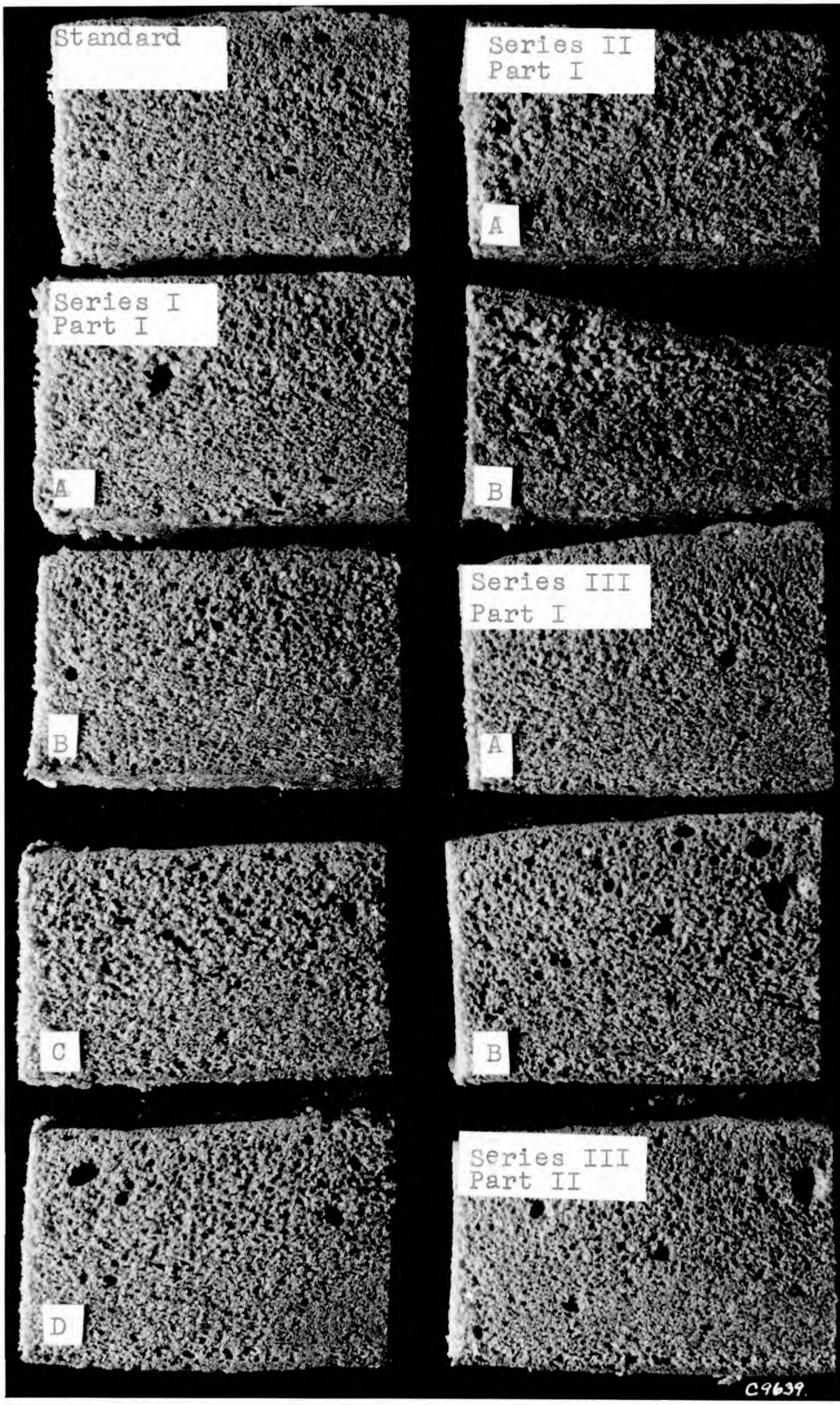
Cakes in which a portion of the egg was replaced with soy flour and the ones in which a portion of the egg and the fat

Table 2. Summary of data for caramel devil's food cakes.

		Ingredients					Results											
		Cake flour g	Soy flour g	Eggs g	Fat g	Milk g	No. cakes baked	Temperature Room	Temperature Batter	Line spread 1/8 in.	Height cm	Shortness g	Compressibility mm 24 hrs.	Compressibility mm 48 hrs.	Sand retention g	Water absorption g	Palatability committee evaluation basis 100% Average score	Palatability committee evaluation basis 100% Eating quality
Standard		192	0.0	96	100	244	4	30.0°	27.6°	-1.00	4.88	127.15	5.09	3.61	1.28	5.36	83.92	86.12
Series I Part I	A	186	7.2	96	100	244	2			-1.00	5.10	140.00	4.01	3.36	1.25	4.42	80.94	83.93
	B	180	14.4	96	100	244	2			-1.00	4.71	160.65	2.96	3.14	1.25	4.47	77.26	79.62
	C	174	21.6	96	100	244	2	30.+°	28.0°	1.00	4.85	150.30	3.13	3.34	1.38	4.45	82.34	82.00
	D	168	28.8	96	100	244	2	29.0°	26.0°	1.00	4.71	138.30	5.31	2.99	1.65	5.35	80.88	81.87
Series II Part I	A	192	7.2	72	100	244	3	30.5°	28.5°	-1.00	4.70	117.76	5.30	3.81	1.24	5.00	80.86	82.12
	B	192	14.4	48	100	244	2	30.0°	27.0°	-1.00	4.33	102.30	4.19	5.19	1.30	4.87	73.78	76.06
Series III Part I	A	192	7.2	96	87.5	244	3	30.0°	28.0°	1.08	5.20	152.83	4.11	3.12	1.51	4.78	80.52	83.83
	B	192	21.6	96	62.5	244	2	30.0°	28.0°	-1.00	5.45	161.30	3.76	3.48	1.47	5.27	82.28	79.50
Part II		192	21.6	96	62.5	287.75	2	30.5°	27.5°	-1.00	5.11	183.95	3.06	2.56	1.52	5.95	82.15	81.81
Series IV	A	192	14.4	72	87.5	261.50	4	29.7°	27.2°	-1.00	5.03	115.72	5.94	6.27	1.37	6.17	84.58	84.84
	B	192	28.8	48	50.0	279	4	29.7°	25.7°	-1.00	5.06	123.30	4.99	4.52	1.30	6.00	83.52	82.43
	C	192	21.6	72	62.5	287.75	2	29.5°	27.0°	1.00	5.12	159.95	3.30	2.96	1.57	5.20	82.67	81.87

PLATE VI

PLATE VI


Standard
Series II
Part I
A
Series I
Part I
A
B
B
Series III
Part I
A
C
B
D
Series III
Part II
C9639.

EXPLANATION OF PLATE VI

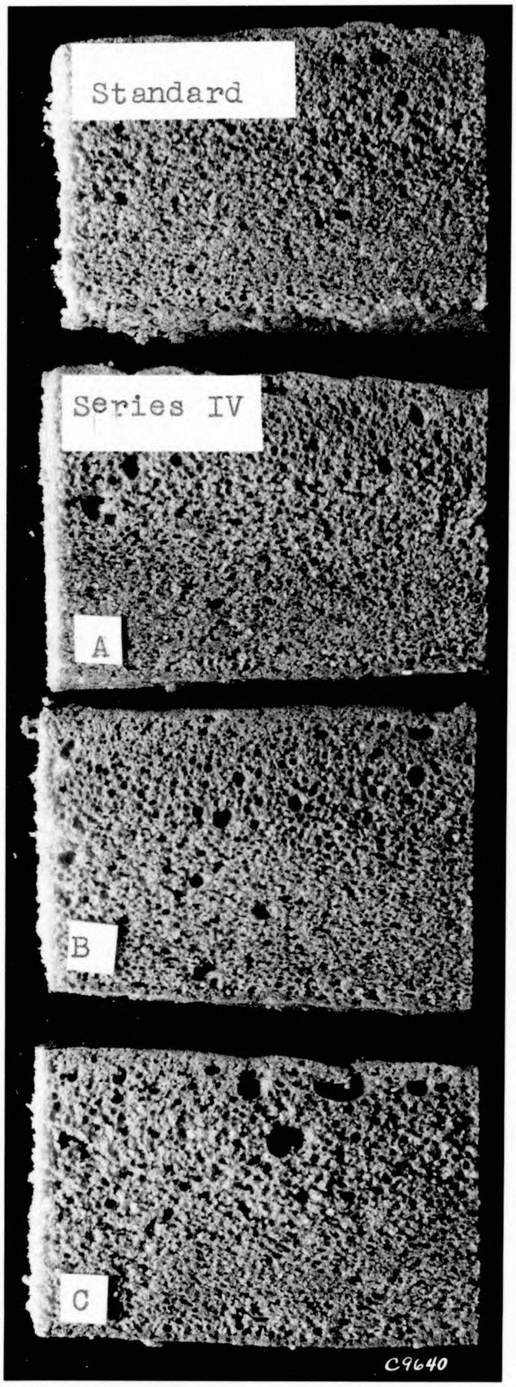
Caramel devil's food cakes

Standard

Series I, Part I.	Varying portions of cake flour replaced with equal measure of soy flour.
Series II, Part I.	Varying portions of egg replaced with soy flour.
Series III, Part I.	Varying portions of fat replaced with soy flour.
Series III, Part II.	Varying portions of fat replaced with soy flour and milk increased.

PLATE VII

PLATE VII



EXPLANATION OF PLATE VII

Caramel devil's food cakes

Standard

Series IV. Varying portions of egg and fat replaced with soy flour and milk increased.

was replaced accompanied by a small increase in the amount of milk gave lower shortometer readings than did the standard cake (Table 2). The cakes with a portion of the fat replaced and the one with a portion of the fat replaced accompanied by an increase in the milk were the least tender.

The compressibility of the cakes in which flour was replaced was lower than that of the standard cake with the exception of the one containing the largest amount of soy flour which had greater compressibility than the standard cake (Table 2). Some of these cakes gave slightly higher compressibility 48 hours after baking but two of them including the one with the largest amount of soy flour showed a decrease in compressibility (Table 2). Cakes with one-fourth of the egg replaced gave greater compressibility than that of the standard cake but decreased at the end of 48 hours. All cakes with a portion of the fat replaced with soy flour gave low compressibility tests at the end of 24 hours and still lower at the end of 48 hours. The cakes in which one-fourth of the egg and one-eighth of the fat were replaced and the milk increased gave higher compressitility than that of the standard cake at the end of 24 hours and a further increase at the end of 48 hours (Table 2).

The sand retention was higher than that of the standard cake as larger amounts of flour were replaced. When one-fourth of the egg was replaced the sand retention was lower than that of the standard cake while in all other cakes in which eggs or fat or both were replaced there was higher sand retention. In a few cakes it was observed that there were some large holes but this could not be correlated with any other qualities.

The water absorption was lower than that of the standard cake except when: one-fourth of the fat was replaced with soy flour and the milk increased; when one-fourth of the egg and one-eighth of the fat were replaced and the milk increased and when one-half of the egg and one-half of the fat were replaced and the milk increased.

The cakes with one-fourth of the egg and one-eighth of the fat replaced and the milk increased were scored higher than the standard cake but rated under the standard cake in eating quality. The least desired cake was one in which one-half of the egg had been replaced with soy flour. The cakes in the fat replacement series were scored higher and rated higher in eating quality than those in the series of flour replacement or egg replacement, but not as high as those in which a portion of both eggs and fat were replaced and milk increased (Table 2).

The temperature of the room varied during this study but the temperature of the cake batters was kept quite constant and only in three cases was it the same as the room temperature. It was observed that on days when the humidity was high the cakes had slightly less volume and had a greater tendency to pull away from the sides of the pans; this was particularly true in the plain cake.

The plain cakes in which the largest amounts of soy flour were present had browner crusts than the standard cakes and the ones containing smaller amounts of soy flour. Plain cakes were capable of carrying higher flour replacements than the caramel devil's food cakes before they fell. This characteristic was attributed to the fact that the formula used for the caramel devil's food cakes had, in addition to chocolate, a higher proportion of fat and sugar, than that used for the plain cake.

There was no mark placed on the table indicating the 10 plain cakes in which Spry was used in place of Cudahy's White Ribbon shortening because the cakes gave similar results in all mechanical tests and were no more acceptable to the palatability committee than the cakes made with the original fat.

According to the score sheets (Form I) the palatability committee did not record objectionable color in any case for either the plain cake or the caramel devil's food cake. Comments on the color such as "pale", "dark", "white", and "grayish color" were made in less than three percent of the cases for the plain cakes and no comments were made for the caramel devil's food cakes. It was believed by the writer that these comments were made as a comparison of the cakes scored at a given time. When considering the average score plus the eating quality (Tables 1 and 2) for both types of cake, the standard cakes were the choice of the palatability committee over any cake that contained soy flour.

The choice of cakes (Tables 1 and 2) from first to fifth as indicated on the score card (Form I) has not been used in evaluating this study because it was not practical to repeat specific cakes in a definite pattern. Due to this fact, there is a wide variation in the rating given a cake, from first to fifth, at the various times it was baked. There also was considerable variation in the rating for a given cake from first to fifth as designated by the different members of the palatability committee. Part of this variation was attributed to the personal preferences of each member of the committee. No cake was made that was entirely undesirable according to the palatability committee (Tables 1 and 2).

According to the compressibility tests, the presence of soy flour extended the period prior to "staling" in some of the cakes. The compressibility of 47.8 percent of the plain cakes (Table 1) and 33 1/3 percent of the caramel devil's food (Table 2) was greater at the end of 48 hours than after 24 hours.

SUMMARY

The purpose of this study was to determine the effect of replacing a portion of the cake flour, egg and fat with Vivasoy high protein soya flour in cakes containing fat. A plain cake and a caramel devil's food cake were used for this study.

The experimental work was divided into four series:

Series I

Part 1. Varying portions of cake flour replaced with equal measure of soy flour.

Part 2.* Varying portions of cake flour replaced with equal measure of soy flour and milk increased.

Series II

Part 1. Varying portions of egg replaced with soy flour.

Part 2.* Portion of egg replaced with soy flour and sugar reduced.

Part 3.* Varying portions of egg replaced with soy flour and milk increased.

Series III

Part 1. Varying portions of fat replaced with soy flour.

Part 2. Varying portions of fat replaced with soy flour and milk increased.

Part 3.* Portions of fat and cake flour replaced with soy flour and milk increased.

Series IV

Varying portions of egg and fat replaced with soy flour and milk increased.

* Omitted for devil's food cakes.

The ingredients in each series were as nearly identical as possible. A model D Hamilton Beach electric mixer was used to combine the ingredients by a four-minute method of mixing. All preparation and baking was done in the Experimental Laboratory. The baked cakes were cooled three hours, stored and tested the following day in the Research Laboratory.

The following determinations were made: temperature of room and batter at the end of the mixing period; line spread; height of center slice of baked cake, shortness, compressibility approximately 24 hours after baking and again approximately 48 hours after baking; sand retention; water absorption and the quality as determined by a palatability committee.

Following are findings resulting of this study:

The replacement of a portion of the egg with given amounts of soy flour increased the tenderness of the cakes. When such replacements were carried too far, the cakes had a crumbly texture.

The replacement of a portion of the fat with given amounts of soy flour increased the volume but decreased the tenderness of the cakes.

The replacement of a portion of the egg and a portion of the fat with soy flour produced satisfactory cakes with more desirable volume and texture than when either of the replacements was used alone.

The use of additional milk did not improve the cake when used as an accompaniant to flour replacement, but resulted in improvements when portions of the fat were replaced.

The plain cake mixtures permitted the replacement of larger portions of cake flour with soy flour than the caramel devil's food; however, both cakes were satisfactory when one-eighth of the cake flour was replaced with soy flour.

Although different substitutions were used, replacing one tablespoon of cake flour with one tablespoon of soy flour, one egg with two tablespoons of soy flour and one tablespoon of fat with one tablespoon of soy flour proved satisfactory.

Soy flour was used satisfactorily in the plain cakes to replace 25 percent of the egg; 16.6 percent to 33.3 percent of the fat; or a combination of 25 percent of the egg and 16.6 percent of the fat; or 21.4 percent of the cake flour and 33.3 percent of the fat.

Soy flour was used satisfactorily in the caramel devil's food cakes to replace 25 percent to 50 percent of the egg; 12.5 percent to 33.3 percent of the fat; a combination of 25 percent of the egg and 12.5 percent of the fat; or 50 percent of the egg and 50 percent of the fat.

The compressibility of 47.8 percent of the plain cakes and 33.3 percent of the caramel devil's food cakes containing soy flour was greater at the end of 48 hours than after 24 hours. The compressibility of the standard cakes decreased after 24 hours.

Cakes containing soy flour were often indicated as the choice of the palatability committee, but when all points were considered, only once was the average score of the plain cake containing soy flour greater than that of the cake containing none and only once for the caramel devil's food. In both types, the cakes containing no soy flour scored highest in eating quality.

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