THE EFFECT OF TWO MIXTURES CONTAINING LECITHIN ON SHORTENING QUALITIES, PALATABILITY, AND KEEPING QUALITIES OF CERTAIN BAKED PRODUCTS

by

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INTRODUCTION

During the war, the bakery industry suffered from shortages of both fats and sugars, ingredients which are closely associated with high quality in bakery products. Much work was done with sugar substitutes and attempts were made to develop fat-extenders by using mixtures containing lecithin as the basic ingredient.

The purpose of this study was to use two commercial mixtures containing lecithin in three baked products, varying the amounts of fat in the standard formulas to determine the effect on shortening qualities, palatability, and keeping qualities.

REVIEW OF LITERATURE

Lecithin, a phospholipid, is a triglyceride in which one fatty acid radical is replaced by phosphoric acid and choline. Sherman (1946) stated that phospholipids belong to the lipoid group of substances which are "fat like", but do not include the fats and fatty acids themselves. The 1942 edition of Webster's Unabridged Dictionary gave the following definition for lecithin(s): "Any of several complex, waxy, crystallizable phospholipids widely distributed among animal and vegetable products especially conspicuous in brain and nerve tissue and yolk of egg." Lecithin took its name from the Greek word, lekithos, meaning yolk of egg.

Although the occurrence of lecithin in nature is so widespread that it can be said that every living cell of both vegetable and animal tissue contains at least some lecithin, most experimental work has been done on cottonseeds (Science, Sept. 8, 1944), corn and peanuts (Schoen, 1944). Extractions on a commercial scale have been made from egg yolk and soybeans.

Sleigh (1942) stated that the first extractions of lecithin were from egg yolk which contained 11 percent lecithin. The product was heavy, waxy, and unmanageable; it had an offensive odor, and the costs of extraction were too high to be practical. Some time after the commercial extraction from egg yolk was discontinued, a process for manufacturing lecithin from soybean oil was perfected in Europe by German and Danish oil processors at costs that were not prohibitive.

The process was brought to the United States, but according to Sleigh (1942), not until the increased acreage of soybeans in this country occurred about 20 years ago, did it become commercially important. This prolific source of soy lecithin inspired much research in the field of its application to industry. Semrod (1943) listed the following industries in which lecithin is used: rayon, rubber, soap, paint, ink, glue, toothpaste, cosmetic, pharmaceutical, confection and other food industries.

During the process of extracting and expressing, the soybean phospholipids are incorporated into the soybean oil from which they may then be separated by hydration, centrifuging,

and drying in vacuo (Stanley, 1946). Sleigh (1942), in discussing the manufacture of commercial lecithin, gave the following figures: one ton of soybeans yields 250 pounds of oil; the 250 pounds of oil yield five pounds of phospholipids, 25 percent of which is pure lecithin. Thus, from one ton of soybeans, one and one-fourth pounds of pure lecithin are produced.

Eichberg (1939), Sleigh (1942), and Stanley (1942) agreed that the product of soybean phospholipids, the lecithin of commerce, is invariably associated with 35 to 40 percent absorbed soy oil, which serves as a carrier, and 60 to 65 percent phospholipids which are the active substance. According to Eichberg (1939), the oil guards against any change in the active substance and renders it soft and easy to use.

Concerning the nomenclature of the soy phospholipids, Eichberg (1939) maintained the term lecithin refers to soy lecithin of commerce unless qualified by context, and Stanley (1946) agreed that by convention, it is customary to call the product soybean lecithin or just plain lecithin.

It was formerly thought that soy phospholipids contained only soy oil, lecithin, and cephalin, but recent analyses have shown considerable amounts of carbohydrates and phytosterols (Stanley, 1946).

In discussing its properties, Stanley (1946) described commercial soybean lecithin as a light brown, waxy material of bland taste and neutral odor. It is substantially anhydrous and imputrescible; consequently, it may be stored for years

without decomposition. It can be bleached with hydrogen peroxide to a light yellow color.

The absorbed soybean oil in commercial lecithin may be removed with acetone to obtain a purified lecithin which is much less soluble than commercial lecithin. The purified product is demanded by the pharmaceutical trade (Eichberg, 1939). In describing purified lecithin, MacLean (1927) stated that it is very labile and undergoes changes as the result of oxidation; it gradually becomes insoluble in alcohol and ether, and soluble in water. Thus, a highly oxidized sample of purified lecithin will differ materially from a fresh sample in solubility and other properties.

Lecithin has been described as having a "split personality."[1] It has a lipophylic fatty acid group and a hydrophylic phosphoric acid amino group (Stanley, 1946). This chemical structure gives it its emulsifying and colloidal properties which adapt it for use in a wide variety of products mentioned before.

The chemical properties which make lecithin valuable in the food industry were listed by Working (1936), Sleigh (1942), and Cook[2]:

(1) It is a surface active substance.
(2) It is an anti-oxidant.
(3) It reduces surface and interfacial tensions.

Because of the first and third properties listed above, lecithin is an efficient wetting agent and emulsifier. It was

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[1] "Lecithin, Industrial Ally," Progress Through Research, General Mills Publication. 1(1):1. 1946.

[2] Cook, L. Russell, "Lecithin and the Baking Industry," Booklet, W. A. Cleary Corp., New Brunswick, N. J. 9 p.

lecithin's power to reduce surface and interfacial tensions that prompted experiments to use it as a shortening extender. Lowe (1943) stated, "The degree of shortening produced by a fat or oil in a given product depends primarily upon the surface area of flour particles covered by the fat." Fat globules have a relatively high surface tension. If this surface tension can be reduced, thus spreading the fat more efficiently over the surface of the flour, the shortening ability of the fat will be increased. Therefore, the addition of lecithin to a baker's formula might be expected to reduce the amount of fat needed to produce the desired degree of shortness.

According to Stanley (1942, 1946) when lecithin is dispersed in a heterogeneous system such as ice cream, chocolate, or cake dough, it can be visualized as forming a layer one molecule deep at the interface between the different constituents, the fatty acid group facing the fat surface, and the phosphoric acid group facing the water surface. He claimed that higher percentages than 0.05 percent lecithin can be added to baking fats to increase shortening and emulsifying effects in bread, cake, and biscuit dough. He stated that lecithin acts as a lubricant, causing shortening to spread rapidly and uniformly throughout the batch. This action promotes tenderness, moisture retention, and even texture with reduced amounts of fats.

The literature showed conflicting opinions regarding the role of lecithin as a fat extender in bakery products. Stanley (1946) maintained that the shortening effect is improved by

adding small percentages of soy lecithin to bread dough and cake batter, thus making considerable saving of shortening possible. Sleigh (1942) was also of the opinion that lecithin added to shortening not only facilitates distribution of shortening in the batch, but increases its effectiveness, so that an equivalent shortening effect is obtained with reduced amounts. He claimed the use of lecithin will permit a reduction of 12 to 25 percent of the amount of shortening normally required. He made the following recommendations:

Product	Percent of lecithin per unit weight of shortening	Percent of shortening saved
cake	1	15-20
pie	1	15
bread and sweet dough	2	25

Business Week (Feb. 26, 1944) reported that lecithin assists fats to disperse more freely among the other ingredients of bread, cake, packaged biscuits, and cookies, therefore less fat is required to achieve a given result.

On the other hand, Cook[3] of the W. A. Cleary Corporation, New Brunswick, N. J., which produces "Clearate," did not consider commercial lecithin a fat extender. He said:

> Lecithin is being very extensively and successfully applied to the baking industry not as a replacement or a substitute for any other item with particular emphasis on shortening, but as an ingredient which has a sufficient number of desirable characteristics of its own that it is fast becoming a standard of all bakery formulas which include fats of any kind.

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[3] Cook, L. Russell, "Lecithin and the Baking Industry," Booklet, W. A. Cleary Corp., New Brunswich, N. J. 9 p.

In a later article (1945), he pointed out that some of the values of shortening in bakery products are not entirely due to lubrication, but to the actual bulk of the fat present. He maintained that shortening adds certain definite qualities to bakery products, and lecithin adds just as definite but a different series of qualities and that the only point of overlap is their lubricating effect. Semrod (1943) stated that lecithin is primarily an emulsifying agent with wetting and anti-oxidant properties and is not a fat substitute.

Cook (1945) contended that the most common error made in the application of lecithin to the bakery industry is in its use in replacing or "saving" fats. He maintained this fallacy had a natural growth. He said:

> It is known that in suspensions of insoluble solids in fats (chocolate, non-aqueous coatings, and icings), fat must be eliminated when lecithin is used if viscosity standards are to be maintained. It is then incorrectly assumed that the same is true in emulsions where moisture and dissolved solids are present as the continuous phase in doughs and batters. Omitted in this deduction was the fact that lecithin operates at aqueous interfaces just as it does at fatty interfaces, with the result that the former are extended to the same extent as the latter...When used to "save" fats, there will be a sacrifice of quality in bakery products.

Although all who work with lecithin do not entirely agree as to its place in the baking industry, recent reports showed the use of lecithin in bakery products and in other food industries, as well as a great deal of experimentation to determine its special advantages.

Recent United States patents show an increase in the use of lecithin in a variety of food products. Patents for dry

shortenings show the use of lecithin as an aid to increase the speed of solubility when moisture is added. The use of lecithin as an anti-oxidant, wetting-agent, and emulsifier is shown in patents for egg substitutes and dough conditioners.

Confectioners have found that when lecithin is added to the oil in icings and non-crystalline candies such as caramels, the quality of the product is improved (Eichberg, 1939). Stanley (1946) explained that lecithin functions as a high temperature emulsifier when boiled with sugar solutions to prevent the separation of the fat from the sugar solution, and to avoid greasy and grainy textures.

The use of a high cacao butter content in chocolate normally produces a smooth texture. According to Schoen (1944) the present tendency is to save cacao butter by the addition of lecithin. The lecithin reduces the viscosity of the chocolate as does the high percentage of cacao butter. The viscosity reducing effect of five percent cacao butter is equaled by three-tenths percent lecithin. Lecithin not only saves cacao butter, but counteracts the thickening of the chocolate caused by the added moisture when products such as ice cream and various candies are dipped in the chocolate.

One-tenth of one percent to three-tenths of one percent lecithin added to margarines disperses the water evenly throughout the fat and stabilizes the emulsion, which prevents drops of water from separating to cause spattering when heat is applied (Eichberg, 1939). Semrod (1943) stated that lecithin also improves the spreadability of margarines.

Cook (1945) contended that lecithin added to peanut butter serves as an anti-oxidant and improves spreadability; however, in this case, it aggravates the separation of oil.

Eichberg (1939) found the addition of one-half of one percent to two percent lecithin to shortenings increases their lubricating effect (shortening value), as well as their emulsifiability. He claimed lecithinated shortening has a greater physical stability and is less subject to separation, streaking, and granulation than untreated shortening.

In a discussion of the use of lecithin as an anti-oxidant in fats and oils, Stanley (1946) observed that the addition of one-half of one percent lecithin counteracts hydrolysis and rancidity. According to Cook (1945), the factors that govern the extent of anti-oxidant protection provided by lecithin are: (1) the extent of unsaturation of fatty acids in the glyceride; (2) the absence or extent of hydrolysis of lecithin itself; and (3) the quantity present compared to the total surface area exposed by the fat requiring protection.

Eichberg (1939) stated that for unsaturated fats and oils, up to 0.15 percent lecithin is used as an anti-oxidant. He found that the more unsaturated the oils and fats, the more striking are the results. Lecithin attracts oxygen more readily than many other substances; therefore lard is better protected from oxidation when lecithin is dispersed in it.[4] Sleigh (1942) stated that lard sent to overseas forces contain-

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[4]Cook, L. Russell, "Lecithin and the Baking Industry," Booklet, W. A. Cleary Corporation, New Brunswick, N. J., 9 p.

ed 0.05 percent lecithin to protect it against rancidity. McKinney (1945) found, however, that soy lecithin has a remarkable stabilizing effect on oleo oil, but has only a slight effect on lard and no value at all when used as an anti-oxidant for vegetable oils.

Maverty (1946) found that the addition of 0.15 percent lecithin to the fat almost doubled the shelf-life of crackers because of its anti-oxidant property.

Semrod (1943) stated that the addition of two-tenths of one percent lecithin to shortening increased the creaming quality of the product.

According to Stanley (1942), the addition of 0.15 percent lecithin to ice cream reduces the amount of egg yolk required and produces a velvety smooth product. He also states that the addition of one percent lecithin to macaroni made from soft wheat flour produces a product which is equal in quality to macaroni made from hard wheat flour. Macaroni products from hard wheat flour are made even more resistant to disintegration during cooking by the addition of lecithin (Cook, 1945).

In bakery formulas, lecithin promotes homogeneous blending of ingredients. In most cases, lecithin is added directly to the shortening, then incorporated into the formula. However, in making bread, lecithin is usually added in powdered form to the flour. Because of a reaction between the lecithin and the gluten of the flour, the amount of lecithin added to the bread is based on the weight of the flour rather than the weight

of the fat.[5] A lecithinated flour which bakers may use in combination with bread flour is made by the American Lecithin Company.

Pratt (1946), in an experiment to determine the effect of lecithin on bread, found the most notable effect to be the improvement of the handling properties of the dough during the molding of loaves. In a keeping quality test, the lecithin retarded "staling." In the loaf containing lecithin, the crust was more tender, the texture finer-grained, and the loaf more symmetrical.

Lecithin added to cakes with the shortening and sugar at the beginning of the mix reduces the viscosity of the creamed mixture to the point where less air can be incorporated and volume is lost. When the lecithin is added before the last addition of flour and water, there is no loss in volume (Cook, 1945). Stanley (1946) stated that cakes containing soy lecithin have a more uniform structure and are more tender than those made by the standard formula.

Cook (1945) reported the following results for the addition of lecithin to bakery products: In cakes the batter flows more freely and is easier to handle; the color is more uniform as a result of better distribution of the shortening; and the texture is smoother as a result of better dispersion of the fat. Because of anti-oxidant properties, lecithin added to

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[5]Cook, L. Russell, "Lecithin and the Baking Industry," Booklet, W. A. Cleary Corporation, New Brunswick, N. J., 9 p.

cakes retards the development of stale and rancid flavors. In pastry, the layers of fat are thinner and form more frequently to produce increased tenderness; better dispersion of water makes the dough easier to handle. In cookies, the color is more uniform; the dough is easier to handle; the product is more tender and crisp; and the shelf-life of the cookie is lengthened.

METHOD

For this study two commercial lecithin mixtures were used to determine the effect on the shortening qualities, palatability, and keeping qualities of three baked products.

The lecithin mixtures chosen were Bet-R-Short and Clearate. Bet-R-Short was a powder which contained 228 milligrams of soy lecithin to 100 grams of powder.[6] In addition to the lecithin, it contained cereals, vegetable oil, skim milk solids, and mineral and organic salts. It was recommended by the distributors, the H. D. Lee Company, Kansas City, Missouri, for use as a shortening extender replacing up to 50 percent of the shortening in bakery formulas. Claims were made that quality would not be sacrificed, but better products might be obtained by the use of this shortening extender. Clearate, B-60-S, a commercial lecithin especially developed for the bakery trade, was a product of the W. A. Cleary Corporation, New Brunswick, N. J.

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[6]Extract from a letter from Mr. C. R. Boyle to the author. May 20, 1947.

It had a fluid, syrupy consistency which made it easily incorporated into batters and doughs. Clearate was not recommended by the manufacturer as a shortening extender, but as an agent to improve workability and quality by increasing the lubricating value of the shortening.

The three baked products chosen for the study were plain pastry, a modified shortbread cooky, and plain cake. Formulas were chosen in which only basic ingredients were used in order to eliminate the possibility of variations in flavor by causes other than the addition of lecithin mixtures or the changes in the amount of fat in the formulas.

The work was divided into three parts and each part into two series. Series I, in each case, consisted of a group of products in which the mixture, Bet-R-Short, was used to replace various percentages of the fat in the standard formulas. The manufacturer's directions for using Bet-R-Short were followed. Replacement of the weight of the fat reduced was made by equal amounts of Bet-R-Short and water. For example, a 50 gram fat reduction was replaced by 25 grams of Bet-R-Short and 25 grams of water.

In Series II, two types of changes were made in the standard formula. For one group of products Clearate was added according to the recommendations made by the manufacturer: Two percent Clearate based on the fat in the standard formulas was added to the pastry and cookies and one and five-tenths percent was added to the cakes. For the other group of products, the same additions of Clearate were made, but the

fat was reduced in percentages corresponding to those in Series I.

All products were baked in the Magic Chef gas heated oven equipped with a thermostat and checked by a Taylor oven thermometer. Kodak timers were used for measuring mixing time, and a Cenco timer for measuring the baking time.

A palatability committee composed of two graduate assistants in the department of Food Economics and Nutrition and one assistant in foods research served throughout the study.

Part I

A plain pastry recipe high in fat was used for the standard. The formula accepted as a standard was as follows:

Ingredients	Weights in grams	Approximate measure
Fat	43.0	3½ T
Flour	82.5	3/4 C
Water	30.0	2 T
Salt	1.5	¼ t

The flour was Gold Medal, the fat Primex.
All ingredients were weighed on a Cenco laboratory balance.
All ingredients were at room temperature except water which was chilled with ice to a temperature of 5° to 8° C.
Flour was sifted once before weighing and once with salt.

Steps followed in preparing the standard plain pastry:

Fat was creamed with spoon, 20 strokes, to allow for the changes in consistency as a result of the manipulation necessary to incorporate the Bet-R-Short and Clearate into the fat.

Fat was cut into flour and salt with a pastry blender using 40 strokes.

The water was added and the mixture stirred with a spoon 40 full strokes.

Pastry was molded into a patty with the hands and placed between sheets of waxed paper on a molding board.

Pastry was rolled with a wooden rolling pin to a uniform thickness controlled by wire gauges which were attached to the molding board.

Because of the restriction of the wire gauges, there was some variation in the rolling procedure. The following method was followed as nearly as possible. Beginning at the center of the patty, two full strokes were made toward the top, two toward the bottom, then two toward each side. Beginning at about a 45 degree angle from the first set of strokes, another series of two each was made around the patty. A total of approximately 20 strokes was used.

Pastry was placed on baking sheets without stretching.

Wafers were marked off using a six inch plastic ruler and the dull side of a paring knife blade. The wafers were one inch by two inches.

Wafers were baked at 425° F. for 12 minutes.

After cooling two or three hours, six to eight wafers from each mix were broken on the gram shortometer. Averages of the weight in grams required to break the wafers were computed.

Series I. In making the product containing Bet-R-Short, the procedure for making the standard plain pastry was followed except that Bet-R-Short and water were added to the fat before the first creaming. Table 1 shows the amount of fat replaced by Bet-R-Short and water and the number of mixes made in each group.

Series II. Clearate was added to the fat before the first creaming. Table 1 shows the amount of Clearate added to each mix and the amount of fat reduced.

A shortometer for testing pastry, which was designed and made by the Department of Physics with the assistance of Dr. J. L. Hall, Department of Chemistry, for use by Lois Meisner,

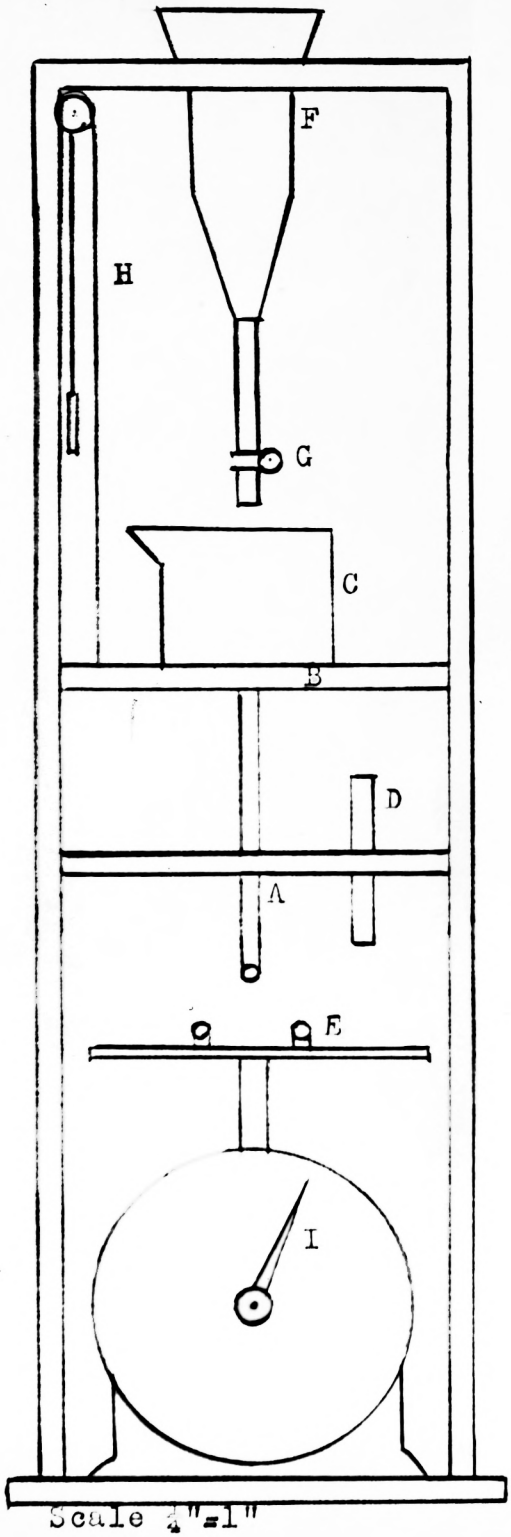
was used in this study. A diagram of the shortometer appears on page 17. The shortometer was used to measure the force in grams required to break the pastry wafers. Each wafer was placed across the two parallel bars attached to the weighing pan of the spring balance. A plunger rod was suspended from the moveable platform which supported the cup into which the shot was let from a funnel. The weight of the cup forced the plunger to press against the wafer. The weight at which the plunger broke the wafer was measured by watching the hands on the 1000 gram spring balance. The arrester kept the plunger from forcing the scale platform down each time a wafer was broken. The pulley drew the platform up when the cup was empty in order that the plunger rod should not hinder the placing and removing of the wafers.

The palatability committee scored the pastry one to three hours after baking. The score card, Form 1, was used for all pastry.

Part II

A modified shortbread cooky recipe was used in this problem. The recipe was originally developed by Hornstein, King, and Benedict (1943) for use in an experiment in which qualities of various types of fat were studied.

The formula accepted as a standard was as follows:



A - Plunger rod
B - Movable platform to which A is attached
C - Cup into which shot is poured
D - Arrester
E - Parallel bars to support wafers
F - Funnel from which shot is let
G - Pinch Clamp
H - Pulley which controls B
I - Gram spring balance

DIAGRAM OF PASTRY SHORTOMETER

Form 1. Score card for pastry

Name _____

Date _____

Sample number							
Appearance							
Color, delicate brown, uniform (5)							
Rough, small blisters (5)							
Not greasy (5)							
Texture							
Light, flaky (5)							
Tenderness							
Tender, crisp (5)							
Moisture content							
Dry (5)							
Flavor							
Pleasing, well-blended (5)							
Off flavors indicate by word, none, slight, pronounced							

Total points (35)

Key - Standard 5
Good 4
Fair 3
Poor 2
Very poor 1

Ingredients	Weights in grams	Approximate measure
Fat	38.3	3 T
Flour	100.0	7/8 C + ½ T
Water	20.0	1 1/3 T
Sugar	41.6	3 1/3 T
Salt	1.5	¼ t

Gold Medal flour was used; Primex was used as the fat.
All ingredients were weighed on a Cenco laboratory balance.
All ingredients were at room temperature at time of mixing.
Flour was sifted before weighing and once with the salt.

Steps followed in preparing the standard shortbread cookies:

Fat was placed in the one-quart bowl of a Hamilton Beach Model D electric mixer and creamed at speed 3 for 60 seconds.

Sugar was added to fat and creamed at speed 3 for 60 seconds.

25 gms flour was added and mixed at speed 3 for 30 seconds.

20 gms water was added and mixed at speed 3 for 30 seconds.

75 gms flour was added and mixed at speed 3 for 60 seconds.

Mixture was molded into a patty with the hands and placed between sheets of waxed paper on a molding board.

The dough was rolled with a rolling pin to a uniform thickness controlled by wire gauges which were attached to the molding board.

The procedure used for rolling the pastry was followed as nearly as possible. The cooky dough was softer than the pastry and often did not require the full 20 strokes for rolling.

The dough was placed on a baking sheet and marked for wafers one inch by two inches using the plastic ruler and dull edge of a paring knife.

Cookies were baked at 375° F. for 12 minutes.

After cooling one to three hours, wafers were broken on the shortometer described in Part I. From six to eight wafers from each mix were broken and the

weight required to break them recorded in grams. Averages of the breakings were computed and used to indicate shortness of the product.

The cookies were scored one to three hours after baking. Form 2 was the scoring device used for the cookies. Wafers from each mix were stored in covered pottery dishes in the laboratory for a period of one week. At the end of the storage period, the palatability committee again scored the cookies, using Form 2. This test was expected to show any effect the mixtures containing lecithin might have on the keeping qualities of the products.

Series I. Replacements of various percentages of shortening required for the standard shortbread cooky were made by adding Bet-R-Short and water according to directions given by the manufacturer. The steps followed in mixing the cookies in Series I were the same as given for the standard cookies with one exception, Bet-R-Short and water were added to the fat before the first creaming. Table 2 shows the changes made in the standard formula when Bet-R-Short was substituted for part of the fat.

Series II. Clearate based on two percent of the weight of the shortening in the standard formula was added throughout the series. For one group of cookies various reductions were made in the fat of the standard formula to determine the effect of the commercial lecithin as a possible fat extender. For a second group of cookies, the two percent Clearate was added to the standard to determine any improvement it might make in the product. Table 2 shows the reductions of fat used in Series

II. The method of combining ingredients was the same as for the standard shortbread with the exception that the Clearate was added to the fat before the first creaming.

Part III

A formula for plain cake containing fat in which the amount of fat was high in proportion to sugar and flour was selected for the standard:

Ingredients	Weights in grams	Approximate measure
Fat	100.0	½ C
Sugar	200.0	1 C
Eggs	96.0	2
Flour	168.0	1 3/4 C
Milk	168.0	5/8 C
Baking Powder	8.9	2⅔ t

No salt or flavoring was used in order to avoid covering any off flavors caused by mixtures containing lecithin or by the reduction in the amount of shortening.
Swansdown cake flour, Primex, a finely granulated sugar, fresh eggs, and milk were used.
The Cenco laboratory balance was used for all weighing.
All ingredients were at room temperature at time of mixing.
Flour was sifted once before weighing and once with baking powder.
The sugar was sifted once before weighing.

The method of combining ingredients was standardized before the experimental cakes were made.

Steps followed in preparing the standard plain cakes:

The fat was placed in the three-quart bowl of the Hamilton Beach mixer.

Using speed 3, the fat was creamed for 30 seconds and the sugar added slowly for 60 seconds; the creaming continued for 60 seconds more.

The slightly beaten egg was added slowly for 60 seconds, and the beating continued for another 60 seconds.

Form 2. Score card for shortbread cookies

Date _____

Name _____

Sample number								
Appearance								
Color	(5)							
Crisp crust	(5)							
Not greasy	(5)							
Texture								
Flaky	(5)							
Tender	(5)							
Crisp, not hard or dry	(5)							
Flavor								
Pleasing with good aroma	(5)							
No aroma or flavor of staleness	(5)							
Total points	(40)							

Key - Standard 5
Good 4
Fair 3
Poor 2
Very poor 1

Using speed 1, additions of 42 grams of flour were made alternately with additions of 56 grams of milk, beating 30 seconds after each addition. The first and last additions were of flour.

Waxed paper was cut to line the bottom of cake tins $7\frac{1}{2}$ inches by $7\frac{1}{2}$ inches.

Batter was placed in pans and baked at a temperature of 365° F. for 43 minutes.

Cakes were removed from the oven and allowed to cool five minutes before removing from the pans.

A paring knife was used to loosen the cakes from the sides of the pans.

Cakes were inverted on a cooling rack, pans were removed, waxed paper was removed, and cakes were turned right side up.

Cakes cooled 30 minutes to two hours before being covered with metal pans and stored for approximately 24 hours.

Series I. The method followed was the same as for the standard plain cakes with the following exceptions: Certain percentages of the fat were replaced by Bet-R-Short and water in the manner recommended by the manufacturer; and the Bet-R-Short and water were added to the fat before the first creaming. Table 3 shows the amounts of fat replaced by Bet-R-Short and water and the number of cakes made for each replacement.

Series II. For one group of cakes, various reductions in the amount of fat were made, and Clearate was added on the basis of 1.5 percent of the fat in the standard formula. The Clearate was added after the second addition of flour which was the method recommended by the manufacturer and suggested by Cook (1945) for the use of commercial lecithins in cakes. For the second group of cakes, Clearate was added to the standard formula in the proportion of 1.5 percent of the

fat since the manufacturers recommend that it be used in addition to the standard to improve quality. Table 3 shows the reductions of fat and the additions of Clearate that were made in the standard formula. Table 3 also shows the number of cakes baked in each group.

Approximately 24 hours after baking, the following determinations were made: standing height as an index to volume, shortness, compressibility, and eating quality as determined by the palatability committee. The score card used for the cakes is Form 3.

Before the mechanical tests could be made, it was necessary to cut the cakes in uniform slices. This was accomplished by using a cake cutting box which consisted of a simple apparatus resembling a mitre box. The box was constructed of wood, closed on two sides and one end. There was a kerf one inch from the closed end into which a long knife fitted. Four uniform slices one inch in thickness were cut from each cake. The first slice was not used for the mechanical tests because of the crust.

Standing height was determined by computing the average of the height in centimeters taken at the center, at each end, and half way between each end and the center of the fourth slice.

The shortness was determined by a gram shortometer, an apparatus consisting of a modified spring balance and a remodeled laboratory scale as described by Kramer (1935) and pictured by Buck (1943). The shortometer measured in grams the force necessary to break a slice of cake one inch in thickness.

Two parallel bars on the weighing pan of the spring balance supported the one inch slice of cake. A third bar suspended from the right hand pan of the remodeled laboratory balance was adjusted to apply pressure on the cake midway between the parallel bars. The dial of the spring gram balance was turned to zero. On the right-hand pan of the laboratory balance was placed a 250 cubic centimeter glass beaker into which water was siphoned at a constant rate. The force necessary to break the cake was indicated by two moveable hands rotating on the face of the spring balance. One hand remained stationary for reading after the cake was broken, the other returned to zero.

Three one-inch slices were tested on the shortometer, and an average breaking determined in grams. The average was accepted as the figure indicating the shortness of the cake.

One-half of each broken slice was then tested for compressibility. The apparatus for this test, similar to that described by Platt and Kratz (1933) and used by Fulks (1936), Miller (1942), Buck (1943), and Tinklin (1944), consisted of a remodeled laboratory balance and an Eastman Timer.

To the under-side of the right-hand pan of the balance was fastened a metal plunger 31 millimeters in diameter. On the upper-side of the pan was placed a 200-gram weight. On the left-hand pan of the balance was a linked chain which equaled the weight on the right-hand pan.

The cake sample was placed on a platform just below the plunger with the plunger resting lightly on the cake. An

additional 10-gram weight placed on the pan above held 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 during a period of 30 seconds and the weight was then allowed to act upon the plunger for two minutes. A pointer suspended from the cross arm of the balance to a scale at the lower part of the balance indicated millimeters compressed. The average of the reading of the three samples was computed as the compressibility of the cake.

The pieces used for compressibility and the remaining half pieces were given to the members of the palatability committee, who scored the cakes for quality.

Two pieces from each cake were stored in a covered pottery dish for five days. Then they were again scored on the basis of eating quality by the palatability committee. This was done because both lecithin mixtures were advertised to improve keeping quality of baked products. Five days were chosen for the storage time for cakes, as stale flavors and changes in texture normally occur well within that length of time.

DISCUSSION AND RESULTS

Part I

To incorporate Bet-R-Short into a bakery formula, the manufacturer recommended that an emulsion be formed by cream-

Form 3. Score card for plain cakes

Sample number							
Shape							
Symmetrical (5)							
Top, smooth slightly rounded (5)							
Crust							
Even brown color (5)							
Tender, crust (5)							
Crumb							
Tender (5)							
Moist (5)							
Fine, even grain (5)							
Light (5)							
Velvety, soft (5)							
Flavor							
Delicate (5)							
Pleasing no off flavor (5)							
Aroma - no aroma of staleness (5)							

Total points (60)

Remarks _____

Name _____

Date _____

Key - Standard 5
Good 4
Fair 3
Poor 2
Very poor 1

ing together the Bet-R-Short and water (used to replace fat) and the remaining fat of the formula. It was believed that less manipulation of the fat might improve the quality of the pastry, so several crusts were made by adding the Bet-R-Short to the flour and the additional water to the water of the standard formula. The shortness of the pastry made by this method compared favorably, but was no better than that for pastry made by the recommended method; therefore, the manufacturer's method for incorporating Bet-R-Short into the dough was used throughout the study.

With the reduction of fat and the increase of Bet-R-Short and water, the pastry dough became sticky and pasty. When the fat was reduced more than 20 percent and Clearate was added, the dough was hard to handle. With both Clearate and Bet-R-Short, there was greater shrinkage in the crusts as the amount of fat was decreased. Doughs made with Bet-R-Short and water gave about the same bulk as the standard formula.

The products made with 50 percent of the fat replaced by the Bet-R-Short method were not acceptable according to results of tests made in this study. The shortometer breakings for these crusts averaged over 1000 grams compared to 341 grams for the standard pastry. The pastry with the 50 percent fat replaced by Bet-R-Short and water had an average palatability score of 23.5 and an average flavor score of 2.72. The average palatability score for the standard pastry was 32.5 and the average flavor score was 4.65. "Off flavors" were indicated four times for the four products made with 50 percent of the

fat replaced by Bet-R-Short and water.

Three crusts were made with 50 percent reduction of the fat and with Clearate added in the amount of two percent of the weight of the fat in the standard formula. None was acceptable, but all scored higher than the products with 50 percent of the fat replaced by 25 percent Bet-R-Short and 25 percent water.

Table 1 shows the average shortometer breakings and the palatability scores for the pastries made. In Series I replacements for 5, 10, 20, 25, and 50 percent of the fat were made with Bet-R-Short and water. In Series II, reductions of 5, 10, 20, 25, and 50 percent of the fat were made and Clearate was added to each in the amount of two percent of the weight of the fat in the standard. In both Series I and Series II, the greater the reduction in shortening, the higher the average shortometer breakings. Flavor scores and palatability scores became lower as the amount of fat was reduced.

Ten crusts were made according to the standard formula and Clearate in the amount of two percent of the fat in the standard was added. According to Cook (1945), the quality of pastry is improved by the addition of Clearate in these proportions. Table 1 shows this group of crusts to be shorter than the standard. The average shortometer breaking for the pastry made with Clearate added to the standard was 241.2 grams. The average shortometer breaking for the standard was 300.5 grams. The palatability scores for the standard with Clearate averaged 32.29; for the standard, 32.20. However, "off

flavors" were indicated three times for the Clearate product and one time for the standard.

In order to determine the effect of Bet-R-Short on flavor, a group of crusts was made using the standard formula and adding Bet-R-Short and water in amounts for 5 percent, 10 percent, and 20 percent fat replacement. None of the flavor scores equaled the score for the standard, nor were they as low as those for products made with reduced amounts of shortening.

The standard pastries had higher average flavor scores than products made with either Bet-R-Short or Clearate, with the exception of the pastries made by adding Clearate to the standard formula.

Part II

The shortbread cooky dough, like the pastry, was difficult to handle when 20 percent or more of the fat was either replaced by Bet-R-Short and water, or removed and Clearate added to the mix. These doughs also showed considerable shrinkage when baked.

Table 2 shows a comparison of the average shortometer breakings for the standard shortbread cooky and for products made with 10, 20, and 30 percent of the fat in the standard formula replaced by Bet-R-Short and water. Table 2 also shows the average shortometer breakings for products made with 10, 20, and 30 percent of the fat in the standard formula reduced and Clearate added in the amount of two percent of the fat in

Table 1. Summary of data for plain pastry.

	Ingredients in gms							Results in averages			
	Flour	Fat	Water	Salt	Bet-R-Short	Clearate	No. baked	Shortometer breakings gms	Palatability committee: Flavor scores	Palatability committee: Total scores	Times off flavor noted
Series I											
Standard	82.5	43	30	1.5			12	341	4.65	32.5	1
5% fat replaced	82.5	40.85	31.07	1.5	1.07		4	377.5	4.5	30.8	0
10% fat replaced	82.5	38.7	32.15	1.5	2.15		10	380.1	4.38	30.78	3
20% fat replaced	82.5	34.4	34.3	1.5	4.3		10	507	3.75	28.87	5
25% fat replaced	82.5	32.25	35.37	1.5	5.37		4	578	3.83	28.45	3
50% fat replaced	82.5	21.5	40.75	1.5	10.75		5	1000	2.72	23.5	5
Standard 5% Bet-R-Short	82.5	43	31.07	1.5	1.07		3	375	4.25	30.45	0
Standard 10% Bet-R-Short	82.5	43	32.15	1.5	2.16		6	352	4.0	30.75	4
Standard 20% Bet-R-Short	82.5	43	34.3	1.5	4.3		3	378	4.0	30.3	2
Series II											
Standard	82.5	43	30	1.5			9	300.5	4.54	32.28	1
Standard Clearate*	82.5	43	30	1.5		.86	10	241.2	4.63	32.29	3
5% fat reduced	82.5	40.85	30	1.5		.86	2	302	4.80	31.00	0
10% fat reduced	82.5	38.7	30	1.5		.86	7	341.5	4.78	31.94	2
20% fat reduced	82.5	34.4	30	1.5		.86	8	390.2	4.3	30.71	2
25% fat reduced	82.5	32.25	30	1.5		.86	5	443.6	4.3	30.34	2
50% fat reduced	82.5	21.5	30	1.5		.86	3	853.5	4.0	27.3	3

*Based on two percent weight of fat in standard.

the standard recipe. In every case, the average weight in grams required to break the shortbread wafers increased as the fat in the formula decreased.

In the five products made with the standard recipe with Clearate added, the shortometer averages and the palatability scores compared favorably with the standard, but were no better than the standard. There was no indication that the addition of Clearate made this dough any easier to handle than the dough of the standard product as suggested by Cook (1945).

Cookies with the highest fat content had the best color. The cookies made with the standard formula plus Clearate had no better color than the standard products.

According to the averages of the palatability scores, the committee found the desirability of the shortbread cookies decreased with a decrease in the fat in the formula. When the flavor scores were studied separately, the standards were found to rate highest. The judges did not indicate "off flavors" as they did with the pastry. This may have been due to the addition of sugar to the basic ingredients of fat, flour, water, and salt.

To determine whether Bet-R-Short had an objectionable flavor or whether the absence of shortening decreased the flavor desirability, several cooky mixes were made with the standard recipe plus Bet-R-Short and water in amounts used for 10, 20, and 30 percent fat replacements. Sufficient cookies were not made for conclusive evidence, but Table 2 shows the average flavor scores for the products made with the standard

amount of fat and the addition of Bet-R-Short are somewhat higher than the averages for the products made with part of the fat replaced by Bet-R-Short and water. Neither group scored as high as the standard product.

As a result of the pastry work, a group of shortbread cookies made with 50 percent fat replaced by Bet-R-Short seemed impractical. Thirty percent fat replacement was used as the greatest reduction from the fat of the standard formula. Cookies with 30 percent of the fat reduced and either Bet-R-Short or Clearate added were not considered desirable by the palatability committee.

The palatability scores for the products stored one week showed a decrease in desirability in every case. The decrease for the standard products without the addition of either Bet-R-Short or Clearate was no greater, if as great, as the decrease for the products in which the lecithin mixtures occurred.

From the work done in this study no conclusions on the effect of the two lecithin mixtures on the shelf-life of commercial shortbread cookies could be drawn, since storage conditions resembled more the home cooky jar storage than the wrapped and boxed storage on the grocers' shelves.

Part III

As a general rule, the cake batters became thinner and more like griddle cake batters as the fat in the formula decreased. Care was taken in every case to incorporate as much

Table 2. Summary of data for shortbread cookies.

	Ingredients in gms								Results in averages						
									Shortometer breakings gms	Palatability committee scores					
										Freshly baked			Stored seven days		
	Flour	Fat	Sugar	Water	Salt	Bet-R-Short	Clearate	No. baked		Flavor	Freshness	Total	Flavor	Freshness	Total
Series I															
Standard	100	38.3	41.6	20	1.5			7	438	4.76	4.86	38.7	4.7	4.5	38.2
10% fat replaced	100	34.5	41.6	21.91	1.5	1.91		6	652	4.76	4.43	38.05	4.4	4.4	36.6
20% fat replaced	100	30.7	41.6	23.83	1.5	3.83		6	674.3	4.38	4.43	36.66	3.8	3.52	33.2
30% fat replaced	100	26.8	41.6	25.74	1.5	5.74		3	879.3	4.2	4.2	32.88	3.3	3.3	30.8
Standard 10% Bet-R-Short	100	38.3	41.6	21.91	1.5	1.91		3	595.5	4.8	4.8	39.1	4.6	4.3	37
Standard 20% Bet-R-Short	100	38.3	41.6	23.8	1.5	3.83		4	488.5	4.57	4.65	37.77	4.25	3.9	37
Standard 30% Bet-R-Short	100	38.3	41.6	25.74	1.5	5.74		3	368	4.4	4.4	38	3.3	3.3	34.5
Series II															
Standard	100	38.3	41.6	20	1.5			6	372	4.94	4.94	39.1	4.5	4.5	37.2
Standard Clearate*	100	38.3	41.6	20	1.5		.77	5	379	4.6	4.66	38.6	4.12	3.86	36.06
10% fat reduced	100	34.5	41.6	20	1.5		.77	5	379	4.32	4.6	37.6	3.92	3.92	34.92
20% fat reduced	100	30.7	41.6	20	1.5		.77	5	544	4.4	4.7	36.3	4.06	4	34.9
30% fat reduced	100	26.8	41.6	20	1.5		.77	4	850	4.32	4.65	35.15	3.65	3.82	34.32

*Based on two percent weight of fat in standard formula.

air as possible into the creaming of fat, sugar, and egg. Bet-R-Short and water did add bulk, but the fluffy texture of the fat, sugar, and egg of the standard product was never duplicated in the cakes with the Bet-R-Short and water substituted for a part of the fat.

The averages for the mechanical tests and palatability committee's ratings for each group of cakes are given in Table 3. In Series I cakes were made with 20, 30, and 50 percent of the fat in the standard recipe replaced by Bet-R-Short and water. In Series II cakes were made with 20, and 30 percent of fat reduced and Clearate added in the amount of 1.5 percent of the weight of the fat in the standard formula. A group of cakes was made which contained the ingredients of the standard with the addition of Clearate in the proportions given above.

According to Table 3, in Series I, the one cake made with 50 percent of the fat replaced by Bet-R-Short and water had the greatest volume. Cakes with 20 and 30 percent of the fat replaced had slightly greater volume than the standard cakes. However, the scores for the mechanical tests and the palatability ratings showed an inferior quality of the crumb for the cakes with shortening reduced. In Series II, the average volume of cakes made with the standard formula and 1.5 grams of Clearate added was slightly greater than that of the standard cakes or cakes made with 20 or 30 percent of the fat reduced and 1.5 grams of Clearate added.

Tinklin (1944) found the standing height varied as much as 0.5 centimeters from day to day when a formula with a high

proportion of liquid to flour was used. She suggested the variation was probably due to a higher percentage of humidity in the room. This great a difference occurred in one instance in this problem.

In both Series I and Series II, the standard cakes were more compressible. Compressibility expresses the velvetiness of a cake and is closely associated with better eating quality. The cake made with 50 percent fat replaced by Bet-R-Short and water was least compressible. Compressibility scores for each group of cakes appear in Table 3.

The average shortometer breakings indicated shortness ranged from breakings at 144 grams for the cakes with 50 percent of the fat replaced by Bet-R-Short and water to 85.83 grams for the standard formula with 1.5 grams of Clearate added. The standards for the two series had the next lowest average shortometer breakings: 91.33 and 93.99 grams.

In the Bet-R-Short groups of cakes, the standard was the most tender and the tenderness decreased as the fat decreased.

Batter for the products made from the standard formula with 1.5 grams of Clearate added was no smoother or more easily handled than the standard product.

There seemed to be no correlation between the amount of Bet-R-Short and Clearate used and the palatability committee's scoring for color.

The preference of the judges in Part III of this study did not always agree with the mechanical scores for shortness and compressibility. The averages of the totals on the committee's

scores showed a slight preference for the cakes in which 20 percent of the fat is replaced by Bet-R-Short and water over the standard cakes. This is possibly due to the slightly larger volume. A study of the individual score cards showed the cakes with 20 percent of the fat replaced by Bet-R-Short and water were scored higher on appearance than the standard cakes. However, the judges consistently scored the cakes with the greatest amount of fat higher on points concerned with quality of the crumb. And the average scores for flavor alone rate the standard products highest.

"Off flavors" and acrid odors were noted on three of the 15 score sheets for cakes with 30 percent of the fat replaced by Bet-R-Short and water; on three of the 12 score sheets for cakes with 20 percent of the fat replaced by Bet-R-Short and water; and on two of the three score sheets for cakes with 50 percent of the fat replaced by Bet-R-Short and water. "Off flavors" and acrid odors were noted on one of the 15 score sheets for the standard cakes.

In Series II, the cakes made with 1.5 grams of Clearate added were not scored lower in flavor than the standard cakes regardless of the decrease in fat.

Slices of cakes were stored for five days in the same manner as the shortbread wafers were stored. In every case, the desirability decreased on standing. The changes in the scores due to staling were certainly no greater for the standards than for the cakes containing the lecithin mixtures.

Bet-R-Short contains a much smaller percentage of soy

Table 3. Summary of data for plain cakes.

	Ingredients in gms									No. baked	Results in averages							
											Mechanical tests			Palatability committee scores				
														Freshly baked			Stored five days	
	Flour	Fat	Sugar	Egg	Milk	Baking powder	Bet-R-Short	Water	Clearate		Shortometer breakings gms	Compressibility mm	Standing height cm	Flavor	Freshness	Total	Flavor	Freshness	Total
Series I																			
Standard	168	100	200	96	168	8.9				5	91.33	4.35	4.91	4.67	4.78	55.12	3.745	3.58	48.83
20% fat replaced	168	80	200	96	168	8.9	10	10		5	96.08	3.06	4.95	4.41	4.83	56.33	3.55	3.88	48.44
30% fat replaced	168	70	200	96	168	8.9	15	15		5	118.79	2.49	4.95	3.99	4.73	53.59	3.57	4.07	46.91
50% fat replaced	168	50	200	96	168	8.9	25	25		1	144.0	1.93	5.38	4.0	4.66	46.66	2.66	4.0	45.33
Series II																			
Standard	168	100	200	96	168	8.9				4	93.99	4.69	4.74	4.33	4.75	54.0	3.49	4.08	48.83
Standard Clearate*	168	100	200	96	168	8.9			1.5	4	85.83	3.57	5.02	4.75	4.75	55.75	3.33	3.83	44.25
20% fat reduced	168	80	200	96	168	8.9			1.5	4	101.83	3.66	4.89	4.33	4.75	55.67	3.66	4.33	48.00
30% fat reduced	168	70	200	96	168	8.9			1.5	4	111.58	3.01	4.80	4.88	4.55	53.08	3.58	3.66	46.00

*Based on one and five-tenths percent weight of fat in standard formula.

lecithin than was recommended in the literature for use as a fat extender or as an ingredient to improve quality and workability of baked products. However, the other ingredients in Bet-R-Short may have been expected by the manufacturer to have some beneficial effect on bakery products in which it was used.

Sleigh (1942) stated the addition of one percent lecithin based on the weight of the fat will save 15 to 20 percent of the fat in cakes, and one percent lecithin based on the fat in pie crust will save 15 percent of the shortening.

According to this recommendation, a pastry formula requiring 43.0 grams of fat could be reduced to 36.55 grams with 0.43 grams of lecithin added. Bet-R-Short would provide only 0.00735 grams of lecithin for 15 percent fat replacement. The standard cake formula containing 100 grams of fat could be reduced to from 85 to 80 grams of fat with one gram of lecithin added. Bet-R-Short would provide only 0.017 grams of lecithin for a 15 percent substitution.

Because of emulsifying and wetting qualities, lecithin mixtures are said to improve workability of dough. In this problem, the texture and consistency of the dough changed with the reduction of fat and the addition of water, but when standard formulas were followed without changes, except for the addition of Clearate or Bet-R-Short, an improvement in the workability of the doughs over the standards was not noticed.

SUMMARY

In this study attempts were made to determine the effect of replacing portions of the fat in three baked products with Bet-R-Short, a commercial fat-extender containing lecithin, and to determine the effect of adding Clearate, a commercial lecithin, to products containing both standard and reduced amounts of the fat.

Basic recipes for plain pastry, modified shortbread cookies, and plain cakes were selected. All three products were scored for shortening qualities and palatability. The pastry and shortbread cookies were stored for periods of seven and five days respectively. They were then scored on the same basis as when they were freshly baked to determine keeping qualities.

Mechanical tests for shortness were performed on the pastry and cookies one to three hours after baking. Mechanical tests were performed on the cakes for shortness, compressibility and standing height approximately 24 hours after baking.

The experimental work was divided into three parts and each part into two series. Part I consisted of work done on plain pastry; Part II, work done on modified shortbread cookies; and Part III, work done on the plain cakes.

In Series I for each, Bet-R-Short and water replaced various percentages of the fat in the standard formulas according to recommendations made by the manufacturer. In Series II, Clearate was added to the standards and to products with

various percentages of the fat reduced. Clearate was added on the basis of two percent of the weight of the fat in the standard formulas for pastry and shortbread cookies, and 1.5 percent for cakes.

Replacement of portions of the fat by Bet-R-Short resulted in a reduction in shortness and produced a less desirable flavor. Reduction of fat with the addition of Clearate also resulted in sacrifice of shortness and flavor desirability, but not to the same degree as in the Bet-R-Short replacement. This may have been due to the fact that Bet-R-Short contained such a small amount of lecithin.

The higher the percentage of fat replaced by Bet-R-Short, the more often the judges noted "off flavors." As a rule, Bet-R-Short products scored lower in total palatability scores than the corresponding Clearate products. The shortest cakes were not always the most palatable according to the judges.

Clearate added to the standard formulas increased shortness in cakes and pastry, and equaled the shortness of the standard for shortbread cookies. In pastry and cakes, Clearate added to the standard yielded a product which scored slightly higher in palatability than the standards.

In no instance did a product containing one of the lecithin mixtures show superior keeping qualities when compared with the standard. The desirability of all products decreased upon standing.

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