A STUDY OF THE EFFECT OF DRIED MILK SOLIDS ON THE KEEPING QUALITIES OF PLAIN CAKE

Thesis for the Degree of M. S.

MICHIGAN STATE COLLEGE

Marguerite Marie Nearnberg

1950

This is to certify that the

thesis entitled

A Study of the Effect of Dried Milk

Solids on the Keeping Qualities of Plain Cake

presented by

Marguerite Marie Nearnberg

has been accepted towards fulfillment
of the requirements for

M.S. degree in Foods and Nutrition

Pauline C. Paul
Major professor

Date May 9, 1950

A STUDY OF THE EFFECT OF DRIED MILK SOLIDS ON THE KEEPING QUALITIES OF PLAIN CAKE

by

Marguerite Marie Nearnberg

A THESIS

Submitted to the School of Graduate Studies of Michigan
State College of Agriculture and Applied Science
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Foods and Nutrition
School of Home Economics

1950

THESIS

ACKNOWLEDGMENTS

The writer wishes to express her appreciation to Dr. Pauline Paul for her counseling of the study; to Dr. William Baten for his aid in the statistical analysis of the data; to Miss Marie Iliff for her assistance while writing the thesis; and to members of the scoring panel for their assistance in scoring.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The search for a food constituent which has the ability to retard staling in baked products has received much emphasis during recent years. For some time, commercial bakers have been interested in securing a method to prevent bread staling. Institutional food services are faced with a similar problem. The discovery of such a food constituent would be a great aid to the housewife as well.

The annual economic loss from staled baked products is tremendous. A food constituent which has the ability to enhance the keeping qualities of baked products would be a great aid in their distribution. In addition, the consumer needs assurance of a palatable baked product for several days after the date of purchase or preparation.

Stamberg and Bailey (1939) suggested edible ingredients which might retard the rate of staling of baked products. Among these ingredients are eggs, milk, and flour. The action of proteins from milk, eggs, and flour in retarding the staling process may be the result of their water-binding capacity when contrasted with that of starch.

Dry milk solids are a convenient form of milk to use in baked products. Retarded staling in cakes with the use of dry milk solids has been suggested by Stamberg et al (1940) and Stamberg and Bailey (1940). However, Bailey (1932) stated that dry milk solids did not delay the staling rate.

Most of the literature discusses the effects of dry milk solids on enhancing the keeping quality of bread. The general principles which pertain to staling of bread may also be applied to cake. The staling of cake proceeds rather rapidly but at a somewhat slower rate than in bread.

As the literature suggests that dry milk solids may or may not have an effect on the keeping quality of cake, it was considered desirable to undertake a study to investigate whether the use of whole and defatted dry milk solids enhance the keeping qualities of plain cake. For this study, dry milk solids at different concentrations were used; equivalent to fluid milk and at 8, 14, and 20 per cent concentrations calculated on the flour basis. Dry milk solids prepared by the spray and by the atmospheric drum processes were compared for desirability.

REVIEW OF LITERATURE

Dry milk solids

Definition

Whole: Definitions and standards for dried whole milk solids were issued by the Food and Drug Administration in November, 1936.

> "Dried milk is the product resulting from the removal of water from milk. It contains not less than 26 per cent of milk fat and not more than 5 per cent of moisture."

Defatted: The Federal Food, Drug and Cosmetic Act of March 2, 1944 has defined defatted milk solids as follows:

> "That for the purposes of the Federal, Drug and Cosmetic Act of June 26, 1938 (ct. 675, sec. 152 Sta. 1040), non-fat dry milk solids or defatted milk solids is the product resulting from the removal of fat and water from milk, and contains the lactose, milk proteins, and milk minerals in the same relative proportions as in the fresh milk from which made. It contains not over 5 per centum by weight of moisture. The fat content is not over 1-1/2 per centum by weight unless otherwise specified. The term milk when used herein, means sweet milk of cows."

Methods of manufacture

Dry milks consumed in the United States are manufactured by three principal processes: spray, atmospheric roller or drum, and vacuum drum. In all processes, the milk is pasteurized before or during the drying procedure. A brief heat treatment reduces fresh fluid milk to a dry form. The method of heat treatment in the drying process may have an effect upon its quality for baking uses. In most drying procedures, the milk is partially concentrated to increase the drying speed. The amount of concentration varies with the method but it may be as great as 40 per cent of the solids. According to Holm (1949), skim milk is usually pre-heated to 185 degrees Fahrenheit since the milk treated in this manner has better baking qualities than skim milk which has received only a pasteurization treatment. Whole milk is heated to 170 or 180 degrees Fahrenheit for 30 minutes to destroy lipases.

Spray: According to Lampert (1947), the fluid milk is sprayed by centrifugal force or by pressure into a chamber where a current of heated air is directed. The fluid milk dries quickly to a powder. Force of gravity or cyclonic motion removes the milk powder from the air.

Atmospheric roller or drum: Holm (1949) explained that revolving metal rollers or drums are coated with a thin film of milk which dries by steam heat as the rollers or drums revolve. A steel blade, which is placed parallel to the surface of the roller or drum, removes the film of dry milk in one complete revolution. The milk product is then reduced to a powder by a grinding device.

Vacuum drum or roller: The drums or rollers are enclosed in a chamber which is maintained under a partial vacuum during the drying process.

Characteristics

Greenbank et al (1927) have shown that drying brings about a change in the degree of hydration and dispersion of proteins in milk products. Dry milk powders manufactured by the spray and vacuum drum processes are 99 per cent soluble and retain many of the properties of fluid milk as reported by Eckles et al (1936). Drum dry milk solids prepared by the atmospheric drum process dissolve in water slowly. According to Holm (1949), the high temperature necessary for drying the film causes denaturation of protein constituents, casein and lact-albumin, which makes them "insoluble." A few seconds contact with the hot drum or roller renders calcium caseinate and albumin incapable of redispersion in water. Davies (1939) stated that the degree of denaturation of the proteins of milk depends upon the time and temperature of heating.

Holm (1949) indicated that dry milks manufactured by the spray and vacuum drum processes are hygroscopic, while the powders produced by atmospheric drum process are partially non-hygroscopic.

<u>Use in cakes</u>

Stamberg and Bailey (1938) observed the use of dry milk solids in loaf and layer cakes. Their tests showed that satisfactory cakes were prepared with good grades of either roller or spray process dry milk solids. If roller milk solids were incorporated in the cake batter, the viscosity of the batter increased, especially when high concentrations of milk solids were used. In the latter case, a change in the formula with an increase of liquid in proportion to dry ingredients for the roller powders gave satisfactory results. Spray process dry milk solids produce very good cakes. Bohn (1935) studied the use of three types of defatted milk powders in cake baking tests. The roller process dry milk powder in the cake batter had a greater emulsifying effect than either the spray or vacuum process powders.

<u>Amount in cakes</u>

Dry milk solids at varying concentrations calculated on the flour basis have been used in the preparation of cakes. The results of Stamberg and Bailey (1939) showed that cakes containing 15 percent defatted milk solids retarded staling but 30 per cent defatted milk solids was still more effective. Fifteen per cent dry milk solids is considered a moderate amount according to Stamberg and Bailey (1940). They also suggested that better results were obtained when 10 per cent more water was added for each 15 per cent concentration of dry milk solids. Stamberg and Bailey (1938) cited the average percentage of milk solids now commonly used in cakes as from 8 to 15 per cent calculated on the flour basis. Lampert (1947) stated that dry milk solids up to 20 per cent may be used to replace fluid milk.

Staling

Theory

Platt (1930) discussed three types of changes which contribute to the staling of bread and cake. First, a loss of volatile constituents may occur. The volatile constituents consist of water, carbon dioxide, alcohol and volatile fatty acids. These constituents contribute to the aroma of a freshly baked product. Secondly, changes due to oxidation occur. Many foods which take up oxygen acquire a tallowy flavor. However, an off-flavor is not noticeable except after long periods of storage. Thirdly, inherent staling consists of changes other than losses or gains from the surroundings that take place in the product. Inherent staling is an approach of the crumb to an equilibrium at a new temperature during aging.

Crust: Crust staling is more simple to interpret than crumb staling but there is no similarity in the process of the staling. According to Katz (1946), the crust attracts moisture and takes up water from the surrounding atmosphere or from the crumb. Alsberg (1935-36) noted that as the moisture was transferred from the interior to the exterior of the product, an equilibrium between the crust and crumb was attained. Since the crust possesses hygroscopic properties, Pyler (1948) believed it absorbed moisture which diffused from the interior to the crust. Fresh crust is dry, crisp, and brittle while the stale crust becomes soft and leathery after absorption of water. An increase in the moisture content of the crust causes a loss and deterioration of flavor. The crust may acquire a slightly bitter flavor during staling. The cause of such a change in flavor of the crust is not known.

<u>Crumb</u>: Alsberg (1935-36), Cathcart (1940) and Pyler (1948) stated that staling of the crumb took place in three stages: the crumb became tough and hard, crumbliness developed and eventually the crumb dried out. All of these changes occur simultaneously but at varying rates. Other detectable differences observed in the staling of the crumb were a decrease in the water-soluble starch content and in swelling power.

Katz (1934d) and others believed that changes in the bread crumb through staling were due to changes in the starch only and not to gluten. Platt (1930) stated that investigators have focused their attention on starch because chemical changes of starch are easier to follow than in gluten. During staling, starch changes to another form which is shown by a different X-ray pattern. The contour of the starch granules are sharp and accentuated in the stale product. Gluten, which is coagulated by heat during baking, produces an X-ray pattern which does not change after several days. Numerous studies have been carried out on the aging of starch pastes to gain knowledge of the chemical nature of the change in starch during staling.

It is necessary to have some knowledge of the starch properties to interpret the phenomena concerned in the staling of bread. Starch grains have a laminated structure, give double refraction and are crystalline in the natural state as described by Alsberg (1935-36). The granules consist of two substances, alpha-amylose which is very insoluble in water and beta-amylose which is somewhat soluble in water. Fuller (1938) suggested that alpha and beta amylose appear to be forms of the same substance; the only difference being in the state of aggregation of the basic starch molecule. Partial disaggregation of the starch micelles which occurs on heating alters the proportion of alpha-amylose to beta-amylose. There would appear to be a definite equilibrium between the two forms at any one temperature. The phenomenon of staling may be attributed to a slow attainment of an equilibrium between the two forms of starch; if so, staling could be affected only by a major alteration in the equilibrium proportion of alpha to beta amylose.

When starch granules are heated in water, gelatinization takes place according to the amount of water present and the temperature. Gelatinization is defined as the conversion of starch to a gel by heating with water. Fuller (1938) explained that the extent of gelatinization of starch affected to some degree the rate of staling. Alsberg (1935-36) reported that during the first degree gelatinization, the starch was converted from one crystalline form to another in a manner demonstrated by X-ray. The granules swell and become permeable and translucent. When the starch is heated to 100 degrees Centigrade, second degree gelatinization changes the starch from a crystalline to an amorphous state. The granules are greatly swelled and nearly opaque. During the baking of bread, the glut′en is coagulated and loses most of its power to hold water. However, the starch granules become partially gelatinized and take up some water from their surroundings.

Alsberg (1935-36) stated that as the bread left the oven, the moisture was distributed as follows: in the form of vapor filling the pores of the crumb, in the gluten, as a solvent for the salts and sugars in the crumb solution, and in the partially gelatinized starch.

As the bread cools, the soft starch jelly sets and becomes a still gel which contains less water than is necessary for complete gelatinization. Starch gels and possibly the gluten shrink. Katz (1934b) found that as the gel lost water and became smaller, the starch separated from the coagulated gluten. Crumbliness developed due to strains caused by a change in the moisture distribution. Kuhlmann and Golossowa (1936) have reported that the water-binding capacity of the bread crumb decreased with staling.

In the aging of a gel as starch paste, two phenomena occur: retrogradation and syneresis. Retrogradation is defined as the change from an amphorous to a crystalline form in second degree gelatinized starch. Syneresis may be defined as a physical process whereby gel particles unite into a denser gel and partial extrusion of liquid from the starch gel occurs. Alsberg (1935-36) reported that the two phenomena did not necessarily proceed at the same rate. He believed that retrogradation was a slow process but staling proceeded quite rapidly. However, Katz (1934c) believed that the primary cause of bread crumb's staling was the retrogradation of starch gelatinized through baking. The various starches show different degrees of retrogradation indicating differences in the molecular structure. These differences have not yet been explained. According to Katz (1934c), wheat starch which has retrograded may be rejuvenated if a loss of moisture is prevented. Alsberg (1935-36) and Fuller (1938) reported that during retrogradation, the water-holding capacity of the starch gel decreased. Syneresis may occur. Many kinds of dilute gels show the phenomena of syneresis due to a change in the starch. Fuller (1938) suggested that the retrogradation of starch gels, the syneresis which they undergo and the changes which take place in bread on staling were all manifestations of the same phenomenon; that is, a decrease in the hydration capacity of starch gels with aging.

Rate

According to Olsen (1931), the rate of staling for all cakes was more rapid during the first 24 hours in their study. The cakes staled fairly rapidly from 24 to 48 hours but continued at a slower rate from 48 to 96 hours.

Measurements

Compressibility: Platt (1930) recommended compressibility as one of the best methods for determining the velocity of staling. Many of the methods described by various investigators for measuring compressibility of a baked product are based on the same principle; the sample of a given thickness is subjected to a specified weight for a given period of time. The amount of compression is measured. Usually the apparatus constructed for measuring compressibility obeys Hooke's Law; "that the strain produced is in proportion to the stress producing it."

Fuller (1938) criticized compressibility methods of determining staleness because of the great variations between samples and the fact that crumb pore structure affected the results without being a staleness factor.

Katz (1928) showed that the greatest change in compressibility occurred during the first eight hours after baking. The consumer cannot detect staleness at this point. Platt (1940) concluded that the most logical period for determining compressibility was between 12 and 48 hours after baking.

Moisture absorption: Another method for evaluating staleness of baked products is the moisture absorption test. Fresh cake absorbs water readily, but this power decreases with staling. Swartz (1938) showed in her experiments that the ability of the cake to absorb water decreased with an increase in the age of the cakes. The method involved weighing a sample and dipping it for five seconds into a dish containing a specified volume of water at room temperature. The sample was inverted and reweighed. The difference in the weights represented the moisture absorbing capacity of the cake.

Moisture: The rate of evaporation of moisture is a possibility for measuring the rate of staling. However, Platt (1930) has shown that differences in the rate of loss of moisture in fresh and stale bread are very small. Loss of moisture may be measured accurately, but it does not have much relationship to the changes in starch. Cathcart (1940) mentioned the significance of moisture loss in wrapped bread. If the bread had been wrapped in moisture-proof paper, a loss of two per cent moisture occurred after 72 hours of storage. Staling takes place when the loss of moisture is prevented; therefore, measurement of moisture in fresh and stale samples of baked products was considered unsuitable for measuring staleness.

Subjective testing: Pyler (1948) explained that chemical staling did not necessarily correlate with staling which was perceptible by subjective tests. Consumers show a preference for 12 hour old bread on the basis of flavor and texture. King et al (1937) indicated that flavor tests were not sensitive enough for evaluating early staling. In their studies, a comparison of 12, 24, and 48 hour old bread was used. The judges showed a preference for 12 hour loaves on the basis of taste and aroma.

EXPERIMENTAL PROCEDURE

Preparation of cakes

A basic forumla for plain cake was mixed by a conventional method. Dry milk solids were substituted for fluid milk in the formula at varying concentrations; equivalent to one cup of fluid milk and at 8, 14, and 20 per cent concentrations calculated on the flour basis. Spray whole and defatted as well as atmospheric drum defatted milk solids were incorporated into the basic formula. The cakes were baked and then cooled for three hours. Five replications were prepared for each of the variables.

Formula

The basic formula used in the preparation of the cakes was taken from Lowe (1943).

Ingredients	Amount
Hydrogenated fat	224 gm.
Sugar	600 gm.
Eggs, whole	192 gm.
Milk, fluid	490 cc.
Flour, cake	568 gm.
Baking powder (S.A.S.)	16 gm.
Salt	12 gm.

Dry milk solids were substituted for fluid milk in this formula as recorded in Table 1 on page 15. The fat content of the formula was not adjusted to the normal fat content of fluid milk when defatted dry milk solids were added. A preliminary investigation (Appendix, Tables 16 and 17) showed that addition of fat to this formula for the defatted milk solids did not improve the baked cakes.

Table 1

Substitution of dry milk solids for fluid milk

Amount of dry milk solids	Kind of dry milk solids	Weight of dry milk solids	Volume of Water
		gm.	cc.
Equivalent to two cups of fluid milk	Whole	62.0	423
	Defatted	45.6	423
8 per cent (flour basis)	Whole	45.4	423
	Defatted	45.4	423
14 per cent (flour basis)	Whole	80.0	422
	Defatted	80.0	422
20 per cent (flour basis)	Whole	113.6	422
	Defatted	113.6	422

<u>Source of ingredients</u>

Fluid milk was obtained daily from the Michigan State College Dairy. The spray whole and defatted milk solids were purchased in one lot from the Michigan Milk Producers Association, Incorporated. Atmospheric drum defatted milk solids were obtained in one lot from the Michigan State College Dairy. All of the milk solids were held under refrigeration throughout this study.

<u>Assembling ingredients</u>

All of the ingredients in the formula were stored at or allowed to attain room temperature before mixing. The ingredients, with the exception of liquid and egg, were weighed on a Torsion balance. Liquids were measured in cubic centimeters.

The eggs were beaten 50 turns by a rotary beater prior to weighing on a trip balance. The flour, baking powder, salt and dry milk solids were sifted together twice. Both the dry and liquid ingredients were divided into three portions.

Mixing ingredients

The cakes were mixed in lots; eight cakes were baked from each lot. For the mixing process, the mixer* with a flat beater and a five-quart capacity bowl was used. Throughout the mixing process, the mixer was set at low speed. After 30 second intervals of mixing, the mixture was scraped from the paddle and sides of the bowl with a rubber spatula.

The hydrogenated fat was creamed for one minute, then the sugar was added gradually over a period of two minutes of creaming. The beaten eggs were added to the creamed mixture and allowed to mix for three minutes. A one-third portion of the dry ingredients was added to the creamed mixture and mixed for ten seconds. One-third of the liquid (milk or water) was added during the next 20 seconds. Dry and liquid ingredients were incorporated into the batter through three additions. A final one-minute mixing completed the procedure. One hundred and eighty grams of batter were poured into each aluminum foil pan. All of the pans measured 5-1/2 x 4 x 1-3/4 inches. Waxed paper was used to line the bottom of each pan.

* KitchenAid Mixer, Hobart Manufacturing Company, Troy, Ohio.

<u>Baking</u>

The cakes were baked for 35 minutes in pre-heated gas ovens at 350 degrees Fahrenheit.

<u>Cooling</u>

As the cakes were removed from the oven, they were placed upon a wire cooling rack in the pans and allowed to stand for 20 minutes. The cakes were loosened from the sides of the pans with a spatula, removed from the pans, and turned upright on the rack to cool for approximately three hours.

Storage of cakes

Each cake was labeled and wrapped in moisture vapor-proof cellophane for storing. The cellophane was sealed with a heated spatula. All the cakes were stored in a wooden cupboard in the food research laboratory at room temperature and humidity with the exception of the cakes which were tested while fresh (three hours after baking). The room temperature ranged from 20 to 26.6 degrees with an average of 24.3 degrees Centigrade. The relative humidity ranged from 29 to 53 per cent with an average of 39.8 per cent.

Testing

<u>Subjective</u>

A panel of five members from the Food and Nutrition Department scored the cakes. Four cakes, placed in random order, were scored in each period. The cakes were sliced one-half inch thick in a mitre box and placed on a white background for judging. Volume, appearance and outside color were scored before the judges removed a slice of each cake to a white plate. The other factors, inside color, flavor, tenderness, texture, general conclusion, and acceptability, were then scored. A sample of the score card is included in the appendix.

Objective

Specific gravity: Specific gravity is the ratio of the weight of a given volume of batter to the weight of an equal volume of water. The batter and water were weighed in a measuring cup on a trip balance. After mixing the batter, the cup was filled approximately two-thirds, tapped 10 times on the surface of the table, and completely filled. The batter was leveled off with a spatula for weighing.

Viscosity: Viscosity of a solution is the measurement of resistance to flow. A viscosimeter* (Fig. 1, page 21) with a 26 gauge wire was used for determining the viscosity of the cake batter. Following the mixing procedure, the small inner cup, which measured three centimeters in diameter, was filled with approximately 30 cubic centimeters of batter at room temperature. The one centimeter cylindrical plunger was immersed in the cup of batter for a rotation (20 R.P.M.) period of five seconds. The reading was taken in MacMichael degrees.

*MacMichael Viscosimeter, Fisher Scientific Co., Pittsburgh, Pa.

Volume: The seed displacement method was used in measuring volume of the freshly baked cakes. (Fig. 3, page 21).

Compressibility: The instrument used for the compressibility test was a penetrometer.* (Fig. 2, page 21). For this test, four samples were taken from the middle sections of two adjoining slices of cake. The samples were one inch in diameter and approximately one-half inch in thickness. A plunger of the same diameter as the sample was attached to the penetrometer. The needle bar and plunger weighed 72.5 grams. A 50 gram weight was placed on the needle bar: the total weight upon the sample was 122.5 grams. As the sample was placed in position, the stage was adjusted to bring the upper surface of the cake into contact with the lower surface of the plunger. The needle bar was released for five seconds and the extent of compression was read on a dial in millimeters.

Moisture absorption: Duplicate samples of each cake were tested for their moisture absorbing capacity. The cake discs, which measured one inch in diameter and one-half inch in thickness, were cut from the middle section of one slice of cake. The cake discs were weighed on an analytical balance and dipped for five seconds into a petri dish cover containing 25 cubic centimeters of distilled water at room temperature. As

* New York Testing Laboratory Penetrometer

the samples were removed, they were inverted and reweighed. The difference between the two weights of the sample represented the moisture absorbing capacity of the cake.

Moisture content: A semi-automatic moisture tester* was used for determining the moisture content of the cake samples. Readings in per cent moisture were taken after two hours of drying at 120 degrees Centigrade with forced air circulation.

Cake prints: Prints were prepared of the fresh cakes. The sliced portion of cakes was placed on an inked pad for absorption of black ink. After one minute of absorption, the cake was transferred to a sheet of paper, pressed lightly on the paper, and removed carefully.

Statistical methods

Analysis of variance and correlation coefficients were calculated according to the methods recommended by Snedecor (1946).

* Brabender, Brabender Corporation, Rochelle Park, New Jersey.

Fig. 1
Viscosimeter

Fig. 2
Penetrometer

Fig. 3
Volumeter

DISCUSSION OF RESULTS

Subjective tests

The judges scored the cakes three hours after baking and at storage periods of 24, 48, and 72 hours. Their scores for volume, appearance, inside color, outside color, flavor, tenderness, texture, general conclusion, and acceptability are discussed in the following pages.

Volume: Analysis of variance of the volume scores showed that the storage time was significant. (Table 2) A slight decrease in volume was noted with an increase in storage time, but the decline in scores was not always consistent. The storage time produced variations which may have been due to a slight shrinkage or possibly a difference in the individual cakes. The batter for each cake was weighed into the pan; therefore, individual cake differences should have been negligible. Possibly the judges could not detect small differences accurately.

Analysis of variance of the volume scores showed that the amounts of dry milk solids produced highly significant differences. When dry milk solids at the eight per cent concentration were added to cakes, the volume remained approximately the same. As the concentrations of dry milk solids were increased above eight per cent, the volume of the cakes decreased.

The differences between volume scores of the cakes prepared with spray whole, spray defatted, and drum defatted milk solids were very small. Analysis of variance of the kinds and the interaction between amounts and kinds of dry milk solids did

Table 2

Mean scores for volume

(Scores range from 1 to 7; 7 is excellent)

Kinds of dry milk solids	Storage time	Control (fluid milk)	Amount of dry milk solids: Equivalent of fluid milk	8 per cent	14 per cent	20 per cent
	hours					
Spray whole	3	5.5	5.6	5.5	5.1	5.5
	24	5.0	5.4	5.1	5.2	5.1
	48	5.7	5.3	5.5	5.0	4.9
	72	4.8	5.0	5.2	5.2	5.2
Spray defatted	3	5.1	5.6	5.3	5.3	5.3
	24	5.1	5.5	5.1	5.3	4.7
	48	5.3	5.5	5.1	5.1	5.0
	72	5.7	5.3	5.0	5.0	4.9
Drum defatted	3	5.4	5.5	5.5	5.0	5.2
	24	5.0	5.3	5.3	5.5	4.8
	48	5.2	5.2	5.2	5.5	4.6
	72	5.1	5.2	5.1	5.3	4.7

Analysis of variance

Source of variation	F values
Amount of dry milk solids	4.65**
Kind of dry milk solids	.30
Amount x kind of dry milk solids	1.43
Storage time	3.65*

*Significant (5 per cent level)
**Highly significant (1 per cent level)

not show any significant differences.

Appearance: The scores in Table 3 show that the kinds and amounts of dry milk solids produced little effect on the appearance of cakes. As the storage period was increased, the appearance scores declined slightly. The cakes which were wrapped and stored developed a moist crust.

Inside color: The amounts of dry milk solids used in the cake formula caused greater differences in scores than did the kinds of dry milk solids. (Table 4) Cakes prepared with dry milk solids at the 14 and 20 per cent concentrations were given lower scores in color than the other amounts of dry milk solids and the control. The effect of the use of dry milk solids on color in a yellow cake was not pronounced. However, a white cake might show the color differences with increased concentrations of dry milk solids. A change in color did not occur upon aging as the scores varied little between the 3 and 72 hour old cakes.

Outside color: The results of the scores for outside color of the cakes are recorded in Table 5. Changes of the crust color during aging were small and inconsistent. Dry milk solids did not improve the crust color of the cakes as shown by the scores of the judges. However, Stamberg et al (1940) believed that the use of dry milk solids did improve the crust color. When dry milk solids at the 20 per cent amount were substituted, the cakes received lower scores than cakes con-

Table 3

Mean scores for appearance

(Scores range from 1 to 7; 7 is excellent)

Kinds of dry milk solids	Storage time	Control (fluid milk)	Amount of dry milk solids			
			Equivalent of fluid milk	8 per cent	14 per cent	20 per cent
	hours					
Spray whole	3	5.5	5.3	5.3	5.1	4.9
	24	4.9	5.2	4.9	4.9	5.0
	48	5.2	5.3	5.1	4.9	5.0
	72	5.1	4.5	5.0	5.0	4.8
Spray defatted	3	5.1	5.4	5.2	5.2	5.3
	24	5.1	5.1	4.8	5.0	4.7
	48	5.5	5.2	5.0	5.1	5.0
	72	5.4	5.0	5.1	5.1	4.9
Drum defatted	3	5.2	5.3	5.2	5.4	5.2
	24	5.3	5.2	5.4	5.2	4.8
	48	5.3	5.1	4.9	5.3	4.6
	72	5.4	5.1	5.0	5.0	4.7

Table 4

Mean scores for inside color

(Scores range from 1 to 7; 7 is excellent)

Kinds of dry milk solids	Storage time	Control (fluid milk)	Amount of dry milk solids			
			Equivalent of fluid milk	8 per cent	14 per cent	20 per cent
	hours					
Spray whole	3	5.8	5.8	5.8	5.6	5.3
	24	5.7	5.9	5.6	5.3	5.3
	48	5.7	5.7	5.6	5.4	5.5
	72	5.8	5.5	5.6	5.5	5.3
Spray defatted	3	5.8	5.8	5.7	5.6	5.4
	24	5.8	5.6	5.7	5.4	5.2
	48	5.7	5.8	5.7	5.6	5.2
	72	5.7	5.6	5.4	5.5	5.4
Drum defatted	3	5.8	5.8	5.6	5.8	5.4
	24	5.8	5.6	5.7	5.6	5.2
	48	5.7	5.4	5.5	5.6	5.4
	72	5.7	5.5	5.6	5.5	5.4

Table 5

Mean scores for outside color

(Scores range from 1 to 7; 7 is excellent)

Kinds of dry milk solids	Storage time	Control (fluid milk)	Amount of dry milk solids			
			Equivalent of fluid milk	8 per cent	14 per cent	20 per cent
	hours					
Spray whole	3	5.7	5.7	5.9	5.4	5.3
	24	5.5	5.4	5.8	5.1	5.0
	48	5.3	5.6	5.7	5.1	5.1
	72	5.5	5.4	5.2	5.2	5.2
Spray defatted	3	5.6	5.8	5.6	5.7	5.2
	24	5.6	5.5	5.3	5.0	5.2
	48	5.6	5.5	5.1	5.3	5.2
	72	5.3	5.4	5.4	5.2	5.0
Drum defatted	3	5.4	5.8	5.6	5.7	5.2
	24	5.6	5.3	5.7	5.4	5.4
	48	5.4	5.3	5.4	5.4	5.2
	72	5.5	5.2	5.3	5.4	5.4

taining the other amounts of dry milk solids and fluid milk. At the highest concentration of dry milk solids, the lactose content is greater. Caramelization of lactose produces the darker crust color and therefore, a darker crust color is anticipated at the 20 per cent concentration of dry milk solids. From the writer's observation of the baked cakes, all of the cakes containing dry milk solids appeared darker than the control.

Flavor: The mean scores and an analysis of variance of flavor scores are shown in Table 6. An analysis of variance of the flavor scores was made to ascertain differences due to variations in the amounts and kinds of dry milk solids, to the interaction between amounts and kinds, and to the storage time. The variations which showed highly significant differences were the amounts of dry milk solids used and the storage time. At the highest concentration of dry milk solids, the scores decreased. The kinds of dry milk solids used in the cakes had no effect on flavor scores according to the results of the analysis of variance. Flavor losses were greatest between the 24 and 48 hour periods of storage. In certain cases, the cakes which were stored for 72 hours did not show a decrease in scores from the fresh cakes. In other cakes, the storage time did cause a decline in scores. The judges detected a metallic flavor which may be due to a baking powder residue in some of the staled cakes. Dry milk solids seemed to have no affect on

Table 6

Mean scores for flavor

(Scores range from 1 to 7; 7 is excellent)

Kinds of dry milk solids	Storage time	Control (fluid milk)	Amount of dry milk solids			
			Equivalent of fluid milk	8 per cent	14 per cent	20 per cent
	hours					
Spray whole	3	5.2	5.1	5.5	5.1	5.1
	24	5.3	5.3	4.7	5.2	4.9
	48	5.1	4.9	5.0	4.8	5.0
	72	4.9	4.9	4.8	5.0	4.9
Spray defatted	3	5.4	5.1	4.9	5.2	5.0
	24	5.6	5.1	5.1	5.0	4.7
	48	5.0	5.0	5.0	4.9	4.7
	72	5.4	4.8	4.7	4.9	4.5
Drum defatted	3	5.3	5.3	5.2	5.1	4.9
	24	5.2	5.2	5.3	5.2	4.8
	48	5.5	4.7	5.0	5.0	4.7
	72	5.0	5.1	5.0	5.0	4.6

Analysis of variance

Source of variation	F values
Amount of dry milk solids	6.52**
Kind of dry milk solids	.29
Amount x kind of dry milk solids	.86
Storage time	5.29**

** Highly significant (1 per cent level)

retarding losses of fresh flavor.

Tenderness: Scores of tenderness, which are tabulated in Table 7, showed greater differences than the other subjective scores. Analysis of variance of the tenderness scores revealed that the variance attributable to the amounts of dry milk solids used in the preparation of the cakes was highly significant. Tenderness scores of the cakes prepared with fluid milk were highest; whereas the tenderness scores of the cakes prepared with the 20 per cent amount of dry milk solids were lowest. An adjustment of the liquid in the formula may be necessary for the 20 per cent amount of dry milk solids since there was a tendency toward a less tender cake.

The kinds of dry milk solids produced a significant F value from the analysis of variance. Drum defatted milk solids produced a more tender cake than the other kinds compared in this study.

A highly significant F value was obtained from an analysis of variance of the storage time. The storage period caused a decline in tenderness scores of the cakes. The decrease in tenderness was due to the fact that the crumb became harder during aging. A large spread in scores was shown between 3 and 72 hours. The rate of decrease in tenderness scores of the cakes prepared with dry milk solids was comparable to the control. Therefore, dry milk solids did not retard the decline in tenderness of the cakes with aging.

Table 7

Mean scores for tenderness

(Scores range from 1 to 7; 7 is excellent)

Kinds of dry milk solids	Storage time	Control (fluid milk)	Amount of dry milk solids: Equivalent of fluid milk	8 per cent	14 per cent	20 per cent
	hours					
Spray whole	3	5.9	5.7	5.8	5.5	5.6
	24	5.3	5.3	5.1	5.4	5.1
	48	5.2	5.0	5.0	5.0	4.7
	72	5.0	4.8	5.0	4.9	4.8
Spray defatted	3	5.7	5.6	5.3	5.6	5.1
	24	6.0	5.6	4.9	5.8	4.8
	48	5.4	5.3	4.8	5.2	4.4
	72	5.4	4.5	4.6	4.6	4.3
Drum defatted	3	6.2	5.9	5.4	5.7	5.5
	24	5.8	5.8	5.6	5.6	5.1
	48	5.2	5.0	5.0	5.3	4.6
	72	5.3	4.8	5.1	5.2	4.5

Analysis of variance

Source of variation	F values
Amount of dry milk solids	14.67**
Kind of dry milk solids	3.17*
Amount x kind of dry milk solids	1.92
Storage time	40.83**
Storage time x amount of dry milk solids	.67
Storage time x kind of dry milk solids	1.38

*Significant (5 per cent level)
**Highly significant (1 per cent level)

Texture: The texture of the cakes prepared with fluid milk was rated higher by the judges than cakes containing dry milk solids. (Table 8). When considering different amounts of dry milk solids in cakes, the scores were not materially different from one another. Scores which showed the effect of storage on the cakes were very inconsistent and difficult to evaluate. During the study, the judges frequently commented that the aged cakes were dry. The kinds of dry milk solids used in the cakes had no effect on the scores.

General conclusion: Analysis of variance was used on the general conclusion scores to separate variations due to the kinds and amounts of dry milk solids, storage time and the interactions between amounts and kinds of dry milk solids. (Table 9) All of the variations except kinds of dry milk solids were highly significant. The interactions between amounts and kinds indicated that the scores due to the kinds of dry milk solids were altered by the amounts of dry milk solids used. Scores for the control were slightly higher than for any of the cakes containing dry milk solids. At the 20 per cent concentration, the scores for the cakes dropped. Such a decline in scores at the highest concentration may be attributed to the fact that more liquid is required for the amount of dry milk solids incorporated into the formula. The greatest decline of scores with aging occurred between 3 and 48 hours of storage of the cakes.

Table 8

Mean scores for texture

(Scores range from 1 to 7; 7 is excellent)

Kind of dry milk solids	Storage time	Control (fluid milk)	Amount of dry milk solids: Equivalent of fluid milk	8 per cent	14 per cent	20 per cent
	hours					
Spray whole	3	5.4	4.7	5.4	4.8	5.0
	24	4.5	4.7	4.5	5.1	5.0
	48	4.8	4.8	4.5	5.0	4.7
	72	5.0	4.3	4.8	4.6	4.6
Spray defatted	3	5.2	5.0	5.0	5.0	5.3
	24	5.3	5.0	4.4	5.3	4.8
	48	5.4	4.9	4.2	5.0	4.7
	72	5.3	4.6	4.8	4.9	4.5
Drum defatted	3	5.5	4.9	4.8	4.9	4.8
	24	5.5	4.9	4.9	5.1	4.7
	48	5.1	4.8	4.4	5.1	4.3
	72	5.2	4.9	5.2	5.1	4.5

Table 9

Mean scores for general conclusion

(Scores range from 1 to 7; 7 is excellent)

Kind of dry milk solids	Storage time	Control (fluid milk)	Amount of dry milk solids			
			Equivalent of fluid milk	8 per cent	14 per cent	20 per cent
	hours					
Spray whole	3	5.3	5.0	5.5	5.2	5.1
	24	5.0	5.0	4.9	5.1	4.8
	48	5.1	4.8	4.8	4.9	4.9
	72	4.9	4.7	4.9	4.9	4.7
Spray defatted	3	5.3	5.3	5.1	5.1	5.1
	24	5.5	5.2	4.9	5.2	4.7
	48	5.1	5.1	4.8	5.1	4.7
	72	5.4	4.8	4.8	5.0	4.6
Drum defatted	3	5.4	5.4	5.2	5.3	5.0
	24	5.2	5.1	5.4	5.2	4.8
	48	5.2	4.9	4.9	5.0	4.6
	72	5.0	5.0	5.0	4.9	4.4

Analysis of variance

Source of variation	F values
Amount of dry milk solids	17.13**
Kind of dry milk solids	2.38
Amount x kind of dry milk solids	2.75**
Storage time	22.75**

** Highly significant (1 per cent level)

Acceptability: The cakes were considered acceptable by the judges who served on the scoring panel. In a few cases, two of the judges designated cakes as unacceptable after 48 and 72 hours of storage.

Objective tests

Specific gravity and viscosity tests were performed upon the batters of the cakes in this study. Readings of volume, compressibility, moisture absorption, and moisture content were recorded from the objective tests of the baked cakes. Ink prints were prepared of all the freshly baked cakes.

Specific gravity: According to Pyke and Johnson (1940), the specific gravity of the batters is dependent on the amount of air incorporated. The batters prepared in this study received approximately the same amount of aeration; therefore, great differences in the specific gravity of the batters would not be anticipated. The amounts and kinds of dry milk solids produced very little variation in the specific gravity readings of the batters. (Table 10) Specific gravities for cake batters usually range from 0.7 to 1.0. The readings for these batters were high. Thin batters are often associated with high specific gravities.

Table 10

Mean readings for specific gravity

Kind of dry milk solids	Control (fluid milk)	Amount of dry milk solids			
		Equivalent of fluid milk	8 per cent	14 per cent	20 per cent
Spray whole	.96	.97	.97	.98	.98
Spray defatted	.97	.97	.97	.97	.97
Drum defatted	.97	.97	.97	.98	.98
Averages	.97	.97	.97	.98	.98

The batters showed greater differences in viscosity than the specific gravity readings indicated by the results in Table 10. The fluid milk batters were always thinner than batters containing dry milk solids. In turn, batters which contained drum defatted dry milk solids were much thicker than the other dry milk solid batters. The higher concentrations of dry milk solids produced thicker batters also.

Specific gravity is correlated with volume according to Tinklin and Vail (1946). The small differences encountered in the specific gravity of the batters were related to the small differences in the volumes of the baked cakes as observed in this study.

<u>Viscosity</u>: Analysis of variance of the viscosities for the cake batters showed that all of the variations were highly significant. (Table 11) Cake batters containing dry milk solids produced higher viscosities than the batters containing

Table 11

Mean readings for viscosity in MacMichael degrees

Kind of dry milk solids	Control (fluid milk)	Amount of dry milk solids			
		Equivalent of fluid milk	8 per cent	14 per cent	20 per cent
Spray whole	79	99	89	103	112
Spray defatted	86	87	76	96	97
Drum defatted	85	127	108	140	170

Analysis of variance:

Source of variation	F values
Amount of dry milk solids	14.72**
Kind of dry milk solids	32.86**
Amount x kind of dry milk solids	3.30**

** Highly significant (1 per cent level)

fluid milk. As the amounts of dry milk solids increased, the viscosity of the batters increased except in the case of the eight per cent amount. The kinds of dry milk solids showed greater differences since the drum defatted milk solids produced viscosities which were greater than those of the spray whole or defatted milk solids. These results are in agreement with the viscosities of batters observed by Stamberg and Bailey (1938). The fact that drum defatted milk solids are not as easily dissolved in the batters as the other kinds may account for the greater differences in viscosity. Apparently, the variations of viscosity of the batters produced little or no effect upon the texture and volume of the baked cakes as shown by the judges' scores.

Volume: The mean volume readings and an analysis of variance are recorded in Table 12. Analysis of variance of the volumes of the cakes was made but there were no significant differences in volumes due to the amounts or kinds of dry milk solids used in the preparation of the cakes.

Table 12

Mean readings for volume

Kind of dry milk solids	Control (fluid milk)	Amount of dry milk solids			
		Equivalent of fluid milk	8 per cent	14 per cent	20 per cent
	cc.	cc.	cc.	cc.	cc.
Spray whole	482	487	488	478	496
Spray defatted	477	497	490	497	506
Drum defatted	478	495	490	493	484

Analysis of variance

Source of variation	F values
Amount of dry milk solids	.91
Kind of dry milk solids	.55
Amount x kind of dry milk solids	.37

The differences between the volumes of the cakes were very small. When dry milk solids were included in the cakes, the volumes were slightly greater than in the cakes containing fluid milk. As the amounts of dry milk solids were increased, the volumes did not increase accordingly.

A correlation coefficient of the volume scores and volume readings was calculated. An insignificant value of $+ 0.0249$ was obtained. Apparently, no correlation of any significance was present between the two tests. The judges indicated by their scores that the amounts of dry milk solids did affect the volume slightly but the results of the physical test did not agree.

Compressibility: The tenderness of the crumb is expressed by compressibility. As the crumb becomes stale, compression decreases. An analysis of variance and the mean compressibility readings are shown in Table 13. The amounts and kinds of dry milk solids and the storage time showed highly significant differences. There was no interaction of any significance between amounts and kinds of dry milk solids. The cakes containing fluid milk produced higher mean readings of compressibility than the cakes containing dry milk solids. The equivalent of fluid milk and the eight per cent concentration of dry milk solids approximated the compressibility of the control. As the amounts of dry milk solids were increased to 14 and 20 per cent, the compressibility readings decreased. Drum defatted milk solids produced cakes which showed greater compressibility than the other kinds used in the study.

The length of the storage period caused a decrease in compressibility of the cakes; the greatest decrease occurred in the first 24 hours of storage. Platt (1931) stored cakes three days and his results showed the same rate of decrease in compressibility. Such a decrease in compressibility may be

Table 13

Mean readings for compressibility

Kind of dry milk solids	Storage time	Control (fluid milk)	Amount of dry milk solids			
			Equivalent of fluid milk	8 per cent	14 per cent	20 per cent
	hours	mm.	mm.	mm.	mm.	mm.
Spray whole	3	5.36	4.88	5.35	4.94	4.88
	24	2.41	2.62	2.44	2.15	2.13
	48	1.56	1.61	1.62	1.46	1.39
	72	1.33	1.26	1.33	1.21	1.15
Spray defatted	3	5.34	4.80	4.69	5.07	3.98
	24	2.97	2.49	2.39	2.46	2.09
	48	1.74	1.60	1.64	1.61	1.38
	72	1.50	1.19	1.34	1.25	1.03
Drum defatted	3	5.37	5.31	5.44	4.89	4.81
	24	2.82	3.05	2.83	2.58	2.48
	48	1.72	1.73	1.85	1.75	1.50
	72	1.50	1.49	1.38	1.47	1.16
Averages		2.80	2.67	2.69	2.57	2.33

Analysis of variance

Source of variation	F values
Amount of dry milk solids	6.94**
Kind of dry milk solids	5.72**
Amount x kind of dry milk solids	1.97
Storage time	772.00**

** Highly significant (1 per cent level)

attributed to the staling of the crumb which becomes tough and hard. Dry milk solids did not retard the velocity of decrease in compressibility.

A correlation coefficient of the tenderness scores and the compressibility readings was calculated. A highly significant correlation of $+$ 0.6819 exists for the two tests. The judges' scores for tenderness were related to the mechanical test of compression.

Moisture absorption: Cakes vary in their ability to absorb water. A decrease in the moisture absorbing ability occurs as the cake becomes stale. The mean readings and an analysis of variance of moisture absorption for the cakes are included in Table 14. Amounts of dry milk solids and the storage time were both highly significant. The amounts of dry milk solids which appear equal or exceed the moisture absorption of fluid milk were the equivalent of fluid milk and the eight per cent. Moisture absorption readings decreased as the concentration of the dry milk solids was increased in the cakes. The added protein content from the milk solids did not increase the water-holding capacity of the baked cakes. Differences due to the kinds of dry milk solids used and the interaction between amounts and kinds of dry milk solids added to the cakes were not significant.

A decrease in water absorbing ability was shown with the aging of the cakes. The greatest decrease in water absorption occurred in the first 24 hours of storage; over one-half

Table 14

Mean readings for the moisture absorption test

Kind of dry milk solids	Storage time	Control (fluid milk)	Amount of dry milk solids: Equivalent of fluid milk	8 per cent	14 per cent	20 per cent
	hours	gm.	gm.	gm.	gm.	gm.
Spray whole	3	3.32	3.14	3.32	2.97	3.00
	24	2.86	2.90	2.81	2.55	2.67
	48	2.74	2.63	2.60	2.56	2.43
	72	2.51	2.47	2.55	2.30	2.48
Spray defatted	3	3.17	3.19	3.39	3.16	3.03
	24	2.70	3.02	2.80	2.81	2.70
	48	2.64	2.72	2.72	2.79	2.50
	72	2.46	2.64	2.62	2.43	2.52
Drum defatted	3	3.24	3.18	3.29	2.93	2.94
	24	2.87	2.88	2.67	2.57	2.63
	48	2.59	2.76	2.65	2.71	2.38
	72	2.39	2.60	2.44	2.30	2.41
Averages		2.80	2.84	2.82	2.67	2.64

Analysis of variance

Source of variation	F values
Amount of dry milk solids	3.76 **
Kind of dry milk solids	1.31
Amount x kind of dry milk solids	.60
Storage time	48.24**

** Highly significant (1 per cent level)

of the water absorbing ability was lost in this period. Swartz (1938) stored cakes for seven days and the results of her tests showed the same decrease in water absorption with storage. Spray and drum defatted milk solids at the equivalent of fluid milk and at the eight per cent concentration may have a slight effect on retarding the decrease in water absorption of cake and thus the rate of staling.

Moisture content: The results of analysis of variance and the mean readings of moisture content of the baked cakes are recorded in Table 15. The amounts of dry milk solids and the storage time showed highly significant F values. Cakes containing fluid milk showed a slightly higher moisture content than the cakes containing dry milk solids. At the 20 per cent amount of dry milk solids, lower moisture contents were shown. An adjustment of the amount of liquid to the dry milk solids may be necessary for a formula balance.

The total moisture loss during the 72 hour storage period was slight but the loss was nearly constant with storage. When moisture vapor-proof cellophane is used for wrapping the cakes, the loss of moisture is retarded; therefore, a decrease in percentage of moisture is small with storage.

Cake prints: The cake prints are shown in Figure 4. The cakes containing dry milk solids were similar to the control. Apparently the kinds of dry milk solids had little effect on the volume and texture of the cakes as recorded by the cake prints.

Table 15

Mean readings of moisture content

Kind of dry milk solids	Storage time	Control (fluid milk	Amount of dry milk solids			
			Equivalent of fluid milk	8 per cent	14 per cent	20 per cent
	hours	pct.	pct.	pct.	pct.	pct.
Spray whole	3	21.80	21.19	21.25	20.33	20.88
	24	21.64	21.42	21.03	20.21	19.99
	48	21.45	20.57	20.91	20.02	20.02
	72	21.42	21.02	20.59	19.52	19.77
Spray defatted	3	21.82	21.15	21.78	21.29	21.11
	24	21.95	21.01	20.58	21.10	20.45
	48	20.90	20.82	20.64	20.15	20.15
	72	21.12	20.47	20.20	20.60	19.96
Drum defatted	3	22.20	21.67	21.87	21.28	20.42
	24	21.29	21.23	21.09	21.04	19.98
	48	21.42	20.80	20.34	20.46	20.18
	72	21.10	20.14	20.56	20.52	19.84

Analysis of variance

Source of variation	F values
Amount of dry milk solids	16.05**
Kind of dry milk solids	.53
Amount x kind of dry milk solids	1.34
Storage time	13.49**

** Highly significant (1 per cent level)

Figure 4

14 per cent amount of dry milk solids

1. Control (fluid milk)

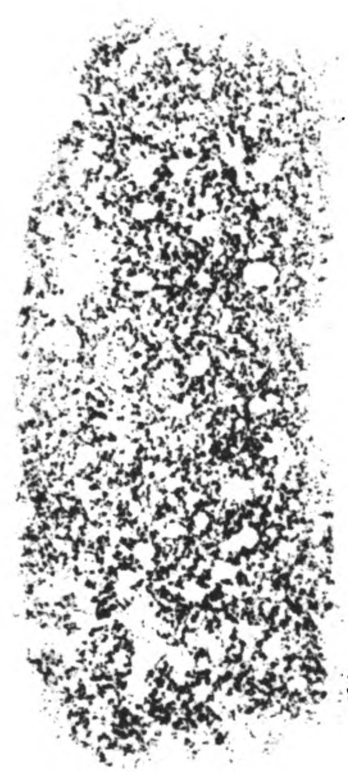
2. Spray whole milk solids

3. Spray defatted milk solids

4. Drum defatted milk solids

1

2



3

4

SUMMARY AND CONSLUSIONS

An investigation was made of the effect of the use of dry milk solids on the keeping qualities of plain cake. Dry milk solids at different concentrations were used; equivalent to fluid milk and at 8, 14 and 20 per cent concentrations calculated on the flour basis. Three kinds of dry milk solids, spray whole, spray defatted and drum defatted milk solids, were compared. The cakes were tested while fresh (three hours after baking) and at storage periods of 24, 48, and 72 hours. A panel of five judges scored the cakes for volume, appearance, outside color, inside color, tenderness, flavor, texture, general conclusions, and acceptability. Specific gravity and viscosity tests were performed upon the batters of the cakes. Objective tests were made for volume, compressibility, moisture absorption, and moisture content of the baked cakes. Ink prints were prepared of all the freshly baked cakes.

The score card factors, with the exception of appearance, were affected by the amounts of dry milk solids used. Higher scores for texture and tenderness were obtained when cakes were prepared with fluid milk. Cakes containing the 20 per cent amount of dry milk solids were scored lowest, which may have been due to the need of a formula adjustment in liquid to the solids content. Cakes prepared with fluid milk showed the highest moisture content, while those with the 20 per cent amount of dry milk solids showed the lowest. The control and dry milk solids at the equivalent of fluid milk and at the eight per cent amounts showed the greatest moisture absorption and compression; whereas the higher concentrations of dry milk solids showed a decline in both tests. The kinds of dry milk solids had little effect on the subjective scores and the objective test readings for baked cakes. Tenderness scores and compression readings were higher when drum defatted dry milk solids were used in the formula.

Dry milk solids produced very little variation in the specific gravity readings although variations in the viscosities of the batters were present. The highest concentration of dry milk solids produced the highest viscosity readings. Dry milk solids produced higher viscosity readings than fluid milk, while the drum defatted dry milk solids produced higher viscosities than the spray whole and defatted milk solids.

The subjective scores, except for appearance and color, and objective test readings for baked cakes showed a decline with storage. The greatest decline in flavor and tenderness scores, compression and water absorption occurred between 24 and 48 hours of storage. The total loss of moisture was slight but fairly constant with storage. The use of dry milk solids did not retard the rate of loss in flavor and tenderness scores and compressibility. Spray and drum defatted milk solids at the equivalent of fluid milk and at eight per cent amounts had a slight effect on retarding the decrease in water absorption of cake.

On the basis of these results, the conclusions are as follows:

1. Cakes prepared with fluid milk were better in texture, tenderness and moisture content than the cakes prepared with dry milk solids.
2. The 20 per cent amount of dry milk solids showed lower subjective scores and objective test readings than the other amounts of dry milk solids; therefore, an adjustment in this formula may be necessary for the 20 per cent amount of dry milk solids.
3. Drum defatted dry milk solids increased the tenderness and compressibility of cake more than the other kinds of dry milk solids.
4. Dry milk solids produced higher viscosity readings than fluid milk; drum defatted dry milk solids and the 20 per cent amount produced the highest viscosity readings. However, the difference in viscosity did not seem to have any effect on the quality of the baked cakes.
5. All of the subjective scores, except appearance and color, and the objective test readings of the baked cakes showed a decline with storage indicating the presence of staleness in the baked cakes.

6. The use of dry milk solids did not enhance the keeping qualities of the cakes.

REFERENCES CITED

Alsberg, Carl, 1935-36. The stale bread problem, Food Research Institute, Wheat Studies 12:221-247.

Bohn, R.T., 1935. Milk powder for the cake baking test, Cereal Chemistry 12:300-302.

Cathcart, W.H., 1940. Review of progress in research on bread staling, Cereal Chemistry 17:100-121.

Davies, W.L., 1939. The Chemistry of Milk, 2nd ed. D. Van Nostrand Company, Incorporated. New York.

Eckles, C.L., Combs, W.B., and Macy, Harold, 1936. Milk and Milk Products, 2nd ed., McGraw-Hill Book Company, Incorporated.

Fuller, C.H.F., 1938. Starch and bread staling, Chemistry and Industry 18:562-568.

Gortner, R.A., Gortner, R.A.Jr., and Gortner, Willis, 1949. Outlines of Biochemistry, 3rd ed. John Wiley and Sons, New York, New York.

Greenbank, George R., Steinbarger, M.C., Deysher, E.F., and Holm, G.E., 1927. The effect of heat treatment of skim milk upon the baking quality of the evaporated and dried products. Journal of Dairy Science 10:335-342.

Holm., G.E., 1949. Dried milks. U.S.D.A. Research Administration, Bureau of Dairy Industry Information Bulletin No. 25, October.

Katz., J.R., 1934a. What is the fundamental change in the staling of the bread crumb? Baker's Weekly 84 (no. 9):31-34, December 1.

Katz, J.R., 1934b. The staling of bread. Baker's Weekly 81:43, January 20.

Katz, J.R., 1934c. X-ray investigation of gelatinization and retrogradation of starch and its importance for bread research. Baker's Weekly 81:34-37, 46, March 24.

Katz, J.R., 1934d. Further changes that occur in the starch during staling of bread crumb. Baker's Weekly 83:26, August 25.

Katz, J.R., 1928. Gelatinization and retrogradation of starch in relation to the problem of bread staling. A Comprehensive Survey of Starch Chemistry edited by R.P.Walton (New York Chemical Catalog Company) vol. 1, part 1:100-117.

King, F.B., Coleman, D.A., and LeClerc, J.A., 1937. Report of the U.S.D.A. Bread Flavor Committee. Cereal Chemistry 14:49.

Kuhlmann, A.G. and Golassawa, O.N., 1936. Bound water in bread making. Cereal Chemistry 13:202-217.

Lampert, L.M., 1947. Milk and Dairy Products. Chemical Publishing Company, Brooklyn, New York.

Lowe, Belle, 1943. Experimental Cookery, 3rd ed. John Wiley and Sons, Incorporated. New York, New York.

Olsen, Anna M., 1931. The Effect of the Extent of Mixing the Ingredients on the Staling of Plain Cake. Unpublished M.S. Thesis, Iowa State College.

Platt, Washington, 1930. Staling of bread. Cereal Chemistry 7:1-39.

Platt, Washington, and Dratz, P.D., 1931. Measuring and recording some characteristics of test sponge cakes. Cereal Chemistry 10:73.

Platt, Washington and Powers, R., 1940. Compressibility of the bread crumb. Cereal Chemistry 17:601-621.

Pyke, W.E. and Johnson, G., 1940. Relation of mixing methods and a balanced formula to quality and economy in high-sugar ratio cakes. Food Research 5:335-359.

Pyler, E.J., 1948. The staling of bread. Baker's Digest 22:99-101.

Snedecor, G.W., 1946. Statistical Methods. 4th ed. The Collegiate Press, Incorporated. Ames, Iowa.

Stamberg, O.E., and Bailey, C.H., 1938. Dry milk solids for cake baking. Baker's Technical Digest 13 (no. 6):103-104,107.

Stamberg, O.E. and Bailey, D.H., 1939. Effects of dry milk solids on the keeping quality and batter stability of sponge cakes. Baker's Helper 71:1104-1105.

Stamberg, O.E., Brouilett, H.G., McDuffee, C.A. and Nolte, L.W., 1940. Milk in Cakes. American Dry Milk Institute, Incorporated, Chicago, Illinois.

Swartz, Ve Nona W., 1938. Two further simple objective tests for judging cake quality. Cereal Chemistry 15:247-250.

Tinklin, G.L. and Vail, G.E., 1946. Effect of the method of combining the ingredients upon the quality of the finished cake. Cereal Chemistry 23:155-165.

Toulmin, Harry Aubrey Jr., 1942. A Treatise on the Law of Food, Drug and Cosmetics. The W. H. Anderson Company, Cincinnati, Ohio.

APPENDIX

Table 16 Cake Score Card

Name____________________ Date____________________

Sample Number									
Volume									
Appearance									
Color	Inside								
	Outside								
Flavor									
Tenderness									
Texture									
General Conclusion									
Acceptability, yes or no									

Key:
1. very poor
2. poor
3. fair
4. medium
5. good
6. very good
7. excellent

	Defects:	Standard
Volume:	uneven volume, sunken, fallen	even volume, good height in proportion to width
Appearance:	sticky, sugary crust, too peaked, too flat, pillow	slightly rounded, smooth surface
Color:	outside - pale, dark brown inside - gray, white	evenly browned creamy, yellow white
Odor:	rancid, foreign odors	
Flavor:	rancid, foreign flavor, unevenly blended ingredients	
Tenderness:	tough, heavy, hard	light, fluffy, tender
Texture:	coarse, crumbly, soggy, dry, tunnels	slightly moist, fine uniform grain, velvety, resilient

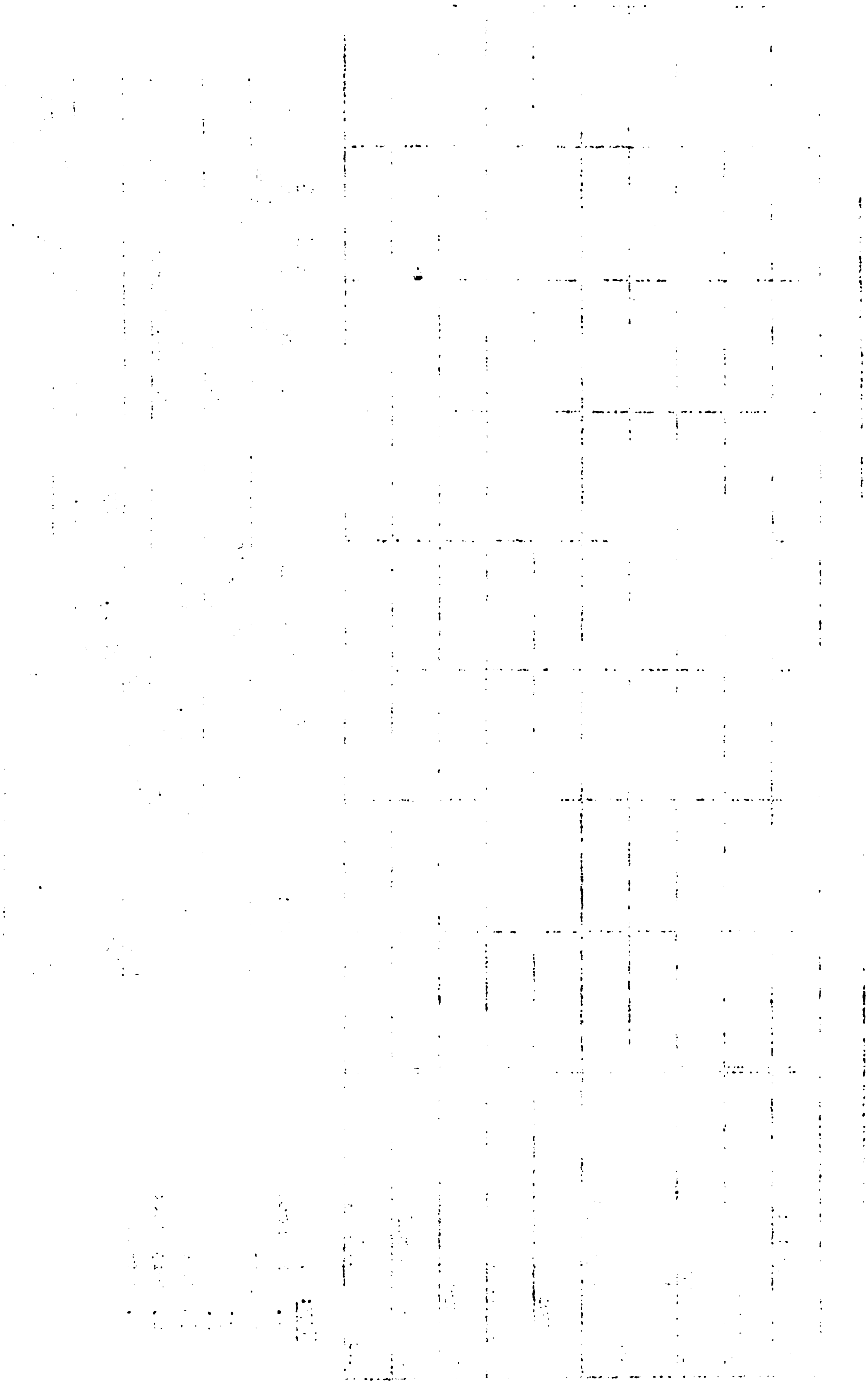


Table 17

Mean values for objective tests of fat addition to the formula to compensate for fat removal in defatted milk solids

Objective tests	Control (fluid milk)	Dry milk solids			
		Drum defatted		Spray defatted	
		Added fat	No added fat	Added fat	No added fat
Specific gravity	1.01	.99	.99	1.01	1.01
Viscosity (MacMichael degrees)	114	148	149	142	137
Compressibility (mm.)	3.60	3.00	3.60	3.90	3.50
Volume (cc.)	494	519	520	512	504

Table 18

Mean values for subjective scores of fat addition to the forumla to compensate for fat revoval in defatted milk solids.

(Scores range from 1 to 7: 7 is excellent)

Subjective scores	Control (fluid milk)	Dry milk solids			
		Drum defatted		Spray defatted	
		Added fat	No added fat	Added fat	No added fat
Volume	5.0	5.2	5.2	5.7	5.7
Appearance	5.1	5.0	5.1	5.2	5.4
Color, inside	5.8	5.6	5.7	5.6	5.5
Color, outside	5.7	5.8	5.8	5.9	5.8
Flavor	5.6	5.1	5.1	5.6	5.3
Tenderness	5.4	5.5	5.7	5.5	5.4
Texture	4.6	4.2	4.6	4.8	4.6
General conclusion	5.1	5.0	5.2	5.1	5.0