THE COMPARISON OF QUALITY OF PLAIN CAKES PREPARED FROM DRY AND FROZEN MIXES

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THE COMPARISON OF QUALITY OF PLAIN CAKES PREPARED FROM DRY AND FROZEN MIXES

By

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INTRODUCTION

Recent advances in food technology have resulted in the introduction of many new types of products to the retail market. Among these new commodities, baked products in frozen or ready-to-mix form have become increasingly popular.

In the frozen food field, various types of ready-to-bake frozen batters and doughs, as well as the prebaked variety, may be found. Homemakers are interested in frozen pies, doughs, and baked products of all kinds, although their sale has been limited heretofore by a lack of home freezer storage space.

Ready mixes are sold throughout the country, with cake, roll and pie crust mixes the most popular. Last year, there were 38 companies making 72 cake mixes, 20 manufacturers sold a mix for rolls and 45 companies made pie crust mixes. Each month 30 to 40 million baking mixes are sold, quadrupling the sale of three years ago (Paddleford, 47).

The advantages of these commodities to the homemaker are obvious. A quality product at a reasonable cost is the goal of both homemaker and manufacturer. A homemade product without the labor required to produce it is the desire of many homemakers.

Evidence that freezing may be a means of retarding the appearance of aging characteristics in baked products has

been offered. Freezing has been a partial solution to the problem of staling which has long been a matter of economic importance.

Although ready mixes and frozen unbaked and prebaked products are widely used, very little technical data are available concerning the relative qualities of these products. This study was initiated to obtain some information concerning the merits of frozen cakes, cakes prepared from frozen batters, a commercial ready mix and a laboratory ready mix as compared with freshly baked plain cakes. Since there is some evidence of deterioration in the quality of cakes prepared from frozen batters and of frozen cakes, storage tests were included in the study. Costs and preparation times were also recorded for comparative purposes.

REVIEW OF LITERATURE

Frozen Cakes and Batters

History

The freezing of baked products is not new. Midwestern farmer's wives, Alaskans and prospectors have been freezing doughs and pies for many years. In northern latitudes, freezing temperatures were used for preservation of food long before their use was considered for commercial purposes.

More recently, locker renters were among the first to experiment with frozen baked goods, and in 1936 frozen unbaked goods were first marketed commercially in Chicago. However, due to a lack of cabinets the venture failed, to be revived again in 1944 in Illinois. In 1938, United Airlines became interested in keeping pastry dough overnight by placing it at a temperature of 38-40°F. Later, they kept dough in a frozen state 90 days or more in perfect condition (Anon,2). Since then, homemakers and bakers alike have been freezing baked goods of all kinds. This practice has grown tremendously with the increased use of the home freezer.

Baked vs. Batter

Baked products, such as bread and cake, may be frozen as batters or doughs and as baked products. Both methods

have advantages. In the case of batter, it is easier to package; it requires less freezer or locker space; it requires less preparation before freezing, but more after its removal from the freezer; the finished cake seems more moist with a flavor more like that of a freshly mixed and baked cake; the crust is crisp. A frozen baked cake, on the other hand, requires less time to prepare for serving after it is taken from storage, as it only requires thawing; there is less chance of failure. In general, baked cakes are more successful as frozen products than are unbaked batters due to superior keeping quality.

As is the case with so many frozen products, the storage life of frozen batter or of frozen cake is limited. The quality of any frozen product slowly decreases in proportion to the length of storage time. Recommendations vary as to maximum storage times for quality cakes.

	Frozen Batter	Frozen Cake
Dawson (17)	6-8 weeks	-----
Eckblad (21)	-----	4 months
Fenton and Darfler (22)	2-8 weeks	4 months
Graham (25)	2 months	2 months
Hudson (30)	2 months	11 months
Meyer, Buckley, Moore (40)	6 months	9 months
Sunderlin, Collins, Acheson (57)	4 months	-----
Tressler and Evers (61)	2-8 weeks	4 months
Winter, Hustrulid, Anderson (64)	-----	3-4 months

The crust of a fresh bread is dry, crisp and brittle. The crust has hygroscopic properties so that it readily absorbs moisture. As bread ages, moisture from the interior penetrates the crust making it soft and leathery. During

aging, the crust loses some moisture to the atmosphere, especially in relatively dry places. When this moisture evaporation is prevented, by wrapping or by storage at high relative humidities, the staling of the crust is accelerated.

The staling of the crumb is not as easily explained. Crumb staling is characterized by a hardening of the texture. The crumb becomes tougher and more crumbly as bread stales. There is a deterioration in flavor, both in aroma and taste. Alsberg (4) stated that staling of the crumb is a change in flavor and texture that develops with time. The rate at which the changes occur varies with the characteristic observed.

The changes in the crumb during staling are apparently of a physical nature. Cathcart (12) reported that a chemical analysis showed little appreciable difference between fresh and stale breads. Alsberg (4) concluded from the nutritional data available that there was no material difference in the food value or wholesomeness of fresh and stale breads.

Several theories as to the cause of staling in bread have been expressed. Excellent reviews of the theories may be found in the articles by Cathcart (12), Geddes and Bice (24), and Pyler (53).

The deterioration of a baked product with storage has been investigated to a greater extent than of an unbaked product. The changes occurring during the storage of the unbaked frozen products do not resemble those in the baked

frozen product.

The physical changes occurring during the storage of bread and of cake are similar. Much of the research has concerned the changes in bread.

Aging of Baked Products

Bice and Geddes (8) stated "Staleness is a generic term covering a number of ill-defined changes occurring in bread as it ages." Softness of bread appears to be the criterion used as the index of freshness.

The term "staling" includes all the changes that occur in the finished loaf of bread or cake on storage. These changes include volatile losses, oxidative changes and changes in the structure of the crumb.

Much research has been conducted to determine the causes of staling of baked products, especially in the case of bread. Two of the most effective methods of delaying staling are the use of high and of low temperatures. Of the two, the use of low temperatures is more practical (Cathcart, 12).

Bread and cake stale more rapidly than crackers and cookies. Shelf life of the latter is limited by stability of the shortening, the actual staling reactions occurring at an almost imperceptibly slow rate (Pyler, 52). The higher the actual moisture content of a baked product in its initial fresh state, the more pronounced are the changes

occurring in staling.

Temperature and Staling

High temperatures: Hutchinson (32) stated that staling of the crust might be retarded by storing bread in a moderately dry place. However, the staling of the crumb was accelerated by such a procedure. In general practice, the crust is sacrificed for a fresh crumb.

Fuller (23) reported that the staling of the crumb could be retarded by holding the bread at 60°C (140°F) or higher. Bradley (9) reported bread would keep fresh indefinitely at 165°F. Bread staled more rapidly during the first 12 hours.

The chief limitation to the use of heat in preserving the freshness of bread is the practical difficulty involved in preventing the development of bacteria and molds within the crumb. Sporiferous bacteria gave bread a penetrating off-aroma, which was apparent within 12 to 24 hours, rendering the bread unsalable. Katz (34) stated that this difficulty might be overcome by the addition of some acid reacting ingredient.

Another difficulty encountered in high temperature storage is the humidity conditions of the storage cabinet which must be carefully controlled to prevent the crust either from becoming soft and leathery or from drying out.

A third difficulty to this method may be found in the statement by Geddes and Bice (24) that vitamin losses might

become significant, as thiamin losses become greater with increased temperature and moisture during storage.

Cathcart (12) believed that heat as a means of retarding the aging of bread did not seem to offer practical possibilities due to the development of penetrating off-aromas and to the crusty flavor which was generally imparted to the crumb.

Low temperatures: Several investigations (6, 13, 14, 34) have been made concerning the use of low temperatures as a means of retarding the aging of bread. In general, they have concluded that the maximum rate of staling occurred between -2 and -3°C (27°F) and the rate decreased as the temperature was raised or lowered. The lower the temperature, the longer the bread remained in a fresh condition. At -10°C staling was greatly retarded. At -22°C bread remained in a fresh condition for several days. Bradley (9) reported bread remained fresh months at -30°F. It is thought that if the temperature were low enough, bread would never stale.

The chief limitation to this method of retarding staling in baked products is cost.

Aging of Batters

Normally, batters are baked as soon after preparation as possible, but they may be kept in a frozen state for a while. A number of studies (22, 26, 27, 30, 40, 57, 61) have shown that freezing has a deleterious effect on volume, appearance, texture and flavor of cakes baked from frozen

batters. The longer the storage time, the greater the changes.

The cakes produced from the stored batters have small volumes, are apt to have grainy, coarse, heavy or soggy textures with a tendency toward large air holes or tunnels. Poor flavors and appearances have also been reported. The crusts may be hard, smooth and pale. Meyer, Buckley and Moore (40) reported that cakes baked of unthawed batters were more compact, had slightly smaller volumes and were humped rather than rounded in shape when compared to cakes baked of thawed batter.

The changes occurring during storage of cake batters have been attributed to loss of some of the leavening action during the freezing and thawing processes. Hutchings and Evers (31) believed the prolonged exposure of the baking powder with moisture in the frozen cake batters to be the cause of poor products. Tressler and Evers (61) recorded an acrid off-flavor, associated with baking powder reactions, to be more pronounced with longer storage times. Watts, Lehmann, and Goodrich (62) stated that frozen products made with combination baking powder developed off odors more rapidly than those made of pyrophosphate baking powder. Hudson (30) recommended phosphate baking powder for leavening plain cake batter.

Graul (26) related the theory of denaturation to the characteristics observed in the cakes baked from frozen

batters. She reported a tendency for the cakes baked from older batters to shrink from the sides of the pan during baking and cooling. A lack of glaze on the top crusts and a rounded shape were also noted. An increase in moistness of cakes baked from frozen batter stored 8 months was evident. These characteristics resemble those observed in overbeaten batters, and mechanical agitation is one of the ways in which denaturation may be attained.

Tressler and Evers (61) also suggested that denaturation of certain proteins might occur as a result of freezing. That colloidal systems age and become irreversibly changed upon freezing is a well known fact. It seems obvious that aging cannot be separated from such denaturation.

Recommendations for freezing batters and cakes

Colleges, government laboratories and the frozen food industry have been experimenting with the production of frozen cooked and baked products. Their results have been released in the form of recommendations or guides of the "how to do it" type (17, 21, 22, 25, 46, 47, 61, 64).

Rabak (54) asserted that the protective efficiency of a package was a deciding factor in the storage life of frozen foods. Baked products normally have a moisture content of about 20%. Woodroof (66) stated that frozen baked products whether cooked or uncooked gradually lost moisture through desiccation or evaporation. Cathcart (12) listed

packaging as one of the most effective ways of controlling the moisture content of a frozen baked product. This is especially important if the product is to be stored for any length of time. Most studies recommended that all baked goods be sealed in moisture and vapor proof wrappings. Suggested wrappings included moisture-vapor-proof cellophane, pliofilm, latex and aluminum foil, besides the containers used in freezing fruits and vegetables for the frozen batters.

Desiccation is known to occur if large pockets of air are retained inside the package. The internal drying within a package is evidenced by a heavy deposit of frost on the inner surface of the vapor barrier and around the food. The transfer of moisture from the food to the surrounding air has been attributed to fluctuations in storage temperature. Therefore, air space around the product should be reduced to a minimum to prevent excessive dehydration and staling. A solid pack is essential to good keeping quality. Dawson (17) recommended that room be allowed for expansion of the batter during freezing if containers are used in the storing of batter.

Baked frozen products tend to dry out and develop a staleness of flavor more quickly than do similar freshly baked products after thawing. Cakes should be used as soon as possible after thawing.

It is generally recommended that baked products be thawed in the wrapping material as an aid in preventing con-

densation of moisture on the crust and the consequent loss of crispness of the crust. Thawing of batter in the wrapper aids in preventing desiccation and flavor volatilization. Frozen batters should be baked immediately after thawing.

Thawing may be accomplished by any of several methods:

1. at room temperature for several hours
2. in front of a fan
3. in a slow oven (250-300°F) for 20 to 30 minutes
4. in the refrigerator. This method is preferred for thawing a filled or frosted cake. This type of cake is generally not recommended for freezing as the filling or frosting does not always freeze satisfactorily.

Several investigators have reported the need of thawing loaf or cup cake batters completely before baking in order to prevent formation of humps or cracks. These are caused by the setting of the outside of the batter before the center has had time to thaw and expand. If batters are frozen in cartons, they should be transferred to baking tins before they have completely thawed; then allowed to finish thawing in the pan before baking. Layer cakes, because the batter is shallow, may often be baked without thawing.

Ready Mixes

Prepared mixes, no matter how good or bad, give an oven freshness to a product which customers cannot have from a baker's product baked several hours before they are served.

History

Technically, the present pre-mix industry dates to the Civil War and the first blending of baking powder about 1860. The first acid phosphate baking powder was patented in 1864 (Anon, 1). Shortly thereafter, cream of tartar, alum and sodium aluminum sulfate powders appeared (Anon, 1; Holton 29). Since then, homemakers and bakers alike have been combining large batches of dry ingredients for future use in baked products. Self-rising flour was first marketed in 1873. However, it was not until about 1900 that the first commercially successful self-rising flour was produced (Holton, 29). Aunt Jemima Ready Mix for Pancakes, introduced in 1889, became the first nationally distributed ready mix (Paddleford, 47). Ready mixes of various kinds for home consumption came onto the market in the early 1930's (Holton, 29).

As the general trend toward convenience and time saving in the preparation of meals grew, the use of the ready mix was accelerated. Mixes have had a definite development

during war periods. During World War I with a shortage of help, many bakers developed their own mixes. During World War II with many product shortages, such as sugar and fat, and with the improvements made by producers of mixes, many homemakers turned to them as time and point savers. In general, the specific advantages of a ready mix are its keeping qualities at room temperature and its adaptability.

Much research has gone into the commercial development of ready mixes for baked products. Such research has involved studies of rancidity of fats, packaging materials, use of dried milks and eggs, chemical reactions between ingredients during storage, and misuse of the product in the preparation of the final product in the home (Dietrich, 19). Since the product does not leave the factory in the form in which it is consumed, there is need for a large margin of error in the use of a commercial ready mix. Such information was obtained for the benefit of the individual company conducting the research, and very little concerning the results of these studies is available to the general public. A few published papers have brought to the foreground some information about commercial ready mixes which might be applicable to a home prepared mix.

Commercial Ready Mixes

There are two general types of commercial ready mixes. Some are fully prepared and require only the addition of

water. The semi-prepared mixes require shortening, egg, sugar, or spices and other ingredients, in addition to the liquid. In either case, a homogeneous ready-mix is desired. The brands vary in quality of ingredients, manufacturing techniques and packaging materials. Most are a blend of materials naturally in a fairly dry state with the addition of some materials which have been commercially dried.

Usually a plastic fat is mixed with the pre-blended mixture of powdered ingredients. The time of mixing depends on the degree of penetration of fat into the flour particles, and the flow properties desired in the final mix (Holton, 29). However, a dried fat, egg, milk premix may be added to the other dry ingredients. This gives different results than those produced with the addition of shortening in plastic form (Holton, 29).

The baking powder used in most mixes is of the phosphate type (Anon, 3). Calcium acid pyrophosphate baking powder is slow acting a room temperature, while monocalcium acid phosphate acts more rapidly (Marx, 39). Usually, the leavening agent in a commercial ready mix is increased to a percentage above that included in ordinary cake formulas. The leavening agent will usually comprise about 1% of the dry mix formula, flavoring as low as 0.0025% and flour or sugar 30 - 50% (Dietrich, 19). Shortening is usually 10-25% of the total dry mix (Holton, 29).

There are problems with every ready mix. Besides the

formula and actual compounding of a ready mix, shelf life or keeping quality is probably the most important consideration. Biochemical changes occurring during the storage of cake mixes have a serious effect on the baked product (Dietrich, 19; Holton, 29). Ingredients must be compatible from the chemical standpoint. The addition of emulsifiers and antioxidants to shortening has helped to remedy the rancidity problem, prevalent in early (1915) ready mixes (Marx, 39). Much of the trouble encountered in ready mixes has been due to the moisture content. Moisture can be controlled by the avoidance of hygroscopic materials in ready mixes and by packaging. Fat exuded through an inadequate wrapping is apt to become rancid and affect the whole product. Therefore, the wrapping material should be greaseproof.

Laboratory Mixes:

Contrary to the frozen food industry, in which a number of laboratories and homemakers have experimented with the freezing of baked products, the ready mix experimentation has been confined almost entirely to commercial production. Recently, however, Sunderlin and co-workers at Purdue University (36, 58) devised a "master mix" (to be made at home) which can be used for many baked products with slight modifications. In making the mix, the shortening should contain an emulsifier. This emulsifier allows the batter

to take up more sugar and liquid than is ordinarily accomplished in the creaming process (Briewa, 10). For storage at room temperature, a hydrogenated shortening should be used in the ready mix to retard rancidity development.

Sunderlin and co-workers (36, 58) recommended the addition of cream of tartar to the mix. Slightly better results were obtained if the cream of tartar was used in cake mixes. The main difference was in tenderness. Less destruction of thiamine during baking occurred if the reaction was slightly acid. A slightly alkaline reaction in a white cake caused an off-color crumb (Dietrich, 19).

Subjective and Objective Measurements of Cake Quality

Characteristics of a standard cake

Butter cakes are of (a) loaf, layer or cup type, or (b) of the pound type. They should be of good volume; have an evenly browned, level top that is dull rather than shiny; have a fine uniform grain with thin cell walls; have a texture that is soft and resilient, not crumbly or moist, with a light tender crumb; and have a delicate, sweet evenly blended taste (Halliday and Noble, 28; Lowe, 37; Miller and Barnhart, 41; Nason, 42).

Subjective measurements

The ultimate test for any product is its eating quality. The best flavor, texture or eating quality is that which the

public prefers in a given food. Organoleptic tests are conducted to decide how near the standard the unknown sample comes.

The validity of organoleptic tests is based on several fundamental assumptions (Platt, 50).

1. Reaction of the same judge to exactly the same food will continue to be the same throughout the period of the test.

2. Difference between two samples is greater than the difference between successive lots or batches of the same sample.

3. Preferences expressed represent reliable, reproducible decisions and not mere guesses which may easily be reversed.

Organoleptic tests are the only ways in which many important qualities of food products may be expressed. In the laboratory, eating quality or palatability of a product is divided into its component parts. Trained judges are asked to discriminate between samples by noting large and small differences in the various characteristics. These differences are usually rated as to their degree of acceptability. Written records of sensations and impressions are kept. An evaluation of these records is used as a basis for determining the relative quality of a sample.

Organoleptic tests are not sensitive enough for critical evaluations in some cases. In storage tests, characteristics may have to be remembered for a period of time. In order to eliminate the personal factor, much time and thought have been spent on the development of objective tests for use in testing the quality of foods. The results of these tests are correlated with those obtained by organoleptic procedures.

Objective tests of batter

In the case of baked products, means have been devised to measure objectively many of the physical characteristics of both the unbaked and final product. For the unbaked product, viscosity (the resistance of a system to flow) and specific gravity (the ratio of the weight of batter and the weight of an equal volume of water) of a batter are used.

Viscosity: It became evident during the preliminary studies that there were vast differences in the viscosities of the cake batters made from ready mixes and fresh cake batters. The relationship between the batter and its final product has been reported by several people. These investigators reported positive correlations between the viscosities of plain cake batters and cake scores (7, 15, 38, 52). Cake batters having high initial viscosities produce cakes of good volume and crumb texture, whereas those having low

viscosities produce cakes of small volume, coarse grain and harsh rubbery texture.

Viscosity is apparently affected by the extent of mixing as well as variations in formula. Lowe (37) stated that the texture of the finished product varied with this variation in viscosity.

Brody (11) stated that the greatest single factor affecting viscosity of batter was air content. Air content of batters, in turn, was affected by mixing method and time, temperature of ingredients, type of shortening used, proportion of liquid ingredients at each stage, and kind and amount (if any) of syrup used.

Microscopic examinations (Collins, 15) of the batter indicated that in thin batters, there were very few gas bubbles, which were of large size and scattered throughout the batter irregularly. Evidently, the batter was not viscous enough to hold the gas liberated by the baking powder, and the air incorporated in mixing. Thin pouring batters produced inferior cakes. This type batter is associated with oil in water emulsions. In thick batters, the gas bubbles were numerous, small and were either evenly distributed and close together, or in grape-like clusters. Due to their viscous nature, the thick batters allowed less escape of air and gas bubbles.

Specific gravity: The specific gravity is closely related to the amount of air incorporated in a batter or its lightness. Nason (42) reported that very quick methods of mixing in which small amounts of air were incorporated gave inferior cakes. Dunn and White (20) reported a positive correlation between lightness of batter and cake volume. Tinklin and Vail (60) found that low specific gravity batters tended to give cakes which were tender and compressible and were of good volume.

Objective tests of baked cake

Several tests have also been developed to measure some of the physical characteristics of baked products by objective means. That baked products age may be noted in changes in the physical characteristics which occur with time. The aging rate may be indicated by the degree of change in the characteristic measured when compared with the fresh sample. Besides measuring staling rates, the objective test may also compare the properties of baked products prepared under different conditions. Some methods may not give true pictures, since they are subject to uniformity in pore structure of the crumb.

Compressibility: Compressibility of the crumb is a means of determining the tenderness of a fresh product as well as the increasing hardness of a product during staling. Bice and Geddes (8) differentiate between "crumb softness" and "crumb firmness". The former is deformation of the crumb under a constant load and is an indication of freshness. This method is more common than "crumb firmness" which is the load or weight required to produce a given depression and is an indication of aging. A number of types of equipment have been designed to measure the distance through which a crumb can be compressed. Most of the tests operate on the principle of subjecting a bread or cake crumb, usually in the form of a slice of specified thickness, to a specific weight for a given amount of time and observing the amount of compression obtained (5, 16, 44, 51).

In some cases, crumb elasticity may be measured as well in that the amount of recovery in a given period of time may be determined after compression (Nicolayev, 43).

Fuller (23) stated the chief objection to compressibility in determining staling rates was the lack of uniformity in pore structure of the crumb which affected the results without being a staleness factor. A more open grain was apt to be more easily depressed. The greatest change in compressibility occurred during the first 8 hours after baking, at which time subjective tests indicated the bread to be still fresh.

Moisture content: Baked products lose water through evaporation. However, Platt (48) noted that differences between the moisture contents of fresh and stale breads treated in the same manner were exceedingly small. Weiss (63) stated that cakes having high ratios of sugar and shortening were moister than ordinary cakes.

The absorption capacity or the ability of a crumb to imbibe water decreases during staling. This change may be followed by several procedures in which the crumb is pulverized in water and the amount of water held by the crumb measured by volume of sedimentation after the method of Katz (35) or by centrifugation according to the method of Cathcart and Luber (14). The amount of water absorbed by a known weight of baked product might also be determined (Swartz, 59).

Other methods are available in determining the staling rates of baked products, but are not as widely used as those mentioned above. The tests are discussed by Geddes and Bice (24); Cathcart (12), and Pyler (53).

METHODS OF PROCEDURE

Design of Experiment

The quality of loaf cakes prepared from fresh and frozen batter, laboratory and commercial ready mixes, and a thawed cake that had been frozen were compared objectively and subjectively.

The cakes and batters to be frozen were prepared at the beginning of the study in large batches, and frozen in smaller units to be used at each evaluation period. The laboratory ready mix was also prepared and divided into smaller units.

Evaluations as to quality were made after the units had been in storage for 0, 4, 8, 16, and 24 weeks. Five replications were made at each evaluation period.

Two cakes were prepared for each treatment for an evaluation period. One cake was used for the objective tests, the other for subjective. Each cake would cut into eight 1/2 inch slices using a mitre box.

Ingredients

All ingredients, with the exception of the milk and eggs, were obtained at the beginning of the study and were stored at room temperature in the laboratory until needed.

The shortening (a hydrogenated vegetable oil*) and the cake flour ** were stored in their original containers. A new container of each was used at each evaluation period.

A phosphate double-acting baking powder *** was used. Pure vanilla was the flavoring for all cakes with the exception of those made from the commercial ready mix which already contained the flavoring.

The Dairy Industry Department of Michigan State College supplied the fresh milk as needed. Fresh eggs were obtained from the Food and Nutrition Storeroom at each evaluation period and stored in the refrigerator until needed. The eggs for a day's tests were beaten together and then divided to make the day's series as uniform as possible. Both the milk and eggs were removed from the refrigerator approximately two hours before they were to be used in order to allow them to reach room temperature.

The commercial cake ready mix **** was stored in the original cartons at room temperature throughout the study to simulate home conditions.

* Crisco
** Swansdown
*** Rumford
**** Betty Crocker Party Cake Mix

General Procedures

Records

Room, cake batter, and oven temperatures were recorded as well as the relative humidity at the time of scoring the cakes. Records were also kept as to weighing, mixing and baking times and cost of ingredients.

Pans

All cakes were frozen and/or baked in aluminum all-purpose food pans* (pint size). The pans, 4" x 4-1/2" x 1-3/4" at the top, were lined with waxed paper cut to fit the bottom. The pans were equipped with aluminum lids which were used only with the frozen batters.

Baking

A gas oven **, equipped with a thermostat, was employed throughout the series. The cakes were baked at 350°F (176°C) for 35 minutes.

Cooling

After cooling 15 minutes in the pan, right side up on a wire cake rack, the cakes were removed from the pans and were allowed to finish cooling right side up on the same cake rack.

* Reynolds Aluminum Traypak
** Magic Chef

Preliminary Preparations

Frozen Cakes and Batters

Lowe (37) was the source for the plain cake recipe used for the frozen cakes and the frozen batters.

shortening	1/2 cup	112 grams
sugar	1-1/2 cup	300 grams
eggs	2	96 grams
milk	1 cup	244 grams
cake flour	3 cup	300 grams
salt	1/2 t.	2 grams
baking powder		12 grams
vanilla	1 t.	5 c.c.

At the beginning of the study, ten batches were prepared for the frozen cakes or batters. A batch consisted of three times the formula.

The mixing procedure was as follows. The fat and sugar were creamed two minutes with a flat beater on low speed of a mechanical mixer*. The beaten egg was added and mixed one minute. The batter was removed from the mixer, and two-thirds of the milk was added. The batter was then stirred five strokes by hand. All of the flour was added and the batter was stirred for 100 strokes by hand. The batter was replaced on the mixer and mixed one minute at low speed. The remainder of the milk was added and stirred by hand for 50 strokes. For each cake, 200 grams of batter was used.

The batters to be frozen were covered with a moisture-

* Kitchen-Aid

vapor-proof cellophane slightly larger than the pan and fitted snugly in order to decrease the amount of surface exposed to air. An aluminum cover was then fitted to the pan and sealed mechanically. The batters were then frozen and stored.

The batters to be used for frozen cakes were baked, cooled to room temperature and wrapped and sealed in moisture-vapor-proof cellophane. The cakes were then frozen and stored.

Cakes and batters were frozen in circulating air at -20°C and were stored two months at -18°C. They were then removed to a commercial locker plant where they were held the desired additional length of time.

Laboratory Mix

Sunderlin and co-workers at Purdue University developed the formula for the laboratory or "master" mix (36, 58).

cake flour	300 grams
baking powder	14 grams
salt	5.6 grams
cream of tartar	1.4 grams
sugar	14 grams
shortening	119 grams

The formula made four cups or one pound of mix. For this study a single batch consisted of four pounds of mix.

The mixing procedure was as follows: The baking powder, salt, cream of tartar, and sugar were stirred into the flour and sifted together three times. The shortening was cut

into the flour until the consistency resembled corn meal (two minutes at low speed on the mechanical mixer*). The mix was packaged in 340 gram portions in polyethylene bags which were closed as tightly as possible and fastened with a rubber band. The mix was stored at room temperature throughout the study.

Procedures

At each evaluation period, the cakes were baked in the morning from 10 to 12 and were scored at 1:45 in the afternoon. The order in which the cakes were mixed and baked varied each day so that no one cake was allowed consistently to stand longer than the rest.

Fresh cake

A single recipe of plain cake batter (p 27) was prepared at each test period for comparative purposes. The procedure for mixing was as follows: The fat and sugar were creamed two minutes (about 400 strokes) with a wooden spoon until light and fluffy. The sugar was added gradually. The eggs were added and the mixture was beaten one minute (about 150 strokes). Two-thirds of the milk, containing the vanilla, was added and stirred five strokes. All the flour was added and stirred 150 strokes. The remainder of the milk was added and stirred 50 strokes. Each cake contained 200 grams of batter.

* Kitchen Aid

Frozen Batter

The pans containing the frozen batter were removed from the freezer and placed on wire cake racks at room temperature. The batter was allowed to thaw 2 to 2-1/2 hours or until the batter temperature had reached 20°C, at which time the cakes were baked.

Frozen Cake

The frozen cakes were removed from the freezer and allowed to thaw in the cellophane wrappers on wire cake racks for three hours at which time they had reached room temperature.

Cake Made of Laboratory Mix

The formula for the cake was as follows:

mix	340 grams
sugar	250 grams
milk	244 grams
eggs	96 grams
vanilla	5 cc.

The sugar was stirred into the mix. The milk (containing the vanilla) was gradually added to the mix and the batter was beaten three minutes or until smooth (about 450 strokes). The beaten eggs were added and the batter was beaten another minute (about 150 strokes). Each cake contained 200 grams of batter.

Cake Made of Commercial Ready Mix

The commercial ready mix contained, besides the regular dry ingredients and shortening, artificial flavoring and dry milk solids.

mix	1 - 16 ounce package
water	240 grams
eggs	96 grams

The water was gradually added to the mix, and the batter was beaten three minutes until smooth (about 450 strokes). The eggs were added and the batter was beaten another minute. Each pan was filled with 200 grams of batter.

Objective Tests

Viscosity of Batter

The stiffness or resistance to flow of each batter at room temperature was determined. A viscosimeter* was used employing a No. 26 wire, a small cup (3 cm. in diameter). revolving at 20 RPM, and plunger (1 cm. in diameter) and 30 cc. of batter. The reading in degrees MacMichael was taken at 5 seconds. A low reading indicates a thin batter.

Specific Gravity of Batter

The ratio of the weight of a cup of batter (at room temperature) and the weight of an equal volume of water was obtained.

* MacMichael Viscosimeter

$$\text{Specific gravity} = \frac{\text{wt. batter (grams)}}{\text{wt. water (grams)}}$$

A standard measuring cup was filled 1/2 full with batter, tamped 12 times rotating the while and then filled completely and tamped 12 times more. It was then leveled off with a spatula and weighed.

Volume

The volume of each cake was measured by seed displacement.**

Standing Height

The average height of the center cut of cake was obtained by measuring in centimeters the height at both ends, center and between these places, making a total of five measurements.

Compressibility

A penetrometer *** was used to determine the compressibility or tenderness of the cake crumb. Discs of cake one inch in diameter and 1/2 inch thick were compressed 5 seconds by a flat disc 1 inch in diameter carrying a weight of 122 grams. Measurements were made in millimeters. Four readings were averaged for each cake, using the 3rd and 4th slices, two discs from each slice.

** National Manufacturing Company Volumeter
*** New York Testing Laboratory Penetrometer

Moisture Content

The moisture contents of the cakes were determined by drying the cakes at 120°C with forced air circulation in a semi-automatic moisture tester*. Two determinations were made for each cake, using the 3rd and 4th slices. Readings in percent moisture were taken every half hour for two hours or until the moisture change for two successive half-hour readings was 0.05% or less. The moisture content reported was the average of the final readings.

Subjective Tests

The cakes were scored for volume, appearance, color (inside and outside), flavor, texture, tenderness and general conclusions by five judges. The judges were requested to record comments concerning any outstanding features noted. A sample of the score sheet used is shown on page 69 in the appendix.

* Brabender

DISCUSSION OF RESULTS

The quality of a cake might be evaluated by the batter characteristics, palatability scores, results of objective tests, preparation times and cost of ingredients.

For simplification purposes, LRM will be used to designate the cakes prepared from the laboratory ready mix and CRM for those prepared from the commercial ready mix.

Batter Characteristics

There was a tendency for the ready mixes to clump during storage. If these clumps were broken up before the addition of any liquid, the cake was easier to mix. The addition of the liquid to the ready mix was important when the cake was mixed by hand. If too much liquid was added initially, the resultant batter was apt to be lumpy, a condition which was rather difficult to remedy at that point.

Apparently, the commercial ready mix contained a high proportion of a rapid acting baking powder as its leavening agent, as the baking powder reacted very quickly at room temperature. The cakes were baked as soon as possible after mixing and the objective tests on the batter were made as soon as was practicable, in order to prevent undue loss of leavening. The reaction time of the baking powder in the other cake batters was not discernible.

Viscosity

It became evident in the preliminary studies that there were large differences in the viscosities of the batters prepared from ready mixes and the fresh plain cake batter. The differences persisted throughout the study. The viscosity data are summarized in Table I.

The batters of the ready mixes were generally much thinner and did not offer much resistance to movement. This was especially true of the batter from the CRM which gave the lowest viscosimeter reading. The fresh batters were much more viscous and offered greater resistance to movement as shown by their greater viscosity readings.

The lower readings in viscosity of the frozen batters when compared with the fresh batter may be explained by mixing since the frozen batters had been mixed mechanically. Viscosity is affected by extent of mixing as well as formula variations.

A wide variation in viscosity was often encountered even when proportion of ingredients and mixing techniques were standardized. Collins (15) also observed this tendency. Room temperature and/or humidity variations may have influenced the viscosities of the batters and caused the variations between replications. The variations due to treatment were much greater than those due to length of storage as indicated by the differences in F values in

Table I. Viscosities of Batters (Degrees MacMichael)

Storage Time	Fresh	Frozen	LRM	CRM	Average Per Storage Period
0 Weeks					
Range	165-207	122-154	40-62	10-20	
Mean	176	135	50	13	94
4 Weeks					
Range	170-210	137-169	40-80	10-15	
Mean	191	148	57	12	102
8 Weeks					
Range	194-255	158-218	70-95	10-18	
Mean	228	185	80	15	127
16 Weeks					
Range	210-250	147-164	40-92	12-18	
Mean	232	158	58	15	116
24 Weeks					
Range	188-238	125-185	60-85	13-15	
Mean	210	156	65	14	111
Average per Treatment	207	156	62	14	

F Values

Treatment	535 **
Storage	9.14 **
Treatment & Storage	1.8

** Significant at 1% level

Table 1. From the data available, no explanation is offered as to the cause for the variations due to storage time.

Specific Gravity

The specific gravity is closely related to the amount of air incorporated in the batter or its lightness. The more air incorporated in a given batter, the lower the weight of a given volume of that batter, and therefore the lower the specific gravity. Table 2 summarizes the specific gravity data for the various cake batters.

The fresh cake batter had the lowest specific gravity, indicating a lighter batter than the others. The highest specific gravity values were for the ready mix batters. In general, there was an increase in the specific gravity of the batters with increased storage time. This increase for the frozen batter might be explained by a loss of leavening agent during the long storage period.

There was a significant interaction between length of storage and treatment indicating that all the cakes did not respond in the same manner. There is less than one chance in twenty that this was not a real difference.

Some of the variations in specific gravity might be explained by the highly significant negative correlation

Table II. Specific Gravity of Batters

Storage Time	Fresh	Frozen	LRM	CRM	Average Per Storage Period
0 Weeks					
Range	.84-.87	.92-.99	.91-1.00	1.00-1.10	.95
Mean	.85	.95	.92	1.06	
4 Weeks					
Range	.85-.94	.91-.96	.88-1.01	1.09-1.12	
Mean	.88	.93	.94	1.09	.96
8 Weeks					
Range	.86-.91	.97-1.02	.93-.95	1.05-1.10	
Mean	.88	.99	.94	1.07	.97
16 Weeks					
Range	.86-.89	.97-1.02	.93-.97	1.09-1.11	
Mean	.88	1.00	.96	1.10	.98
24 Weeks					
Range	.87-.91	1.01-1.04	.95-1.09	1.09-1.10	
Mean	.90	1.02	1.01	1.09	1.00
Average per Treatment	.88	.98	.95	1.08	

F Values

Treatment	201**
Storage	9.1**
Treatment x Storage	2.37 *

* Significant at 5% level
** Significant at 1% level

coefficient (-0.596) between specific gravity and room temperature. As the room temperature decreased there was a tendency for the specific gravity of the batter to increase. There was no attempt to maintain a constant room temperature.

Palatability Scores

The mean scores of the cakes in each test period are shown in Table 3. The highest rating a cake might receive for a given characteristic is seven, the lowest one. A rating of seven would indicate an excellent product in that characteristic; a rating of one would indicate a very poor product.

Volume

The cake judged as having the greatest volume was that prepared of fresh batter. Good volumes were also reported for the frozen cakes. There was a tendency for these cakes to raise slightly in the middle, which gave a rounded contour to the cake. On the other hand, the cakes prepared from ready mixes were flat, which gave the impression of much smaller volumes.

The most striking differences in volume were noted with the aging of the frozen batter. The cakes baked of thawed batter, that had not been stored an appreciable length of time, corresponded closely in volume scores to those of the fresh

Table III. Mean Palatability Scores

Characteristic	Storage Time	Fresh cake	Frozen cake	Frozen batter cakes	LRM cakes	CRM cakes
Volume	0 weeks	5.4	5.0	5.3	4.7	4.6
	4 weeks	5.8	5.0	5.3	4.7	4.4
	8 weeks	6.2	5.3	4.8	4.9	4.7
	16 weeks	6.1	5.3	3.8	4.9	4.6
	24 weeks	6.2	5.6	4.2	4.9	5.0
Appearance	0 weeks	5.0	4.8	5.2	5.0	5.0
	4 weeks	5.6	4.8	5.2	4.9	4.7
	8 weeks	5.8	4.6	5.1	4.7	4.9
	16 weeks	5.8	4.6	3.8	4.9	4.5
	24 weeks	5.1	4.9	4.0	4.8	5.3
Color Inside	0 weeks	5.4	5.3	5.3	5.7	5.4
	4 weeks	5.4	5.2	5.3	5.6	5.2
	8 weeks	5.7	5.5	5.5	5.6	5.4
	16 weeks	5.6	5.4	5.1	5.5	5.5
	24 weeks	5.4	5.4	5.1	5.4	5.4
Color Outside	0 weeks	5.3	5.2	5.6	5.4	5.7
	4 weeks	5.4	5.2	5.4	4.9	4.8
	8 weeks	5.7	5.3	5.3	5.0	5.3
	16 weeks	5.7	5.3	4.8	5.3	5.4
	24 weeks	5.1	5.7	4.6	5.0	5.3

Table III. (Continued)

Characteristic	Storage Time	Fresh cake	Frozen cake	Frozen batter cakes	LRM cakes	CRM cakes
Flavor	0 weeks	5.2	5.2	5.4	5.3	4.5
	4 weeks	5.7	5.2	5.3	5.4	3.6
	8 weeks	5.9	5.2	5.0	5.3	3.2
	16 weeks	5.7	5.2	4.5	5.2	3.4
	24 weeks	5.4	5.0	4.4	5.2	3.6
Tenderness	0 weeks	6.0	5.8	6.0	5.7	4.5
	4 weeks	5.8	5.3	5.6	5.1	4.0
	8 weeks	6.2	5.9	5.3	5.8	4.1
	16 weeks	6.3	5.5	4.8	5.8	4.1
	24 weeks	6.2	6.0	5.2	6.2	5.1
Texture	0 weeks	4.7	4.4	4.7	5.2	4.7
	4 weeks	5.4	4.3	4.4	5.0	4.3
	8 weeks	5.5	4.4	4.5	5.0	4.3
	16 weeks	5.0	4.4	3.8	5.4	4.1
	24 weeks	5.0	4.4	4.0	5.7	4.6
General Conclusions	0 weeks	5.3	5.0	5.3	5.1	4.5
	4 weeks	5.8	4.8	5.1	5.0	4.0
	8 weeks	5.8	4.9	4.7	5.2	4.0
	16 weeks	5.7	4.7	3.9	5.0	3.8
	24 weeks	5.2	4.9	4.0	5.3	4.5

cakes. As the time of storage increased, the volume scores for the cakes decreased. There was a tendency for the cakes stored 16 to 24 weeks to hump in the center. The higher volume scores at 24 weeks are not explainable.

There was a general over-all shrinking in the size of the frozen cakes with freezing storage. Since the general relationship of height to width was not altered, this tendency is not indicated in the scores for volume.

Appearance

The fresh cake received the highest appearance scores. This cake had a slightly rounded pebbly top that was not shiny. The crust was crisp and yet not hard.

The cake that had been frozen had a smooth, relatively even crust. The crust had softened, lost its crispness and was slightly rubbery.

The frozen batter produced cakes comparable in appearance to the fresh cakes for the first 8 weeks of storage. However, after 16 weeks of storage, the crust was hard, pale and smooth. The general appearance of the cake resembled that of an over-mixed fresh cake.

The appearance of the ready mix cakes were quite different from those of the fresh cakes. The crusts were shiny, pebbly and were at times sticky, and characteristic of an excessive amount of sugar. The crust of the CRM cake was apt to be hard and rubbery.

Color

Although there were slight differences noted in the color of the exterior and interior portions of the cake with the various treatments there was not much difference in the scores for these characteristics. All the cakes were acceptable whether lighter or darker in color.

When the frozen batter had been aged for 16 and 24 weeks, the crusts of the cakes were pale, which explained the slightly lower scores for these cakes. The crusts of the frozen cakes were generally darker than those of the fresh cakes. The ready mixes produced cakes with slightly darker crusts, which might have been due to the higher sugar content in these formulas.

The color of the cake crumb was determined to a large extent by the egg yolks. In general, except for the CRM cakes, the crumbs of the cakes were creamy white. The commercial ready mix produced cakes with a slightly deeper yellow crumb than did the other batters.

Flavor

The cakes made of fresh batter generally received the highest scores for flavor. The LRM cakes closely rivalled the fresh cakes in flavor. The lower flavor score in some cases might be explained by a sugary crust.

On the other hand the CRM cakes received the lowest scores for flavor. The vanilla flavoring was found to be objectionable by several of the judges. The flavor was described as perfumy sweet. One judge suggested the flavor to resemble that of sour milk and soda.

The storage of the cake or batter in the freezer produced little change in the flavor of the cakes except for an increased stale or aged flavor which was noted after 16 and 24 weeks of storage. The pure vanilla flavoring did not produce off-flavors in the frozen batter or frozen cake, such as those reported by Graul (26, 27) with the use of an artificial vanilla flavoring. After 24 weeks of storage, the flavor of the cakes prepared from frozen batters had traces of the baking powder residue. However, only one person commented on that factor.

Tenderness

In general, the cakes were very tender and resilient. The fresh cakes were given the highest scores for tenderness. The frozen cakes were at times described as being too tender since they crumbled readily when handled.

The cakes prepared from frozen batters were tender through the first 8 weeks of storage. After 16 weeks of storage, the cakes were hard and compact, however.

The cakes prepared from the commercial ready mix were the least tender. Also, they were not as resilient as the other cakes, but tended to stick together.

Texture

The texture of the fresh cake was fine grained though uneven and was scored high. The texture of the LRM cake was even, but was not as fine grained as the fresh cake.

The textures of the frozen cakes were moist and soft. They tended to clump and crumble due to their moistness. The texture of the frozen batter cakes closely resembled that of the fresh cake after 8 weeks of storage. After 16 weeks of storage, however, the cake became more compact and hard and closely resembled heavy bread.

The textures of the CRM cakes were more even than those prepared of plain cake batter. However, the texture was coarse grained. The air holes were larger and the walls were thick and coarse. The texture more nearly resembled that of sponge cake than butter cake. The cakes were moist to the touch and it is believed that this factor was the cause of the peculiar crumbling tendency of the interior.

General Conclusions

In general, the cakes prepared of fresh batter were given the highest scores. Cakes prepared of frozen batter

closely resembled the fresh cakes initially. However, as storage time increased, the scores for this cake dropped. The LRM cakes were generally rated second. The frozen cakes were scored down for moistness and lack of crust. The CRM cake was the least liked cake, due principally to its flavor.

Analysis of Variance of Palatability Scores

The data were analyzed for variation due to treatment, time in storage and the interaction between storage and treatment. Analysis for variation due to replication could not be made, since the corresponding replications of all treatments for each storage period were not comparable. These variations were included in the error term. Table 4 gives a summary of this analysis.

The differences attributed to treatment were highly significant for all scoring factors with the exception of the color factors. The scores for color were not analyzed statistically since the differences were so slight (Table 3). The differences attributed to storage were highly significant for flavor, tenderness, texture and general conclusions.

The interactions between storage and treatment were highly significant, indicating a lack of similarity in response of the various treatments to the length of storage.

Table IV. Average Mean Scores and "F" Values

Treatment	Volume	Appearance	Flavor	Tenderness	Texture	General Conclusions
Fresh cake	5.94	5.43	5.64	6.12	5.11	5.55
Frozen cake	5.24	4.73	5.17	5.68	4.38	4.85
Frozen batter cake	4.68	4.66	4.89	5.39	4.28	4.59
LRM cake	4.80	4.86	5.28	5.72	5.26	5.13
CRM cake	4.64	4.87	3.66	4.36	4.41	4.14
Storage						
0 weeks	4.99	5.00	5.20	5.61	4.74	5.03
4 weeks	5.03	5.03	5.02	5.16	4.71	4.93
8 weeks	5.17	5.01	4.92	5.46	4.73	4.93
16 weeks	4.93	4.70	4.80	5.30	4.52	4.61
24 weeks	5.17	4.82	4.70	5.74	4.79	4.79
F Values						
Treatment	28.4**	12.7**	78.1**	65.2**	27.79**	50.8**
Storage	1.54	2.94*	5.22**	7.9 **	1.22	5.0**
T x S	2.93**	4.77**	2.38**	3.23**	2.33**	4.2**

* Significant at the 5% level
** Significant at the 1% level

Objective Test Results

Weight

The mean weights of the various cakes may be found in Table 5. The figures indicate that the baked cakes weighed about the same. However, a statistical analysis of the results revealed that there were differences due to treatment. The cakes that weighed the least were thos prepared from frozen batter.

Volume

The mean volumes of the baked cakes are listed in Table 6. The figures indicate that the largest cakes were those prepared from fresh batter. The volumes of the cakes prepared of ready mixes and the frozen cakes were similar. As the storage time increased, the volume of the cakes prepared of frozen batter decreased. Storage had little if any effect on the frozen cake volumes. The effects of treatment on volume of cakes might be more clearly seen in the standing heights of the cakes as shown in Table 7.

The volume and appearance of cakes prepared of frozen batter were altered as the length of storage increased. As the over-all volume decreased with storage, the contour or shape of the cake also changed. Whereas initially the difference between the end and center measurement of the

Table V. Mean Weights of Baked Cakes

(gms per cake)

Storage Time	Fresh cake	Frozen cake	Frozen batter cake	LRM cake	CRM cake	Average per Storage period
0 weeks	169.8	170.8	167.9	171.0	170.5	170.0
4 weeks	173.0	168.0	165.3	168.9	171.0	169.2
8 weeks	172.9	171.7	166.2	168.6	169.6	169.7
16 weeks	172.1	171.8	166.4	169.9	168.1	169.7
24 weeks	174.4	170.9	169.8	170.5	171.2	171.4
Average per Treatment	172.4	170.6	167.1	169.7	170.1	

F Values

Treatment	9.56**
Storage	1.66

** Significant at 1% level

Table VI. Mean Volumes of Baked Cakes

(c.c. seeds displaced)

Storage Time	Fresh cake	Frozen cake	Frozen batter cake	LRM cake	CRM cake	Average per Storage period
0 weeks	521	457	480	476	468	480
4 weeks	571	478	494	489	489	504
8 weeks	539	475	440	484	491	486
16 weeks	564	469	399	476	465	475
24 weeks	542	473	384	476	483	472
Average per Treatment	547	470	439	480	479	

F Values

Treatment	98.0**
Storage	10.4**
Treatment x Storage	6.79**

** Significant at 1% level

Table VII. Standing Heights of Baked Cakes

(height in cm. of middle slice)

Storage (weeks)	Time (section)	Fresh cake	Frozen cake	Frozen batter cake	LRM cake	CRM cake
0	end	4.3	3.8	4.2	4.1	4.0
	midpoint	5.1	5.0	5.0	4.4	4.5
	center	5.4	5.4	5.3	4.9	4.7
4	end	4.2	3.8	4.0	3.9	3.9
	midpoint	5.3	5.2	5.1	4.6	4.5
	center	5.5	5.3	5.4	4.8	4.9
8	end	4.3	3.9	3.3	4.1	4.0
	midpoint	5.1	4.8	4.7	4.6	4.6
	center	5.3	5.5	5.0	4.8	4.9
16	end	4.2	3.9	3.1	3.8	3.7
	midpoint	5.2	5.1	4.3	4.4	4.3
	center	5.3	5.4	4.8	4.5	4.4
24	end	3.8	3.7	2.8	3.9	3.7
	midpoint	4.8	5.0	4.1	4.4	4.3
	center	5.1	5.3	4.5	4.8	4.6

middle slice of cake varied between 1.1 and 1.3 cm., after 24 weeks at sub-zero temperatures the difference increased to 1.7 cm. indicating an increased tendency toward humping.

Correlation coefficients between the volume scores and the actual volumes as determined by the seed displacement method were calculated. The correlation coefficient of +0.644 for volumes for the frozen batter cakes was highly significant. None of the other correlation coefficients were large enough to be significant statistically (-0.14 for the CRM cakes to +0.351 for fresh cake).

Compressibility

The results of the compressibility tests are summarized in Table 8. The wide ranges within a treatment and storage period were probably due to texture differences rather than to an actual difference in tenderness. If averages alone are considered, we find that the fresh cakes were the most tender.

Freezing rather than length of storage apparently had the greatest effect on the compressibility of the frozen cakes. Length of storage was probably the more important factor in the case of the frozen batter cakes. As the cakes were held for longer lengths of time at sub-zero temperatures, they became more compact and tougher.

Table VIII. Compressibility Test Results on Baked Cakes

(mm. depressed in 5 seconds)

Storage Time	Fresh cake	Frozen cake	Frozen batter cake	LRM cake	CRM cake	Average per Storage period
0 weeks						
Mean	6.37	4.67	5.31	5.26	5.06	5.33
Range	6.2-7.4	3.4-5.3	4.5-5.9	4.2-7.0	4.4-5.7	
4 weeks						
Mean	5.22	3.16	3.91	4.53	3.38	4.04
Range	4.8-5.7	1.5-4.3	2.5-5.6	3.8-5.4	2.9-4.7	
8 weeks						
Mean	4.30	3.23	1.65	3.62	2.83	3.13
Range	3.6-5.4	1.9-4.4	1.1-2.5	2.1-4.5	2.2-4.1	
16 weeks						
Mean	4.58	3.39	1.66	4.25	3.16	3.41
Range	3.2-5.5	1.7-4.8	1.1-2.6	3.6-5.4	2.6-4.3	
24 weeks						
Mean	4.80	3.18	1.01	4.06	3.79	3.36
Range	3.7-6.0	1.7-5.0	0.6-1.7	2.8-5.9	2.6-5.4	
Average per Treatment	5.05	3.55	2.70	4.36	3.64	

F Values

Treatment	25.19**
Storage	25.54**
Treatment x Storage	2.45**

** Significant at 1% level

There were no significant correlations between the penetrometer readings and the scores on tenderness except for the frozen batter cakes which was highly significant (+ 0.688).

The value of the compressibility test as a means of evaluating the tenderness of baked products prepared by different methods is questionable, since the test is greatly influenced by texture differences.

Moisture Contents

The mean moisture contents of the cakes are summarized in Table 9. There was a highly significant difference in the moisture contents between the various cakes. The differences due to length of storage were also highly significant.

The cakes made of commercial ready mixes had the highest moisture contents; the fresh cakes the lowest. The differences in moisture contents of the baked cakes were probably due to the proportions of liquid and dry ingredients in the formulas. The data suggests no explanation as to the variations due to length of storage.

Table IX. Mean Moisture Contents

(% moisture)

Storage Time	Fresh cake	Frozen cake	Frozen batter cake	LRM cake	CRM cake	Average per Storage Period
0 weeks	25.57	27.26	26.37	28.34	30.07	27.52
4 weeks	23.85	25.32	25.07	26.66	28.36	25.85
8 weeks	24.31	26.06	25.19	26.65	28.52	26.14
16 weeks	22.85	25.83	25.66	26.90	27.99	25.85
24 weeks	25.15	25.54	26.05	27.16	29.12	26.60
Average per Treatment	24.35	26.00	25.67	27.14	28.81	

F Values

Treatment	86.52**
Storage	15.12**

** Significant at the 1% level

Preparation

Preparation Time

A summary of the times required to perform the various operations in the preparation of the cakes is shown in Table 10.

Substantial amounts of time were saved by the preparation of large batches of batter which was then frozen in either prebaked or batter form. However, during the thawing period, many minutes were added thereby increasing the total preparation times for these items.

The preparation of the ready mix in the laboratory also reduced the time required to make each cake. The cake that required the least number of minutes to prepare was that made from a commercial ready mix, in which much of the measuring and mixing had been done previously by others.

In both the preparation of the laboratory ready mix and the batter which was frozen in baked or unbaked form, a mechanical mixer was employed. The preparations might be accomplished manually, in which case, the preparation time required to make either cake would be increased considerably.

Cost of Cakes

The cost of the cakes varied, depending on the cost of the ingredients and the amount required per cake. The

Table X. Mean Preparation Times

(minutes per cake)

	Fresh cake	Frozen cake	Frozen batter cake	LRM cake	CRM cake
Preliminary Preparations					
weighing	--	5.2	4.8	3.4	--
mixing	--	5.6	6.0	2.6	--
baking	--	35.0	--	--	--
wrapping	--	5.0	5.0	--	--
Procedures					
weighing	12.2	--	--	4.8	4.0
mixing	12.4	--	--	8.0	7.4
baking	35.0	--	35.0	35.0	35.0
Preparation Time	59.6	50.7	50.8	53.8	46.4
Thawing Time	--	187.0	140.0	--	--
Total Preparation Time	--	237.8	190.8	--	--

average cost of two 8" layers was

fresh cake	39.97 cents
frozen cakes	39.97 cents
cakes made of frozen batter	39.97 cents
cakes of laboratory ready mix	35.76 cents
cakes of commercial ready mix	44.50 cents

A detailed account of the cake costs may be found in the Appendix. The figures listed include only the cost of the actual ingredients used. Since the same formula was employed for the fresh and frozen items, the cost of ingredients is the same. The costs of wrapping the frozen items and of maintaining a low temperature in order to freeze the items and keep them in a frozen state were additional costs which were not included here.

The cake made of the laboratory mix cost less to make when based on ingredient costs. The proportion of dry ingredients to liquid ingredients was much smaller for this cake which accounts for the differences in ingredient costs.

The cakes made of the commercial ready mix were the most expensive.

SUMMARY AND CONCLUSIONS

The quality of plain loaf cakes prepared from dry and frozen mixes were compared. Large batches of the laboratory ready mix and of the cakes and batters which were to be frozen were prepared, and stored in smaller units for 0, 4, 8, 16, 24 weeks. Evaluations of the cakes prepared from the stored units and from fresh batters were made. Five replications in each evaluation period were made.

Objective and subjective techniques for judging the quality of the cakes were used. The cakes were scored subjectively for volume, appearance, color, flavor, tenderness, texture and general conclusions. Objective measurements included viscosity and specific gravity of the batter, and weight, volume, compressibility and moisture content of the cakes. Records were also kept as to preparation times and costs of the various cakes.

There were significant differences in the viscosities and specific gravities of the batters prepared of the various treatments. Those prepared of ready mixes were much thinner than either the fresh or frozen batters. The batter of the commercial ready mix was the thinnest. Variations due to treatment were much greater than those due to length of storage. A highly significant negative correlation between specific gravity and room temperature may explain some of the variations in specific gravity.

The palatability scores for the various treatments showed the fresh cakes to be best for all factors except texture in which the laboratory ready mix cake scored slightly higher. The preferences for the various cakes as indicated by the general conclusion scores, were: fresh batter cake, laboratory ready mix cake, frozen cake, frozen batter cake, and commercial ready mix cake. With increased storage time, scores for the frozen batter cakes dropped -- the greatest decrease occurring at the 16 week evaluation period. Highly significant interactions in the palatability scores between treatment and storage indicate that the cakes did not respond in a similar manner with increased storage. Although color differences were noted among the treatments, the differences in the scores were not significant.

In general, the results of the objective tests agreed with the palatability scores. Greater differences were noted among the treatments than with length of storage. The fresh cake was of larger volume, more easily compressed and lower moisture content than the cakes prepared by the other treatments. The cakes prepared of the ready mixes had good volumes, were not as easily compressed and had the highest moisture contents. The greatest changes with length of storage occurred in the frozen batter cakes. The volumes of the cakes decreased, the crumb became more compact, and there was a tendency for the cakes to hump in the center.

Correlations between palatability scores for volume and volumes as determined by seed displacement tests, and between tenderness scores and compressibility test results were significant for the frozen batter cakes only.

The preparation of the cakes from the commercial ready mix required the least amount of time, but these cakes were the most expensive. The fresh cakes required the most time to prepare. The laboratory ready mix cake was the least expensive to make.

From these results, it appeared that:

1. Fresh batters produced the best quality cakes as determined by subjective and objective evaluation techniques, but required the greatest preparation time.

2. Cakes may be frozen for future use with slight detrimental losses due to freezing.

3. Initially, cakes prepared of frozen batter were similar in all respects to the fresh cake, but as storage time increased there was a sharp decrease in quality, which was especially noticeable after 16 weeks of storage.

4. The laboratory ready mix produced cakes that were slightly inferior to the cakes prepared of fresh batter, and were the least expensive to make.

5. The cakes prepared of a commercial ready mix required the least amount of time and were the most expensive to prepare. Their quality was the poorest of the cakes included in this study.

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APPENDIX

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 XI. Detailed Account of Cake Costs

Unit in Which Purchased	Cost per Unit	Ingredient	Cost per cake* Fresh Amount Required gms.	Fresh Cost	Lab mix Amount Required gms.	Lab mix Cost	Commercial Amount Required gms.	Commercial Cost
2 3/4 lb.	$.38	cake flour	300	.0913	225	.0685		
12 oz.	.22	baking powder	12	.0078	10.5	.0068		
1 1/2 oz.	.16	cream tartar	---	-----	1.05	.0040		
1 lb. 10 oz.	.09	salt	2	.0002	1.3	.0005		
3 lb.	.85	shortening	112	.0699	89	.0555		
5 lb.	.48	sugar	300	.0634	261	.0552		
doz.	.63	eggs	96	.1050	96	.1050	96	.1050
qt.	.14	milk	244	.0350	244	.0350		
4 oz.	.65	vanilla	5 cc	.0271	5 cc.	.0271		
16 oz.	.34	comm. mix						.34
			1069	.3997		.3576		.4450

* Cake costs are based on batter requirements for a two layer 8" cake.

Table XII. Temperature Data at Scoring Periods

Storage Weeks	Mean Room Temperature °F	Mean Relative Humidity %	Mean Batter Temperatures Fresh °C	Frozen °C
0	81	57	22	21
4	78	37	20	19
8	75	35	25	18
16	76	39	20	20
24	72	49	21	19