EFFECT ON THE BATTER AND BAKED PRODUCT OF EXPANDING A STANDARDIZED QUANTITY FORMULA FOR PLAIN CAKE

by

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INTRODUCTION

Production of optimum quality food is an important concern of food service operators. One factor in realizing this goal is a program of standardization, which, according to Miller and Goodenow (1962), is necessary if food costs are to be controlled. Essential to such a program are standardized recipes, in which the quantity and proportion of ingredients and the procedure result in a product of high quality every time (Shugart, 1962). Cranmore (1954b), has defined a standardized recipe as an approved form establishing ingredients, amounts, and procedures, while assuring constant food of high quality with proven acceptability to customers. According to Eliason (1953), functional standardized recipes are extremely important in the production of good food. Operators with awareness have long realized that standardized recipes rate among the most important tools for efficient management of a food service (MacFarlane, 1959). Aldrich (1955), stated that:

> Standardized recipes, if they are truly functional, can be sharp tools for the dietitian just as the well honed scalpel can be the right instrument for a specific purpose for the skilled surgeon.

Many institutional size recipes have not been standardized for use in quantity production. Different methods for expanding these formulas have been used to meet individual needs of large food production centers. As a result, relative proportion of ingredients may be incorrect, mixing times may be too brief or too long, and/or the specified yield may be inaccurate. When enlarging family-size recipes to large quantities, Janssen (1958), stated that changing the manipulation, the ingredients, or the proportion of ingredients may be necessary to assure satisfactory results. Increasing a formula in quantity by haphazard methods is impractical in cost of ingredients and worker time. In order to maintain quality, guidelines are needed that describe expected results of products as recipes are enlarged.

As a preliminary step in developing a formula expansion project (1965), the Department of Institutional Management, Kansas State University, requested information on recipe development from 25 selected directors of food services each serving over 1000 per meal. Through trial and error each food service had developed procedures to fit individual needs. Most directors reported that no guidelines were used. Several stated that doubling or tripling a recipe did not always produce optimum quality. Generally the formula was not tried a second time if quadrupling did not produce a satisfactory product. The need for guidelines was expressed.

With the increasing size of food service operations, the importance of recipe expansion has been emphasized. The purpose of this study was to determine the effect on the batter and baked product of expanding a standardized formula for plain cake from a batch of 50 servings to batches for 100 and 200 servings.

REVIEW OF LITERATURE

Methods of Recipe Expansion

Factor Method. In this method the desired quantity is divided by the known yield to obtain a factor. This factor is multiplied by the weight of each ingredient to determine amounts to produce the desired yield. Although this method is familiar to most, it tempts workers to estimate or guess amounts. Also, since it takes time, workers are apt to be less accurate in order to lessen time (Callahan and Aldrich, 1959).

Percentage Method. In the percentage method described by Callahan and Aldrich (1959), weights of all ingredients are added to determine the total weight, or 100%. The percentage of each ingredient can then be calculated. An advantage of this method is that the percentages can be used for any desired yield. Callahan (1957) further explained that a slide rule device can be used with a portion weight serving chart to calculate the total weight required for any number of servings of a recipe. Finally, a recipe can be scaled for deriving a new yield.

Procedures for Recipe Development

Converting Family-size Recipes for Use in Food Services. Certain recommendations were made by Aldrich (1953b) when family-size recipes were to be converted to yield large quantities. First, she stressed the importance of knowing the ingredients and their amounts, complete procedure for mixing, and baking time and temperature. Next, the recipe should be developed step-wise, reproducing the original recipe successfully, then doubling. Evaluation of quality and needed alterations in the amount of ingredients or methods should be made after each increase. Aldrich and Miller (1963) stated that when the recipe is enlarged to approximately 100 servings, adjustments for handling or cooking losses should be incorporated. Normally, such losses might range from 3 to 5% of the total recipe size.

Aldrich (1953b) recommended calculation of weights and measures in terms of sensible fractions. She suggested listing ingredients in the order of combination. Opposite each ingredient group the directions can be given. It is her belief that probably most family-size recipes can be adapted for quantity use.

Miller and Goodenow (1962) reported a method of recipe development in which a reliable small recipe, serving 10 or less, was selected. The recipe was prepared in the exact manner as for the original formula, recording specifications and weights of ingredients, method of procedure, yield, and losses attributable to cooking. Then the product was evaluated, basing the recipe revisions upon the suggestions. Depending upon the amount of revision necessary, the product was either increased in quantity or prepared in the original amount. As trials continued, suggested revisions were incorporated until a satisfactory product was obtained. After each trial, the product was evaluated again. When the quantity had been enlarged to 20 to 25 servings with a satisfactory resulting quality, the recipe was produced in quantity—the smallest amount wanted on the final formula and sufficiently large to be prepared conveniently with large quantity equipment. In expansion, if the yield was 10% above or below the anticipated yield, or if the quality was unsatisfactory, the recipe was prepared again. If the quantity-size product was satisfactory, the recipe was written in final form.

MacFarlane (1959) listed steps for expanding home-sized recipes. The small-size recipe was prepared and revised, if necessary, to meet standards of quality. The next step was preparation in a larger quantity, proceeding as follows:

1. Preparation methods and ingredients were discussed with an unskilled, untrained worker.
2. The supervisor demonstrated the process to the workers before the day of production if an unusual ingredient, method, or

piece of equipment was involved.

3. The supervisor altered the recipe to the ingredients needed for the larger quantity, a trebled amount.
4. When the recipe was to be increased, the supervisor was present to observe and instruct.
5. A record was kept by the supervisor of the mixing time and speed, baking temperature and time, and other important information for use in the permanent recipe.
6. The product from the increased recipe was evaluated to determine whether it met the standards of the family-size recipe.
7. If a satisfactory product was produced, different workers prepared the trebled amount on their own, comparing results.
8. If the previous products were of the same quality, the next increase was 8 times the original recipe. Evaluation was carefully made on the basis of the quality of the trebled cake.
9. If the expanded products were desirable, the recipe was increased to the maximum yield desired. This recipe was added to the permanent file.

Multiple Preparation of Recipe. An alternate method of obtaining large quantities is to prepare several smaller batches of the same product. In some cases, lack of equipment may necessitate this process. In others, the product may not be produced successfully in larger amounts.

Aldrich (1953b) stated that if, for example, 400 servings of a product could not be prepared successfully, it may be advisable to prepare 2 batches of the product. Handling of large quantities of mixtures containing mainly foams of cream, egg white, or gelatin is especially difficult. Generally, preparation of these in smaller batches is better, rather than risking overmixing and excessive loss of air.

Proportion of Ingredients

According to Janssen (1958), when increasing recipes the proportion of ingredients may need alteration. Cranmore (1954a) stated that usually as the quantity is increased in baking, the liquid is decreased. She cited ingredients that produce different results in expanded recipes, as thickening agents, flavorings, fruits, nuts, leavening agents, herbs, and spices. The explanation for decreasing herbs and spices was that these ingredients emit their flavors at all times that they and the food are in contact.

Aldrich (1953a) agreed with Cranmore (1954a), that thickening agents, flavorings, spices, nuts, fruits, leavening agents, as well as other ingredients produce different results when used in large quantity and small quantity recipes. Generalization about these substances was not recommended in recipe development, since the characteristics in quality of each of these ingredients varies. Instead, changes in the proportion of ingredients should be made on the basis of careful observations.

MacFarlane (1959) reported that one food service executive believes adjustments in the percentage of ingredients are not necessary when expanding a family size recipe to large quantity. She believed that multiplying or dividing any formula, without changing the percentage of ingredients, is all that is necessary.

However, Cranmore (1954a) suggested caution in expanding home-size recipes and stated that:

> Recipe arithmetic can be deadly when used to develop big ones from little ones. Two and two do not always make four. Only occasionally can a recipe amount be multiplied with successful results.

Amount of thickener necessary for cream pie filling when increasing an 8-pie batch to 16-, 24-, and 32-pie quantities was studied by Billings et al. (1952). A 10% increase in flour was necessary for the 16- and 24-pie batches, while an increase of 35% for the 32-pie batch was required. With increase in quantity, heating was slower, final temperature was lower, and cooking time was altered.

Cake Formulas

Success in cake preparation requires attention to 6 factors: (1) a balanced formula, (2) ingredients at proper temperature, (3) accurate weights, (4) control in mixing of ingredients, (5) correct relationship of pan to batter, (6) correct baking temperature and time (Treat and Richards, 1951, p. 547). In expansion of cake formulas, attention should be given to these factors to assure optimum results.

Inaccuracies in weighing or measuring, improper mixing, under- or overcooking, errors in timing, and improper temperatures or seasoning were cited by Shugart (1962) as practices adversely affecting quality and cost.

Formula Balance. Balancing cake formulas, according to Pyler (1952, p. 601), means combining ingredients in such a ratio that a high quality cake is produced, as determined by consumer acceptance. Proper cake formula balance was believed by Pyke and Johnson (1940) to affect economy and quality of the finished product. Coughlin (1947) maintained that every ingredient affected the general qualities of the baked product. With a fundamental change in one ingredient, the proportion of all ingredients must be adjusted.

Rules for balancing of cake recipes which are often given in bakery trade journals were presented by Lowe (1955, p. 488-9). In large quantity production, liquids must be decreased, whereas an increase in liquids is necessary when preparing small cake formulas. Listed below are suggestions for formula balance:

1. Weight of the fat should not exceed one-half the weight of the sugar.
2. Weight of the fat should not exceed the weight of the eggs.
3. Weight of the sugar should not exceed the weight of the flour.
4. Weight of the liquid (milk and eggs, not the weight of dried milk or eggs) should equal the weight of the flour.

Cranmore (1954a), in stressing the importance of formula balance in baking, suggested a guide for standardization of plain cake recipes, stressing the same rules previously enumerated by Lowe (1955).

General rules for balancing formulas for cakes having a high-sugar or high-liquid content were given by Pyler (1952, p. 603).

1. The weight of the sugar should exceed that of the flour.
2. The weight of the eggs should exceed that of the fat.
3. The weight of the liquid in the eggs and milk should equal or exceed slightly the weight of the sugar.

Pyke and Johnson (1940) reported a study in which a basic whole-egg cake recipe, low in sugar, eggs, and liquid was rebalanced in steps, increasing sugar, egg-solids, shortening, and liquid amounts. In this manner the specific volume could be kept in the final batter and cake. As one of these ingredients is increased, the others should be increased proportionately to keep the cake of high quality. They recommended increasing the total amount of water as the sugar content rises. Otherwise the egg proteins and the starch will not gel at the baking temperature if an excess sugar-water ratio exists.

Temperature of Ingredients. Treat and Richards (1951, p. 548) stressed the importance of temperature of ingredients in making cake. The temperature should be uniform, around 70°-75° F.

Hunter *et al*. (1950) varied the temperature of ingredients for cake from 8, to 22, to 30° C. Temperature, mainly by affecting creaming properties and ease of fat dispersion, influenced batter structure and cake tenderness. However, unsatisfactory effects on the quality of cake often attributed to high or low temperatures were not apparent.

Accurate Weights. Inaccurate scales or poor technique in weighing can cause an otherwise satisfactory formula and procedure to cause a failure in the final product. Aldrich (1953a) stated that when a small cake recipe is adapted to institutional size, scales should be checked frequently for accuracy. Inaccuracy in weights may produce a disproportioned mixture, resulting in failure with a perfected recipe.

Mixing of Ingredients. The main purpose of mixing cake ingredients, according to Pyler (1952, p. 609), is to produce a uniformly dispersed mixture of ingredients with a maximum incorporation of air and minimum gluten development in the flour.

Griswold (1962, p. 409) stressed the importance of mixing when she said:

> There are few foods for which the method of combining the ingredients is so important for success as it is for cakes, or for which small deviations from a recommended method can lead to such dismal failures.

According to the type of cake, however, mixing procedures will vary in the order of adding ingredients, the mixing time and rate, temperature of ingredients, and other factors (Pyler, 1952, p. 609).

Using a plain cake formula, optimum mixing depends upon 6 factors, as given by Lowe (1955, p. 477, 480). These include: (1) completeness of creaming, (2) speed of mixing, (3) temperature of ingredients, (4) type of baking powder, (5) amount of baking powder, and (6) time for adding baking powder. When a sulfate-phosphate powder is used, Lowe stated that 250-300 strokes are required to obtain optimum texture. Plain cake, when mixed until the ingredients were combined but not blended until smooth, was almost level or slightly rounded. The top was well-browned, rough, and had crust with a significant amount of glaze. With increased mixing, the crust did not brown as well, was less rough, had less glaze, and was more rounded on top.

Miller and Allen (1918) determined that there is an optimum amount of beating of cake batter which produces the most desirable product, a cake of fine texture without tunnels. A family-size cake recipe was prepared by the "cake-mixer" method, stirring only enough to mix ingredients. The batter was divided into 5 equal portions by weight and treated as follows: one portion was baked without stirring, while the remaining 4 portions were beaten 1, 2, 5, or 10 min before baking. The optimum time for beating a family-size cake recipe was from 1 to 2 min per recipe, according to how vigorously the beating was done.

In a study reported by Davies (1937), conclusions were drawn regarding the effect of procedure variables upon the quality of small quantity plain whole-egg cakes. Mixing times varied from 3, to 6, to 9 min. A mixing time of 3 min was found to be insufficient for plain whole-egg cake, giving a product that was coarse and somewhat harsh. Nine min mixing time was too long, producing a cake of close texture that was somewhat tough.

Aldrich (1953a) noted that mixing time and speeds should be adapted so that a comparable product could be produced at the various mixing stages for the larger quantity. Results may differ in mixing a batter for 3 min on high speed using a home mixer and mixing 3 min on third speed of a 60 qt mixer. Lowe (1955, p. 477) stated that overbeating beyond the optimum, 300 to 400 strokes, with 150 g of final batter, produces a dull, smooth crust. The top tends to peak, and small holes are sometimes noticeable. With extreme overmixing, 1000 strokes, the top may be level or only slightly rounded, is dull and smooth with a practically white color. When a sulfate-phosphate baking powder is used, the crust of the cake changes as mixing increases. However, the change is not as rapid as for cakes having phosphate or tartrate baking powder.

The amount of mixing affects the characteristics of the final product. Overmixing causes a decrease in volume in relation to the amount of overmixing. In addition, Lowe (1955, p. 480) said that with the same proportion of ingredients the texture of the crust varied with different amounts of mixing.

Mixing time affects the amount of baking powder necessary. Griswold (1962, p. 343) reported data indicating a relationship between the level of baking powder and the mixing method. In a study employing the conventional sponge method, the suggested level of baking powder per cup of flour was 1 tsp, while the pastry-blend method study suggested using 1½ tsp of baking powder per cup of flour. With all three conventional cakes, the level of SAS-phosphate baking powder increased nearly one-fourth when using the faster-acting tartrate and phosphate baking powders. However, since these studies were done by different investigators, the comparative amounts of these 3 baking powders may not necessarily depend on the method of mixing.

Relationship Between Pan and Batter. Cake quality is affected by the size, shape, and material of the baking pan, the manner of filling the pan, and the baking temperature (Griswold, 1962, p. 426). When baked in a shallow or a long, wide pan, cakes are flatter, as compared with narrow, short pans. Also, pans having straight sides produce a cake of better texture (Janssen, 1953).

According to Lowe (p. 460), batter depth affects the texture of the cake. She recommended a depth of at least 1 to 1½ in. for batter, which produces a fine and velvety texture. Janssen (1953) stated that a batter depth of at least 1 to 1½ in. results in cakes with finer grain and texture than when less batter is used. When pans are over-filled, cakes tend to have rounded, split tops.

Davies (1937) studied the quantity of batter placed in a 7-in. round layer pan. With 250 g of batter, the color and grain of the baked product were satisfactory, but the volume was decreased from optimum, resembling improperly leavened cake. Three hundred fifty grams of batter was an excess amount. The best texture and grain were produced with 300 g of batter.

According to Pyler (1952, p. 613) the batter should be panned and baked as soon as possible after mixing. When the baking powder ingredients have gone into solution, they start reacting and evolving carbon dioxide gas. The carbon dioxide escapes from the batter, causing the cell structure to coarsen when a batter mixture remains out of the oven too long.

Nobel (1925) reported an investigation in which a tartrate, a phosphate (monocalcium), and two alum-phosphate baking powders were used in standard cake mixtures. The cake's quality was unharmed when batter made with any of the baking powders remained at a room temperature of 79° F. for 3 hrs and at ice-box temperature over night before baking.

Regarding the type of baking powder to use in cake baking, Griswold (1962, p. 340) stressed the importance of carbon dioxide release prior to crust formation during baking, since a too slow gas release produces cracks. In a fast-acting baking powder, there is less chance of crack formation during baking. A slow-acting baking powder or a high oven temperature result in excess rising after the crust forms, developing a crack.

Baking Temperature and Time. For each cake formula there is an optimum rate of baking (Lowe, 1955, p. 461). The oven temperature and the length of baking determine the speed of baking.

Pyler (1952, p. 613) stated that optimum baking temperature varies considerably, depending on such factors as richness of the batter, size of the pan, and moisture content of the batter. Oven temperature is affected by the type of heat, insulation, and oven load, according to Bailey and Le Clerc (1935).

Specific temperatures have been suggested for baking certain types of cakes. Batters having a high sugar content require low baking temperatures from 325-350^{o} F. Low sugar ratio cakes may be baked at temperatures from 350-400^{o} F. In a study reported by Davies (1937) a baking temperature of 325^{o} F. was too low, while 425^{o} F. was too high for a small quantity plain whole-egg cake of desirable quality. However, with the lower baking temperature, the results were better and more consistent than with higher temperatures. At 325^{o} F., the longer baking time produced a drier cake than desirable.

Cakes baked at higher temperatures have more rounded tops, less shrinkage from the sides of the pan, and an increase in volume in cakes with a high-sugar content (Janssen, 1953). Griswold (1962, p. 427) reported that with too high a temperature, crust formation occurs before the cake has fully risen. A hump or crack forms due to the rising soft batter in the center of the cake.

With too low a baking temperature, protein coagulation and starch gelatinization are slow, while gas is lost from the batter. With loss of gas from some cells, the remaining cells increase in size, have thicker walls, cake volume diminishes, and the baked product may settle in the center. With too high a temperature, crust formation occurs before the cake has fully risen. A hump or crack forms due to the rising soft batter in the center of the cake (Griswold, 1962, p. 427).

As the temperature of baking increases, the baking time decreases. The importance of keeping time of baking at a minimum was stressed by Pyler (1952, p. 614) in order to maintain as much moisture as possible in the cake.

EXPERIMENTAL PROCEDURE

Formula

A quantity formula for plain cake, originally from the recipe by Fowler and West (1950, p. 109), and adapted by Hurley (1958, p. 30) was used as a basis for this study. The recipe for a 12 x 20 x 2-in. pan, for approximately 50 portions, was designated as the control, formula I. This recipe was doubled for formula II and quadrupled for formula III. The dough-batter method of mixing was used for all 3 formulas, and procedures used were adapted from Hurley (1958). In preliminary work, cakes were prepared until uniform products were obtained with all 3 formulas. The formulas and method are shown in Table 1.

Schedule of Experimental Activity

The experiment consisted of 10 baking periods during which a control (formula I) and formulas II and III were prepared and baked. Objective evaluation was made on the batters and baked products, and organoleptic evaluation was made on the baked cakes by a panel of 7.

Procurement and Storage of Ingredients

Ingredients were obtained at the beginning of the study, and, with the exception of the eggs, were stored in covered containers in the laboratory at room temperature. Frozen whole eggs were stored in a walk-in freezer at approximately -10° F. Two days prior to baking, they were placed in a walk-in refrigerator at approximately 36°-38° F. to thaw.

Weighing of Ingredients

All ingredients except eggs were weighed the day prior to baking and stored in the laboratory at room temperature. Flour, nonfat dry milk,

Table 1. Formula for plain cake.

Ingredients	Formula I	Formula II	Formula III	Procedure
Flour, Cake, g	709	1418	2836	Place ingredients in center of bowl in order listed. Mix 2 min in mixer bowl (low speed). Scrape down bowl 6 strokes and beater 8 strokes. Mix 3 min more.
Baking Powder, Double-acting, g	27	54	108	
Dry Milk, Nonfat, g	72	144	288	
Shortening, Hydrogenated, Vegetable, g	284	568	1136	
Sugar, g	850	1700	3400	Mix 2 min (low speed). Scrape down bowl and beater. Mix 3 min more.
Salt, g	7	14	28	
Water, g	262.5	525	1050	
Eggs, whole, frozen, g	243	486	972	Divide each ingredient by weight and add each half in separate containers. Add one portion of egg-liquid mixture; mix 30 sec. Scrape bowl and beater, 8 strokes each. Mix 1 min. Add second egg-liquid mixture, then mix 1 min. Scrape bowl and beater 8 times each. Mix 2½ min.
Water, g	350	700	1400	
Vanilla, g	15	30	60	
				Pour into 12 x 20 x 2-in. wax paper lined pan.
				Bake 43 min at 350° F.

and sugar were placed in paper bags, which were folded and stapled. Salt and baking powder were placed in plastic bags that were securely fastened with wire. Water, the water-vanilla mixture, and shortening were stored in 1-pt, 1-qt, and ½-gal. square plastic freezer containers. Shortening was scaled onto wax paper and placed in plastic containers.

Eggs were weighed on the day of mixing. The water-vanilla mixture was added to the eggs, mixed, and divided into 2 containers.

Mixing the Batter

Ingredients were mixed on a Hobart 30 qt mixer with flat beater. A flexible, 10-in., steel blade spatula was used to scrape down the sides and bottom of the bowl with 6 or 8 strokes. A scrape consisted of one circular motion around the bowl or one scrape straight across the bottom of the bowl. In addition, 8 strokes were needed to scrape down the beater during the mixing process. Each flat side of the beater was scraped with a single stroke of the spatula. Six strokes with a rubber scraper removed batter from the narrow sides and between the ribs of the beater. One scraper was used to clean the other.

Flour, baking powder, dry milk, and shortening were placed, in that order, in the mixing bowl. Shortening was cut into 6 pieces for formula I, 12 pieces for formula II, and 24 pieces for formula III. A rubber scraper was used to remove shortening from the waxed paper. The ingredients were mixed for 2 min before stopping the mixer, lowering the mixing bowl, and scraping the bowl 6 strokes and the beater 8 strokes. This procedure was repeated after each mixing time. The bowl was raised and mixing continued for 3 min.

Next, sugar, salt, and water were added, in that order. Mixing was resumed for 2 min, after which the scrape-down procedure was repeated. The mixture was blended 3 min.

Half of the egg-water-vanilla mixture was added, then mixed 30 sec, and scraped down, using 8 strokes for both bowl and beater. Mixing was resumed for 1 min more. The remaining egg-liquid mixture was added and the batter mixed 1 min before again scraping the bowl and beater 8 strokes each. The batter was mixed 2½ min. The bowl was lowered and removed from the mixer. During the final 2½ min of mixing, the oven temperature was checked.

Evaluation of the Batter

Temperature. After mixing, a centigrade thermometer was placed in the bowl of batter and read after 2 min.

Consistency. Consistency was determined by the funnel test and line-spread technique. In the former, the time necessary for a tablespoon of batter to flow between 2 marks in the stem of a glass funnel was recorded. The funnel was rinsed in tap water and shaken 5 times before batter was added.

In the line-spread technique, a cardboard with concentric lines 1/8 in. apart was placed beneath glass. A metal cup with a volume of 34 ml, about the circumference of the smallest concentric line, was placed on top of the glass. The ring was leveled with batter using a steel spatula. The batter flowed 1 min after the ring was removed. The spread was determined in 4 positions, then the values averaged to determine the consistency of the batter.

Panning and Baking the Batter

Batter (2100 g) was scaled into a 12 x 20 x 2-in., wax paper lined, weighed baking pan. A rubber scraper was used to level batter.

Cakes from each formula were baked separately in a reel gas oven consisting of 4 shelves. Cakes were baked for 43 min at 350° F. One cake was baked from each formula with the exception of the quadrupled formula. For this formula, batter was weighed into 4 pans, but only the first and last pans were baked.

Evaluating the Baked Cake

The cakes were removed from the oven and placed on wire racks without removal from the baking pans. In approximately 2 hours, an 8 x 8-in. section was cut from the center of each cake, using a cardboard cutting frame as a guide. This square section was placed in a wooden mitre box for cutting 4 slices of 1-in. width. The strips were placed on paper in the order cut, top crusts to the back.

Standing Height. The first 3 slices cut were used to determine the standing height (Fig. 1). After tracing around the edges of each slice, the height was measured 2 in. from each end, and in the center, and averaged to find standing height of the slice. The average value for the 3 slices was the standing height of the 8-in. square.

Index to Volume. A tracing was made around the edges of the fourth slice, and the area of the slice was measured in sq in. with a compensating polar planimeter. The area of this slice served as an index to the volume of the cake.

Organoleptic Evaluation. A committee of 7 students evaluated external and internal characteristics of cake samples using a rating scale ranging from 1, unacceptable, to 5, excellent (Appendix, p. 38).

Seven samples were cut from each cake (Fig. 2). The samples from

EXPLANATION OF FIG. 1 AND 2

Eight-inch Square Cut from the Center of the Cake

Fig. 1. Positions 1, 2, and 3 represent location of samples for measuring standing height. Position 4 represents location of sample for determining area of square.

Fig. 2. Positions 1, 2, 3, 4, 5, 6, and 7 represent location of samples for palatability panel. Position 8 represents location of 8 x 4-in. piece for evaluation of external appearance by the palatability panel.

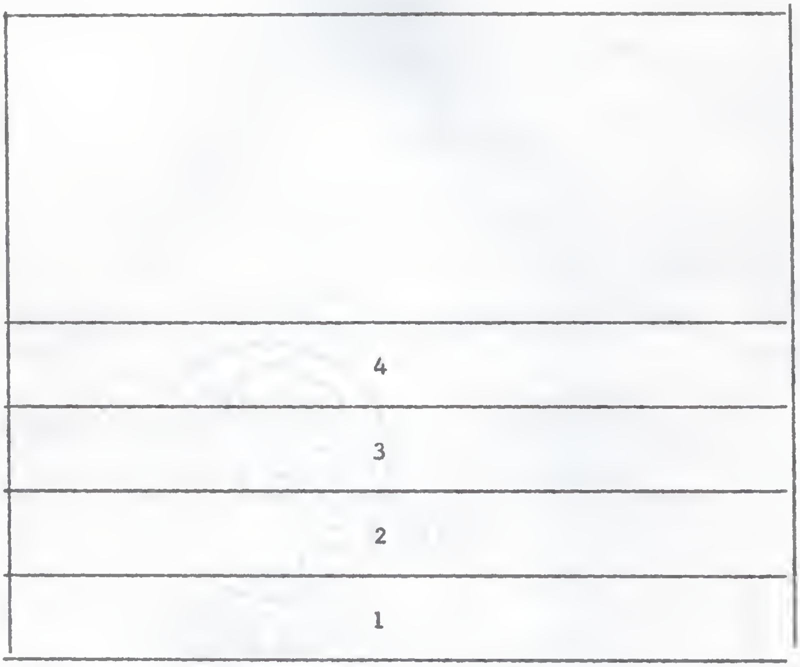

Fig. 1

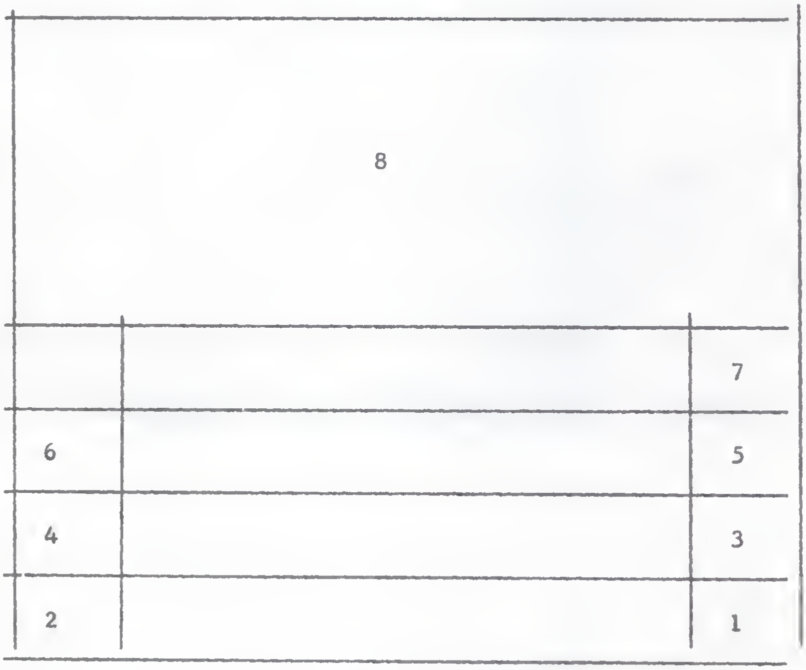

Fig. 2

each of the 4 cakes were placed on white china plates and were labeled A, B, C, and D.

Statistical Analysis

An analysis of variance was run on the data for each factor used to evaluate the batter and cake (Appendix, pp. 33-37). If the F-test was significant, Least Significant Differences were calculated at the 5% level.

RESULTS AND DISCUSSION

With increased expansion of Formula 1, manipulation during scraping became more difficult. This was more noticeable when liquid had been added.

Consistency of the batter was measured by the funnel and line-spread tests. Higher values in the funnel test denoted thicker batters, while the higher the values in the line-spread test, the thinner the batter. Batter temperatures were recorded (Table 4, Appendix, p. 31), but were not included in the statistical analyses.

Consistency of the batter, as measured by line-spread, was the only factor where significant differences attributable to formula occurred. Average data for objective measurements of batter and baked cake and organoleptic scores for the cakes are in Tables 2 and 3, respectively. Complete data are in Tables 4 and 5 (Appendix, pp. 31, 32).

Observations revealed little, if any variation in shape or surface qualities among the cakes baked for this study. In general, they tended to be symmetrical, slightly rounded, without cracks or peaks. Crusts were tender, with a minimum amount of stickiness, and uniform in

Table 2. Effect of recipe expansion on consistency of batter and volume of the baked cake.

Treatment	Batter consistency		Index to cake volume	
	Funnel test (min)	Line-spread test[a]	Area of square (sq in)	Standing height (cm)
I Control	0.73	3.5	12.88	4.1
II Doubled	1.28	3.0	12.98	4.1
III Quadrupled	1.13	2.9	12.85	4.1
		LSD=0.2615		

[a]Average no. 1/8 in. units spread in 1 min.

LSD=least significant difference at the 5% level.

Table 3. Judges' scores for the baked cake.[a]

Treatment	Shape	Surface	Tenderness	Crumb color	Flavor
I Control	3.7	3.7	3.7	4.0	3.9
II Doubled	3.9	3.7	3.9	4.1	4.0
III Quadrupled	3.9	3.8	4.0	4.1	4.0

[a]Range, 5 (excellent)--1 (unacceptable).

thickness. While crust color was a golden brown, internal crumb color was uniform and even.

Judges were instructed to assign a score of 4 if the cake met quality standards enumerated on the score card (Appendix, p. 38). Average scores for appearance and palatability factors indicate that a high quality cake resulted from all 3 formulas. Based on the conditions of this study, a standardized plain cake formula for 50 portions apparently can be quadrupled without appreciable change in quality.

There were significant differences among replications for only 3 of all factors measured either objectively or subjectively. These were line-spread, appearance of surface, and color of crumb values.

SUMMARY

A plain cake formula for approximately 50 portions was prepared in single, double, and quadruple amounts to determine the effect of recipe expansion on batter and baked product. The control formula, for a 12 x 20 x 2-in. pan, was designated as formula I. It was doubled for formula II, and quadrupled for formula III. To standardize techniques cakes were prepared and baked preliminary to the reported study until a uniform product was developed. Formulas I, II, and III were prepared in each of 10 baking periods.

Ingredients were weighed and stored at room temperature the day before baking, except for frozen eggs, which were refrigerated at approximately 36°-38° F. 2 days before. After controlled mixing procedures, 2100 g of batter were weighed into a 12 x 20 x 2-in. pan and baked in a reel oven at 350° F. for 43 min.

After mixing, consistency of batters was measured by the funnel and line-spread techniques. Sections of cakes were rated by a panel of 7 judges for external and internal factors. Volume was measured by standing height and area of the square determinations.

No significant differences were indicated among the treatments for consistency of batter, baked cake volume, shape, appearance of surface, internal color, tenderness, and flavor. Line-spread values were significant at the 0.05 level. Significant differences at the 0.05 level among replications included line-spread, appearance of surface, and color of crumb values.

Observations revealed little, if any, variation in shape or surface qualities among the cakes. In general, they tended to be symmetrical, slightly rounded, without peaks or cracks. Crusts were tender, with a minimum amount of stickiness, and of uniform thickness. Crust color was a golden brown, while internal crumb color was uniform and even.

Average judges' scores for appearance and palatability factors indicated that a high quality cake resulted from all 3 formulas. Based on the conditions of this study, a standardized plain cake formula for 50 portions apparently can be quadrupled without appreciable change in quality.

RECOMMENDATIONS FOR FURTHER WORK

The present study is the first in a series to develop guidelines for quantifying recipes. Before further expansion of the plain cake recipe, an evaluation of the mixing method is needed. Although the formula produces cakes of good quality, the procedure is complicated. Therefore, in further study, simplification of the original procedure is suggested.

Recipe expansion should not exceed quantities impractical for mixers generally found in institutions. Mixers of 60 or 80 qt size are normally the largest used in a food service. Also, manipulation of the scraping process becomes more difficult as amounts are increased.

Further work should include other types of cakes, such as chocolate or spice cake. It is recommended that only one test for consistency be used. Either one will give satisfactory results.

ACKNOWLEDGMENTS

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APPENDIX

Table 4. Measurements of batter temperature and consistency and cake volume.

		Batter			Cake	
Replication	Formula	Temperature (° C)	Funnel test (min)	Line spread[a]	Area of square (sq in)	Standing height (cm)
1	I	20.0	0.50	3.6	13.23	4.15
	II	20.0	1.50	3.3	13.13	4.29
	III	19.0	0.50	3.1	12.81	3.79
2	I	20.5	0.75	3.4	13.36	4.15
	II	19.0	1.50	2.8	12.79	4.37
	III	18.5	2.25	2.6	13.27	4.21
3	I	20.0	2.00	3.0	12.95	4.09
	II	19.0	0.75	3.3	13.32	4.29
	III	19.5	1.25	2.4	12.86	4.28
4	I	20.5	0.75	3.5	12.22	3.89
	II	20.0	1.25	2.6	13.06	4.17
	III	19.0	0.75	2.8	12.92	4.17
5	I	20.0	1.00	2.9	12.85	4.21
	II	22.0	2.00	2.5	12.81	4.09
	III	20.5	0.75	2.6	12.39	3.96
6	I	19.0	0.50	3.5	13.11	4.22
	II	22.0	2.00	2.4	13.20	4.09
	III	21.0	1.50	2.5	13.04	4.13
7	I	20.0	1.00	2.8	12.72	4.23
	II	21.5	1.75	3.3	12.53	4.01
	III	20.0	1.00	3.0	12.71	4.04
8	I	19.5	0.25	4.4	12.09	3.83
	II	26.5	0.75	2.9	13.11	4.01
	III	25.0	1.00	3.5	12.97	4.05
9	I	25.0	0.25	3.9	13.17	4.01
	II	26.0	0.50	3.3	12.94	4.06
	III	26.0	0.50	3.9	13.14	4.03
10	I	20.0	0.25	3.5	13.09	4.05
	II	22.0	0.75	3.5	12.91	3.88
	III	21.0	1.75	3.0	12.34	4.01

[a]Average no. 1/8 in. units spread in 1 min.

Table 5. Average panel scores for shape, surface, tenderness, color of crumb, and flavor. Highest possible score: Excellent--5.

Replication	Formula	Shape	Surface	Tenderness	Color	Flavor
1	I	4.0	3.7	3.8	4.0	4.2
	II	3.8	3.7	3.7	4.2	4.0
	III	3.3	3.6	3.9	4.2	3.9
2	I	4.1	3.4	3.7	4.3	3.6
	II	3.4	3.3	3.4	4.4	3.7
	III	4.1	3.4	3.9	4.3	4.1
3	I	3.9	3.9	3.9	4.0	4.1
	II	4.0	3.9	3.7	4.1	4.1
	III	3.7	4.2	4.1	4.0	4.2
4	I	4.5	4.0	3.7	4.0	4.0
	II	4.0	3.5	4.2	4.2	4.0
	III	4.2	4.2	4.2	4.2	4.0
5	I	3.1	3.3	3.7	4.1	3.4
	II	4.3	3.7	4.1	4.3	4.0
	III	4.1	3.8	4.3	4.1	3.9
6	I	3.5	3.3	3.8	4.0	3.8
	II	4.2	3.7	4.2	4.0	3.8
	III	3.5	3.5	4.1	4.2	3.9
7	I	3.3	3.8	3.2	3.8	3.7
	II	3.2	4.0	3.8	3.8	3.8
	III	4.3	3.9	3.9	4.1	3.9
8	I	3.4	3.9	3.4	4.0	3.7
	II	4.3	3.7	4.0	4.0	4.0
	III	3.8	3.8	3.8	4.1	3.8
9	I	3.7	4.0	4.0	4.2	3.8
	II	3.2	3.5	3.7	4.2	4.2
	III	4.0	4.2	3.8	4.1	3.9
10	I	3.5	3.7	4.0	4.0	4.2
	II	4.2	4.0	4.0	4.0	4.2
	III	3.7	3.8	3.6	4.0	4.0

Table 6. Analysis of variance for the funnel test.

Source of variation	DF	s.s.	m.s.	F
Replications	9	3.2187	0.3576	1.2748 ns
Treatment	2	1.6166	0.8083	2.8816 ns
Error	18	5.0500	0.2805	
Total	29	9.8853		

Critical values:

$F_{0.05}$ (9,18) = 2.46 ns = nonsignificant

$F_{0.05}$ (2,18) = 3.55

Table 7. Analysis of variance for line-spread test.

Source of variation	DF	s.s.	m.s.	F
Replications	9	3.2386	.3598	2.8669*
Treatment	2	1.5806	.7903	6.2972*
Error	18	2.2593	.1255	
Total	29	7.0785		

Critical values:

$F_{0.05}$ (9,18) = 2.46

$F_{0.05}$ (2,18) = 3.55

*Significant at the 5% level

Table 8. Analysis of variance for area of the square.

Source of variation	DF	s.s.	m.s.	F
Replications	9	1.0932	0.1214	1.19840 ns
Treatment	2	0.0986	0.0493	0.48667 ns
Error	18	1.8243	0.1013	
Total	29	3.0161		

Critical values:

$F_{0.05}$ (9,18) = 2.46

$F_{0.05}$ (2,18) = 3.55

Table 9. Analysis of variance for standing height.

Source of variation	DF	s.s.	m.s.	F
Replications	9	0.2259	0.0251	1.3648 ns
Treatment	2	0.0186	0.0093	0.5062 ns
Error	18	0.3311	0.0183	
Total	29	0.5756		

Critical values:

$F_{0.05}$ (9,18) = 2.46

$F_{0.05}$ (2,18) = 3.55

Table 10. Analysis of variance for shape.

Source of variation	DF	s.s.	m.s.	F
Replications	9	0.8403	0.0933	0.4852 ns
Treatment	2	0.1820	0.0910	0.4729 ns
Error	18	3.4646	0.1924	
Total	29	4.4870		

Critical values:

$F_{0.05}$ (9,18) = 2.46

$F_{0.05}$ (2,18) = 3.55

Table 11. Analysis of variance for surface.

Source of variation	DF	s.s.	m.s.	F
Replications	9	1.1346	0.1260	2.9480*
Treatment	2	0.1306	0.0653	1.5285 ns
Error	18	0.7693	0.0427	
Total	29	2.0345		

Critical values:

$F_{0.05}$ (9,18) = 2.46

$F_{0.05}$ (2,18) = 3.55

Table 12. Analysis of variance for tenderness.

Source of variation	DF	s.s.	m.s.	F
Replications	9	0.6013	0.0668	1.2092 ns
Treatment	2	0.2986	0.1493	2.7022 ns
Error	18	0.9946	0.0552	
Total	29	1.8945		

Critical values:

$F_{0.05}$ (9,18) = 2.46

$F_{0.05}$ (2,18) = 3.55

Table 13. Analysis of variance for color of crumb.

Source of variation	DF	s.s.	m.s.	F
Replications	9	0.3763	0.0418	5.2021*
Treatment	2	0.0486	0.0243	3.0137 ns
Error	18	0.1446	0.0080	
Total	29	0.5695		

Critical values:

$F_{0.05}$ (9,18) = 2.46

$F_{0.05}$ (2,18) = 3.55

Table 14. Analysis of variance for flavor.

Source of variation	DF	s.s.	m.s.	F
Replications	9	0.5363	0.0595	2.1956 ns
Treatment	2	0.0980	0.0490	1.8054 ns
Error	18	0.4886	0.0271	
Total	29	1.1229		

Critical values:

$F_{0.05}$ (9,18) = 2.46

$F_{0.05}$ (2,18) = 3.55

Name ____________________

Date ________________ 1966

SCORE CARD FOR PLAIN CAKES

FACTOR	QUALITIES	SAMPLE A	B	C	D	COMMENTS
External Appearance	Shape--symmetrical, slightly rounded top, free from cracks or peaks					
	Surface--tender crust, free from stickiness. Uniform thickness. Golden brown color, free from specks or blotches.					
Internal Characteristics	Tenderness--tender with velvety feel to tongue and finger. Fine, round, uniformly distributed cells. Free from tunnels, no compact layers.					
	Color of crumbs--uniform, free from grayish cast. No uneven color present.					
Flavor	Bland, pleasant. Free from any predominant flavor of individual ingredient.					

RATING SCALE:

5. Excellent
4. Good
3. Acceptable
2. Slightly unacceptable
1. Unacceptable

EFFECT ON THE BATTER AND BAKED PRODUCT OF EXPANDING A STANDARDIZED QUANTITY FORMULA FOR PLAIN CAKE

by

ELIZABETH KATHLEEN MILLER

B. S., Sterling College, 1965

AN ABSTRACT OF A MASTER'S THESIS

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This study was undertaken to determine the effect on the batter and baked product of expanding a standardized formula for plain cake from a batch of 50 servings to batches for 100 and 200 servings. The control formula, for a 12 x 20 x 2-in. pan, was designated as formula I. It was doubled for formula II, and quadrupled for formula III. Formulas I, II, and III were prepared in each of 10 baking periods.

Dry ingredients were weighed and stored at room temperature the day before baking. Eggs were refrigerated two days before baking. After controlled mixing procedures, 2100 g of batter were weighed into a 12 x 20 x 2-in. pan and baked in a reel oven at 350° F. for 43 min.

Consistency of batters was measured by means of the funnel and line-spread techniques. Sections of cakes were rated by a panel of 7 judges for external and internal factors. Indexes to volume were determined by standing height and the area of a square.

Analyses of variance were run to determine the effect of recipe expansion and replications on the consistency of batter, and on the index to volume, shape, appearance of the surface, internal color, tenderness, and flavor of the baked cake. No significant differences were indicated among treatments for these characteristics, except for line-spread values, which were significant at the 0.05 level. Significant differences at the 0.05 level among replications included line-spread, appearance of surface, and color of crumb values.

Observations revealed little, if any, variation in shape or surface qualities among the cakes. In general, they tended to be symmetrical, slightly rounded, without peaks or cracks. Crusts were tender, with a minimum amount of stickiness, and of uniform thickness. Crust color was a golden brown, while internal crumb color was uniform and even.

Average judges' scores for palatability factors indicated that a high quality cake resulted from all 3 formulas. Based on the conditions of this study, a standardized plain cake formula for 50 portions apparently can be quadrupled without appreciable change in quality.