A COMPARISON OF MIXING METHODS FOR MUFFINS

by

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INTRODUCTION

The preparation of quick breads is more of an art than a science because less research has been done on them than on yeast breads or cake (Griswold, 1962). There is little room for art in today's institutions and higher costs of labor and food supplies have forced many institutions to take a more scientific approach. The trend today is toward standardized recipes made up of a list of ingredients and detailed instructions (Watts, 1967).

The scientific approach to quality food production has emphasized the ingredients, their function and proportion rather than their method of combination. Ingredients have been standardized but the method of combining them has not. For example, it is not uncommon that two basically similar muffin recipes each have a completely different method of preparation.

Standardized procedures are important to large institutions. Their necessity is demanded by rising costs, a shortage of trained personnel, decentralization of food service units and the need for consistent products (Zumsteg, 1960). By using standardized procedures lower labor costs would be possible by alleviating the problem of finding trained personnel and by making it easier to train personnel.

For this study, muffins, a form of quick bread, were selected. Muffins are comparatively inexpensive and popular in certain geographical areas. Some institutions have capitalized on this and built for themselves enviable reputations. The purpose of this study was to compare several methods of mixing and their effect on quality to determine if it is possible to standardize the procedure for mixing muffins.

REVIEW OF LITERATURE

Muffins belong to the family of flour mixtures known as Quick Breads which also includes biscuits, popovers, griddle cakes and waffles. Quick breads are aptly named because they are made quickly and usually are baked immediately after mixing (McWilliams, 1966). The viscosity of the various quick breads ranges from a very thin batter to a soft dough.

Peckham (1969) includes muffins in the category of drop batters. The flour/liquid ratio is approximately 2:1 by volume (Sweetman and MacKellar, 1954; Hughes, 1962). Muffins require quick mixing and quick baking and they should be served immediately after baking (Treat and Richards, 1966).

Characteristics of Muffins

A good muffin has a uniform shape, slightly rounded top, good color, a tender crust, an even tender crust and good flavor. They should break easily without crumbling (Miller, 1971).

A high quality muffin is described by Halliday and Noble (1946) as follows:

> To be good, muffins should be very light--so light in fact that when one picks them up one is surprised that anything of their size should weigh so little. The outside should be baked to a golden-brown shade; should be symmetrical in shape, with no tendency to form peaks or knobs at the top; and should have a somewhat pebbled, rather than a smooth and even, surface. The inside should show round holes of fairly uniform size but should have none of the long, narrow ones sometimes called "tunnels."

Vail et al, (1967) described high quality muffins as having:

> . . . a rounded pebbled top and a symmetrical shape. The crust is golden brown, crisp, and tender. The muffin feels light in the hand. A cross section shows a moist crumb, medium-fine evenly distributed air spaces, and no long, narrow tunnels. The muffin is tender and has a good flavor.

Muffin Formulas

Quick breads differ, one from the other, in various ways: ingredients used in their making, proportion of ingredients, manner of mixing, condition of baking, and appearance and flavor of the finished product (Fitch and Francis, 1961). Muffins contain the basic ingredients for all quick breads--milk, flour, salt and shortening. In addition they contain eggs, sugar, and baking powder (McWilliams, 1966). According to Nason (1939) muffins and cakes are the same in kinds of ingredients, but differ in the amount of each. Muffins often are modified by the substitution of other flour or meals for all or part of the wheat flour, and by the addition of fruits, nuts, or other ingredients (Sweetman and MacKellar, 1954). Peckham (1969) stated that muffin variations are limitless.

Muffins may either be bread-like or rich and sweet as cup cakes (Griswold, 1962; McWilliams, 1966). The difference generally is due to the amount of sugar and shortening included in the formula. Increased sugar and shortening produce richer muffins which are a hybrid between muffins and cakes (McWilliams, 1966).

When making muffins, or any baked product, the ingredients should be of good quality (Lowe, 1955). Low protein flour, all-purpose or pastry, generally is used. Sufficient shortening and sugar are needed to produce tenderness and good flavor (Terrell, 1971). The shortening may either be melted or solid depending upon the method of mixing. Muffins depend on steam and chemical leavening agents to make them light and porous. More leavening is required for thin batters than for stiffer ones because carbon dioxide is not retained as well in the thin batters (Peckham, 1964).

The nature of the liquid in muffins is unimportant. The quality of muffins is similar whether they are made with fresh whole milk, dry whole milk and water or fresh whole milk plus tomato juice (Griswold, 1966). Peckham (1969) stated that muffins received good ratings when non fat dry milk replaced whole milk on a one for one basis.

Mixing of Muffins

The main goal in the preparation of a flour mixture is the uniform distribution of all ingredients (Nason, 1939; Peckham, 1969). According to Halliday and Noble (1949), it is important when making muffins to barely dampen the dry ingredients. A gluten structure should not be allowed to develop if at all possible (Halliday and Noble, 1946; Fitch and Francis, 1961). The success of muffins, according to Nason (1939), lies not in the order but in the amount of mixing. Halliday and Noble (1946) stated, "the difference between success and failure for muffins is a matter of a few strokes of the stirring spoon."

Hughes (1962) noted that properly manipulated muffin batter appears lumpy. This is substantiated by Nason (1939) who believes that mixing should be carried to the point of wetting all of the dry ingredients, but not to the point of a smooth batter. McWilliams (1966) indicated that muffin batter should not lose its lumpy appearance.

There are many methods of mixing muffin batter. According to Vail et al. (1967) the most widely used is the muffin method of mixing, referred to by Griswold (1962) as the traditional method of mixing muffins. This method requires the combining of all dry ingredients together. The liquid ingredients (including melted shortening) are added to the dry ingredients and all are mixed enough to wet the dry ingredients but not enough to produce a smooth batter (Sutherland and Nelson, 1954; McWilliams, 1966; Vail et al., 1967; Peckham, 1969).

Several authors (Griswold, 1962; Vail et al., 1967; Peckham, 1969) suggested that muffins could be made by cutting solid fat into the dry ingredients rather than use a melted shortening. According to Peckham (1969) the cutting-in technique is done by placing the fat in a bowl containing the dry ingredients and using a pastry-blender to cut through the mixture. The motion is continued until the fat is uniformly divided and of desired particle size. The liquid ingredients are then added and mixed until the dry ingredients are wet.

When muffins contain large amounts of shortening, Sweetman and MacKellar (1954) and Treat and Richards (1966) suggest using the conventional cake method of combining ingredients which calls for creaming the shortening with the sugar. According to Peckham (1969), creaming involves working the shortening until it is soft and creamy. The cake method incorporates large amounts of air into the mixture. The eggs are added to the creamed mixture and mixed in. Finally, the remaining dry and liquid ingredients are added and the batter is mixed just enough to wet the dry ingredients.

According to Sweetman and MacKellar (1954), the pastry-blend method of mixing which is very similar to the conventional cake method may be adapted for mixing muffins. The shortening is first creamed together with the flour. The remaining dry ingredients are added and mixed in. Finally the liquid ingredients are added and mixed until the dry ingredients are wet.

Pyke and Johnson (1940) and Sweetman and MacKellar (1954) described a single-stage or quick method of mixing which can be used for muffins. It saves time, is subject to fewer variations and makes for uniformity in production. In this method all ingredients except the leavening are combined and mixed, then leavening is added and the mixing is continued.

Effect of Mixing

Mixing has a direct effect on the baked product. Lowe (1955) explained the effect of proper mixing and overmixing on a baked muffin and described the properly mixed muffin:

> The top is slightly rounded and slightly rough with cauliflower-like bumps. It browns well and has a slight sheen or shiny appearance. The volume of the muffin is good, its cells rather medium and uniform in size, and its cell walls of medium thickness. The muffin is tender.

With excessive mixing the baked muffin changes.

> The top of the muffin is less rounded and may come to a sharp point or peak. Its crust is smoother, browns less readily and becomes duller in appearance with less sheen. The muffin is smaller and the muffin less tender. Up through the center of the muffin are found long holes, called tunnels.

Nason (1939) explained the effects of mixing somewhat differently than Lowe.

> If the blending of ingredients is carried to the point of wetting the dry ingredients, but not to the point of a smooth batter, a coarse but tender muffin with a large volume results. The crust browns readily and is always rough but flat on top. When the batter is mixed to the point of a smooth batter, the resulting muffins are of finer grain, tender and of good volume. The crust browns slightly less readily and the top is smooth and slightly rounded . . . . On further mixing the grain becomes finer, tunnels begin to form, the volume decreases, the top becomes more peaked and the tendency to brown diminishes.

Griswold (1962) stated that the peak and tunnel characteristics of overmixed muffins probably are due to the development of gluten and the loss of carbon dioxide as the batter is mixed. Peckham (1969) pointed out that tunnel development may be caused by baking pans with shallow cups or an excessively hot oven. This is supported by Griswold (1962) and Lowe (1955).

An explanation of why the tunneling effect occurs in flour mixtures of the muffin type is given by Fitch and Francis (1961).

> When over-development occurs gluten strands, becoming firmer, offer resistance to the expanding gases (air and carbon dioxide) entrapped within the mesh. But, in baking, when these gases become hotter they, together with the water vapor, build up sufficient pressure so that they push upwards in spurts leaving paths in the now partially coagulated gluten meshwork. The tunnels tend to converge toward the center at the top of the muffin because the batter in this region, not being as hot, hence not as far toward coagulation as that in contact with the metal of the baking dish, offers less resistance to the pressure of upward-pushing gases.

Nason (1939), Lowe (1955) and Griswold (1962) gave similar explanations for the formation of tunnels.

Proportion of Ingredients

The effects of overmixing can be avoided by changing the proportion of several of the ingredients (Griswold, 1962). Nason (1939) gave the reason that some ingredients have an effect on gluten formation. Several authors (Nason, 1939; Lowe, 1955; Kotschevar, 1966; Vail et al., 1967) agreed that increasing the amount of sugar and shortening will permit greater amounts of mixing without causing tunnel formation. Vail et al. (1967) explained that the sugar and shortening interfere with gluten formation. Nason (1939) further stated that during baking the shortening remains soft and makes areas where gases may collect and expand.

When egg is omitted from muffin formulas, there is less tendency for tunnels to form (Lowe, 1955). Increasing the egg makes a tougher, more rubbery, elastic muffin.

Kotschevar (1966) suggested using a weaker flour (one with less protein than normal) to increase mixing tolerance.

Panning Muffin Batter

Muffin batter should be put into the muffin tins as quickly as possible after mixing, according to Lowe (1955) and Kotschevar (1966). Lowe (1955) explained that quick panning lessens the amount of gas lost. According to Kotschevar (1966) some quality is lost if the batter is not immediately panned but Griswold (1962) noted that once the batter was panned, it could be covered and kept in a refrigerator up to 45 min before being baked. This is supported by Halliday and Noble (1946) and Peckham (1969).

Griswold (1962) and Kotschevar (1966) suggested using an ice cream dipper for portioning and panning the muffin batter. Kotschevar (1966) explained that the batter should be dipped from the inside of the batter out to prevent stirring which would toughen the muffins. Several authors (Vail et al., 1967; McWilliams, 1966; Griswold, 1962) agreed that care should be taken when panning muffins to prevent extra mixing.

Baking Time and Temperature

Treat and Richards (1966) and Peckham (1969) recommended baking muffins between 400°F to 425°F. In experiments by Briant and Klosterman (1950), Matthews et al. (1965) and Peckham (1969) a temperature of 425°F was used to produce excellent muffins.

Baking time of muffins varies from 20 to 25 min and will depend upon the size of the muffin cups and on the ingredients used (Peckham, 1969). Matthews (1965) baked muffins for 20 min while Briant and Klosterman (1950) baked them for 22. Treat and Richards (1966) suggested 20 to 25 min of baking time but suggested as much as 30 min baking time for certain muffin variations.

EXPERIMENTAL PROCEDURE

Preliminary Work

Six standardized muffin formulas, three containing high amounts of sugar and shortening (rich formula) and three with the normal amount of sugar and shortening (lean formula) were evaluated using different methods of mixing. The products were compared through visual and subjective evaluation by the investigator. One lean formula, representing a plain muffin, and one rich formula modified from a Cranberry Muffin formula were selected for the study. Both formulas were from Treat and Richards (1966, pp. 413, 418). Cranberries and extra sugar were omitted from the rich muffin formula and both were modified to use dry milk.

Weights of the ingredients were used to find the per cent of each ingredient based on the weight of flour. The original formula size was reduced and the procedure for preparation was disregarded.

The two selected formulas were tested using five methods of preparation to simplify and standardize procedures and to develop techniques for preparing the muffins. The phrase "mix just enough to wet the dry ingredients" was tested at several time intervals. A time of 15 sec was determined to be adequate for all methods.

Those methods requiring melted shortening were tested with tap water at 20°C - 22°C. This caused the shortening to solidify before it was completely dispersed. When water at 37°C was used, the shortening did not solidify and was better dispersed. From this testing it was decided to use water at 37°C for the liquid when the method called for melted shortening.

Formulas Used

The two formulas used in this study are given in Table 1. Formula I is the lean muffin and yields 25 muffins. Formula II is the rich muffin and also yields 25 muffins.

Mixing Methods for Muffins

The five different methods used to mix each type of formula were:

Method A: Muffin Method - Combine dry ingredients in a mixing bowl. Mix 1 min on 1st speed. Combine eggs, water (37°C) and melted shortening (cooled to 37°C) and add to the dry ingredients. Mix on 1st speed for 15 sec.

Method B: Cake Method - Cream sugar and shortening 1 min on 1st speed. Scrape. Cream 10 min on 2nd speed. Scrape. Add eggs and mix 1 min on 1st speed. Scrape. Add remaining dry and liquid ingredients. Mix on 1st speed for 15 sec.

Method C: Biscuit Method - Combine all dry ingredients into a mixing bowl. Using a pastry knife mix on 1st speed for 1 min. "Cut" shortening into the dry ingredients mixing 3 min on 1st speed. Scrape. Replace pastry knife with a flat beater. Add liquid ingredients and mix 15 sec on 1st speed.

Method D: Pastry - Blend Method - Cream shortening and flour 3 min on 1st speed. Scrape. Add remaining dry ingredients and mix 1 min on 1st speed. Add the liquid ingredients and mix on 1st speed for 15 sec.

Table 1. Formulas for muffins

Ingredients	Formula I Lean Muffin		Formula II Rich Muffin	
	Per Cent of Flour Weight	Weight in grams	Per Cent of Flour Weight	Weight in grams
Flour, all purpose	100.0	681	100.0	681
Sugar	15.0	102	25.0	170
Salt	1.3	9	1.5	10
Baking powder	7.0	48	4.5	30
Non-fat dry milk	9.0	61	7.0	48
Shortening, all purpose	21.0	143	30.0	204
Eggs	16.0	109	20.0	136
Water	91.0	620	73.0	497
TOTAL	260.3	1773	261.0	1776

Method E: Quick Method - All ingredients including melted shortening (37°C) and water (37°C) are added together in a mixing bowl and mixed 15 sec on 1st speed.

A flat beater was used for all methods except where noted in Method C.

Design of Experiment

The experiment was designed as a partial incomplete block (Table 2). It was broken down into 10 baking periods during which four different treatments (batches) were prepared and baked. A treatment (Table 3) consisted of either Formula I or II and one of the five methods of mixing. Each treatment was tested four times during the experiment.

Procurement and Storage of Ingredients

All ingredients were purchased in sufficient quantity for the entire study. They were two 50 lb bags of all purpose flour, one 100 lb bag of granulated sugar, one 10 lb can of double-acting baking powder, one 50 lb bag of non-fat dry milk, one 5 lb bag of salt, one 50 lb can of all-purpose, all-vegetable shortening and one 30 lb box (6-5 lb cartons) of frozen eggs.

Prior to beginning the study, the flour and shortening were stored in a walk-in refrigerator (36°-38°F). They were removed shortly before beginning the study to allow them to reach room temperature.

The frozen eggs were stored in a walk-in freezer (-5° to -10°F). A 5 lb carton was allowed to thaw in the refrigerator for two days before being used.

During the experiment, all ingredients except the eggs were stored at room temperature (72°F). Open bags of flour and sugar were stored in covered

Table 2. Schedule of baking periods and partially balanced incomplete block design.

Baking Period	Treatments			
1	2	6	7	10
2	3	4	5	10
3	1	2	5	10
4	1	4	7	8
5	2	3	7	8
6	3	5	7	9
7	2	4	6	9
8	1	3	6	9
9	1	8	9	10
10	4	5	6	8

Table 3. Treatments

Treatment Number	Formula	Method
1	I	A
2	I	B
3	I	C
4	I	D
5	I	E
6	II	A
7	II	B
8	II	C
9	II	D
10	II	E

stainless steel portable bins. The shortening, dried milk and baking powder were kept in their original containers. The salt was stored in a glass jar with a metal lid.

Weighing the Ingredients

Ingredients were weighed on a Toledo Model 4040 scale. One day before the experimental baking period in which they were to be used, all ingredients except the eggs and water were weighed. The flour, sugar, salt, baking powder and dried milk were tightly sealed in plastic bags. Ingredients were added together except where the method called for them to be used separately. The shortening was scaled onto waxed paper and carefully wrapped. When melted shortening was called for, the shortening was melted over boiling water, cooled to 37°C and weighed in a glass beaker just before the batch was to be mixed.

One hour before the baking period began the eggs and water (except where 37°C water was called for) were weighed. When 37°C water was used, it was weighed just before the batch was to be mixed.

Mixing the Batter

All mixing was done on two Model N-50 Hobart mixers (5 quart). Each mixer was connected to a Dimco-Gray electric timer (15 min).

Method A: Muffin Method - The weighed dry ingredients were emptied into the mixing bowl. The ingredients were dry blended using a flat paddle for 1 min on 1st speed. In a separate bowl, the eggs, water (37°C) and melted shortening (37°C) were added in that order and stirred with a rubber spatula.

The liquid ingredients were added to the dry ingredients. The ingredients were mixed for 15 sec on 1st speed.

Method B: Cake Method - The sugar and shortening were placed into the mixing bowl and creamed for 1 min on 1st speed. After the paddle and bowl were scraped with a rubber spatula, the mixture was creamed for 10 min on 2nd speed. The paddle and bowl were scraped with a rubber spatula and the eggs were added, and this was mixed for 1 min on 1st speed. Again the paddle and bowl were scraped. The dry ingredients were added to the creamed mixture and then the water. The ingredients were mixed 15 sec on 1st speed.

Method C: Biscuit Method - The weighed dry ingredients were emptied into the mixing bowl and mixed 1 min on 1st speed using a pastry knife. The shortening was added in small chunks and then cut into the dry ingredients by mixing 3 min on 1st speed. The bowl and pastry knife were scraped and the pastry knife replaced with a flat paddle. The eggs and water were added in this order. The ingredients were mixed for 15 sec on 1st speed.

Method D: Pastry-Blend Method - The flour and shortening were placed in a mixing bowl and creamed together for 3 min on 1st speed. The paddle and bowl were scraped with a rubber spatula. The remaining dry ingredients were added to the flour and shortening mixture and mixed for 1 min on 1st speed. The eggs and water were added and the entire contents was mixed 15 sec on 1st speed.

Method E: Quick Method - The weighed dry ingredients were emptied into the mixing bowl. The liquid ingredients were then added in the following order: melted shortening, eggs, water. The ingredients were mixed for 15 sec on 1st speed.

In order to avoid unnecessary spilling and loss of ingredients during the final mixing stage, the mixing bowl was not in the mixing position when the timer was started. The timer (set for 15 sec) was started and then the bowl was slowly raised into mixing position.

Panning and Baking the Batter

Two muffin pans were used for each batch of muffins. Each pan was constructed for twelve muffins in four rows of three. Cups in the pans measured 4.5 cm at the bottom, 6.8 cm at the top and 2.7 cm deep and were Teflon coated. Muffins were dipped and panned according to the plan in Fig. 1. Their position during baking can also be seen in Fig. 1.

The muffin batter was dipped with a No. 20 dipper. All dipping was done along the side of the bowl to avoid any additional mixing. The bowl was rotated in a counter-clockwise manner.

The muffins were baked in a 6 pan, 6 shelf, gas reel oven. The oven was heated to 400°F one-half hour before the first batch was due to be baked. The temperature was checked 5 min prior to placing the muffins in the oven. Both pans were baked on the same shelf. The muffins were baked at 400°F for 20 min.

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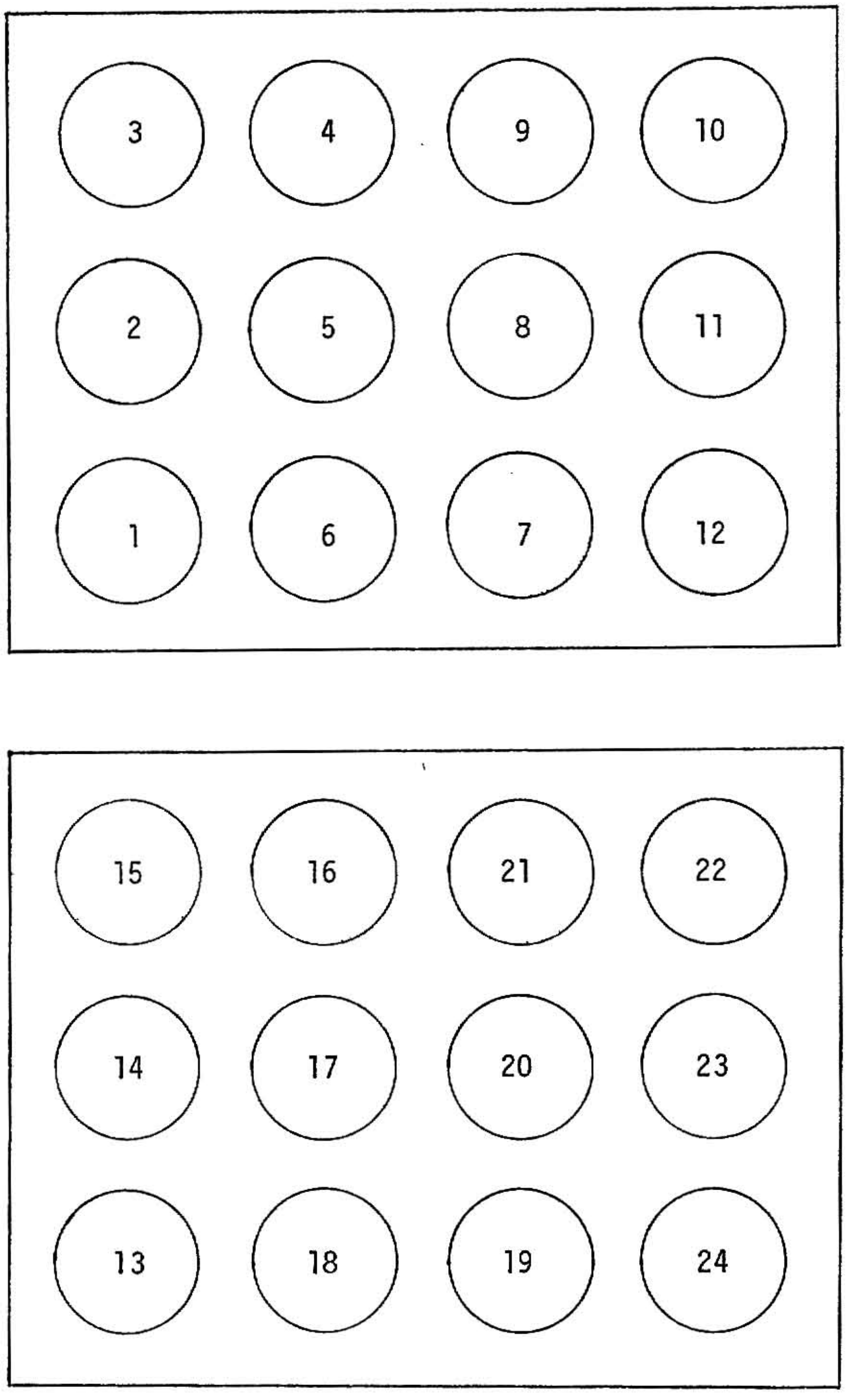

Figure 1. Position of muffins during panning and baking.

Specific Gravity of the Batter

The specific gravity which measures the amount of air incorporated into the muffin batter was determined immediately after the batter was mixed using the AACC method 72-10 as a guide. A stainless steel tumbler (7 oz) measuring approximately 2-3/4 inch, inside top diameter, 1-13/16 inch, inside bottom diameter and depth 3-1/8 inch was used. The true volume of the cup was calibrated to be 212 ml.

The cup was half-filled with batter and tapped down smartly 12 times on a folded towel placed on a solid bench. Between each 2 taps the cup was rotated approximately 30° on vertical axis. The cup was then more than filled and the excess batter was peaked toward the center. The cup was tapped and rotated as before. Using an 8 inch stainless steel spatula with a straight edge, half of the excess, starting with the spatula in the center, was scraped off. Half the remaining excess was scraped off toward the edge and finally the last quarter was removed. The spatula was wiped and then drawn across the top of the cup once again. The cup was wiped with a towel to clean off the edge and weighed on a Toledo Model 4040 scale to the nearest gram. The specific gravity, i.e., weight per unit volume, was calculated to two decimal places.

Evaluation of the Muffins

A random sampling method (Huntsburger, 1966) was used to determine the muffins to be tested during each baking period (Table 4). This method was used to minimize variations due to lack of homogeneity of the batter. Those muffins to be tested by the taste panel were immediately removed from the

Table 4. Random selection by sample number of muffins to be evaluated.

	Baking Period									
	1	2	3	4	5	6	7	8	9	10
Volume	2	11	22	3	13	22	11	24	5	19
	7	9	21	1	1	21	3	9	9	22
	24	5	19	15	6	2	14	13	6	1
	14	6	3	11	12	12	6	6	16	5
	18	18	4	14	5	23	18	3	8	17
	3	17	18	12	9	5	12	8	10	10
Taste Panel Member										
1	15	2	8	22	20	13	16	20	13	6
2	1	14	5	19	8	18	9	22	14	23
3	9	24	10	13	15	15	4	11	3	24
4	10	12	11	6	10	10	24	5	20	9
Photograph	19	8	2	7	11	7	15	1	22	12
	4	15	17	4	17	14	22	10	17	18
	16	3	16	9	14	6	10	17	15	2

baking pans and served to the panel. The muffins to be used for objective evaluation were placed on wire racks and allowed to cool.

Weight. The six muffins selected for objective evaluation were allowed to cool to room temperature. They were weighed in two groups of three on a Toledo Model 4040 scale to the nearest gram. The readings were recorded separately for later use to determine specific volume.

Volume by Seed Displacement. The volume of three muffins of known weight was measured by seed displacement (Griswold, 1966). To facilitate this, special equipment was constructed. This equipment consisted of a round aluminum cake pan 9 inches in diameter and 2-7/8 inches in depth, a square wooden box whose inside dimensions were 13 inches on each side and 4 inches in depth, and a plastic hopper constructed from a one gallon bleach bottle (Fig. 2). The volume of the aluminum pan was determined to be 3003 ml.

The three muffins were centered in the aluminum cake pan which was placed in the wooden box. The hopper containing rape seed was suspended 6 inches above the bottom and over the center of the aluminum pan. The bottom of the hopper was released and the seed was released into the pan below. A straight edge 12 inches long was used to level off the seed and remove excess in the following manner. Beginning in the center, half of the excess was scraped off, then one half of the remaining excess and finally the last quarter was removed. The straight edge was then drawn across the top of the pan once more to pick up any other excess. The filled pan was set aside and the excess seeds in the wooden box were poured back into the hopper.

The filled pan was emptied into the wooden box and the muffins were removed. Seeds that adhered to the muffins were brushed into the box. The

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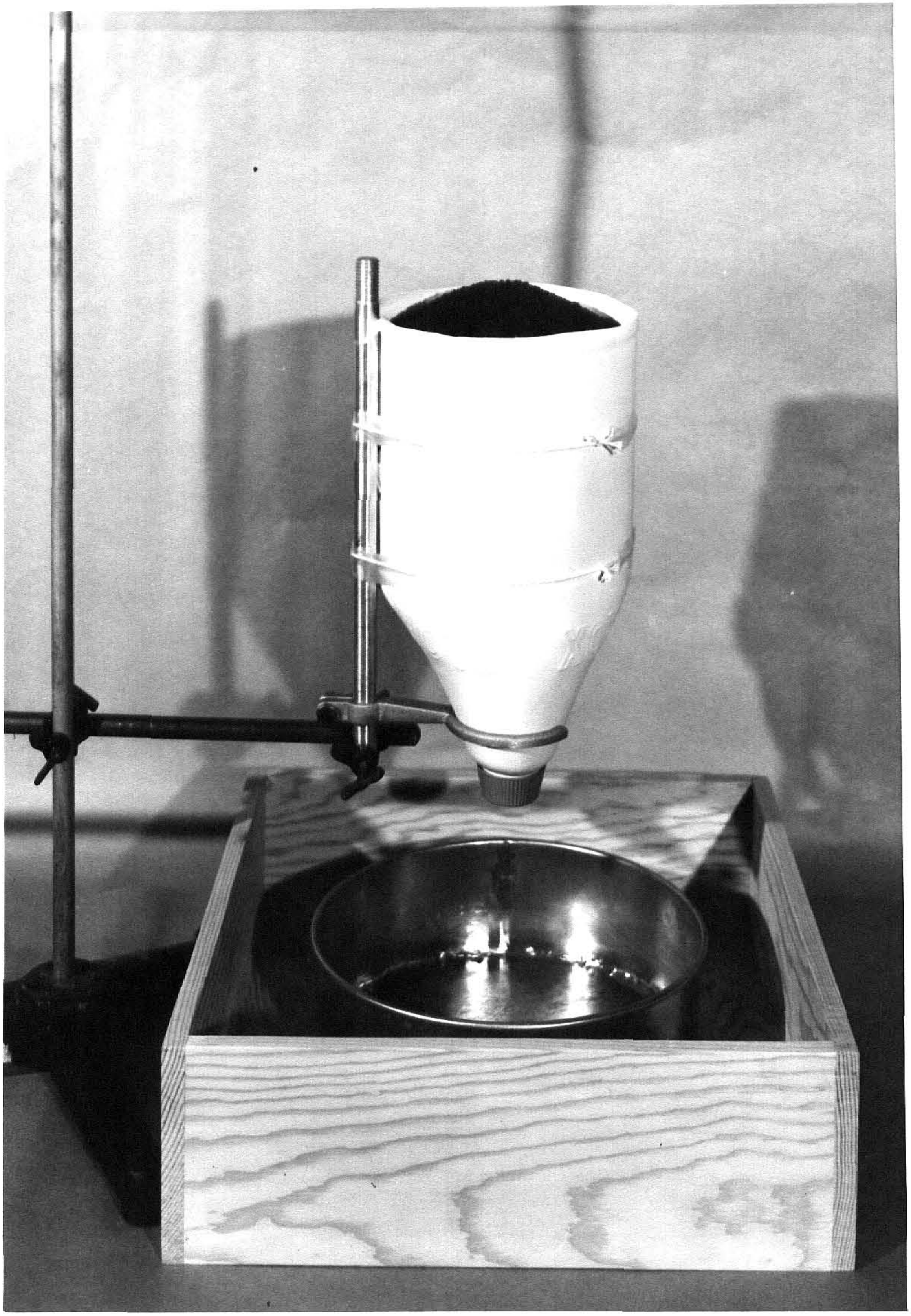

Figure 2. Equipment used for measuring volume.

seeds were poured into a one liter beaker and then poured directly into a 1000 ml graduated cylinder. The seeds were measured to the nearest 5 milliliters. The volume of the seeds was subtracted from the known volume of the pan. The resulting value was recorded as the volume of the three muffins.

Specific Volume. The specific volume of three muffins was determined by dividing their volume by their weight.

Subjective Evaluation. A taste panel consisting of two instructors and two graduate students from the Department of Institutional Management rated the muffins for external and internal characteristics and eating quality. An evaluation sheet was developed and tested before being given to the panel (Appendix, p. 39). The panel members were briefed and allowed to familiarize themselves with the evaluation sheet during two practice periods. Also at this time the techniques for evaluating the muffins were practiced (Appendix, p. 40). As an aid to the panel, each member was provided with a guide sheet (Appendix, p. 42) to aid in determining some of the characteristics.

Each panel member tested one muffin from each batch. As stated earlier, these muffins were selected randomly for each baking period and tested immediately after being removed from the oven. Booths for the panel members were set up with the following: evaluation sheet, guide sheet, pencil, knife and glass of water (Fig. 3).

The evaluation sheet contained only descriptive terms. The actual scoring was done using a system which essentially rated the characteristics "good" or "bad" based on pre-determined criteria. Scores were placed on a template to allow for easy grading scores were used for statistical analysis.

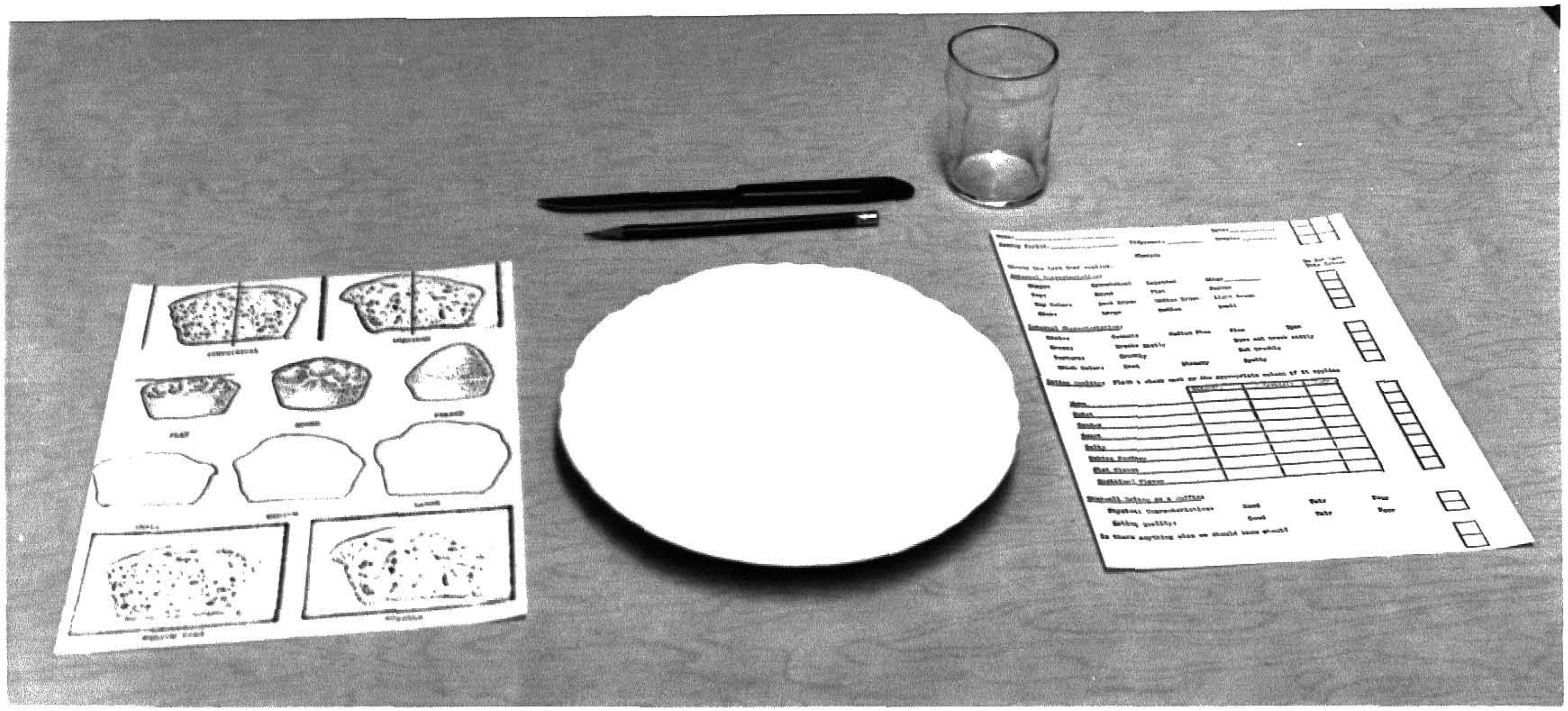

Figure 3. Booth set up for evaluation panel.

OBSERVATIONS

Certain characteristics were observed during the mixing of the batter and at the time the muffins were removed from the oven.

All of the muffin batters were thick regardless of the treatment. Generally, the batters made with the rich formula (II) were thicker in appearance. At times, the batters resembled thick lumpy paste and at other times they would start to build up around the mixer paddle as if to form a very thin dough. There was no relationship between batter appearance and treatment.

As the batter was panned, particles of dry ingredients were often observed at the bottom of the mixing bowl. There did not appear to be any connection between the lack of homogeneity of the batter and the treatments. The only way to incorporate these particles would have been to mix the batter longer, but this would have caused the batter to become over-mixed.

Muffins removed from the oven were usually uniform within the same batch. Muffins made from Treatments 2 and 7 which utilized the Cake Method were an exception. Most of the muffins made from these treatments were good in appearance, but some were flat as if the batter had run over the top of the cup. These flat muffins were very dark in color and the tops had a rough surface.

RESULTS AND DISCUSSION

Data from the study were subjected to an analysis of variance to determine the effect of each treatment on muffin quality. As the primary interest of this study was to determine the effect of method, the mean values of factors affected by method were analyzed for differences.

Specific gravity, weight, volume, and specific volume were affected by both method and formula (Table 5). It was expected that the specific gravities for Treatments 6 through 10 (Formula II) would be lower than those obtained for Treatments 1 through 5 (Formula I). The reason for this expectation was Formula II (rich formula) has more shortening and less liquid than Formula I (lean formula) and therefore would be a better medium within which to incorporate air. As more air is incorporated into a batter, the specific gravity decreases. The specific gravities of the batters made with Formula I were lower than the specific gravities obtained using the same methods and Formula II. These results were the opposite of results normally expected from a rich formula. Method B (Cake Method), as expected, produced batters with the lowest specific gravities as this method incorporates the most air into a batter. A comparison of mean values of specific gravity as affected by method (Table 6) indicated that only Method B was significantly different, while the mean values of specific gravities for the other methods were close in range.

The muffin batter was portioned by dipper instead of weight to avoid extra mixing of the batter. Despite the possibly inaccurate portioning, several correlations can be made (Table 9, Appendix, p. 43). Specific gravity had a direct effect on the weight of the muffins. Muffins made from batter with a low specific gravity weighed less than muffins made from batter

Table 5. Summary for analysis of variance for specific gravity of the batter, and the weight, volume and specific volume of the muffins.

		F - Ratios			
Source	DF	Specific Gravity	Weight	Volume	Specific Volume
Method	4	5.745*	7.862*	12.801*	9.769*
Formula	1	50.262*	13.693*	0.420	24.540*
Error	25++	0.001+	75.764+	433.927+	0.011+

* Significant at the 5% level

++ Error DF of Specific Gravity is 24

\+ Error mean square from least squares analysis of variance

Table 6. Mean values of specific gravity, weight, volume and specific volume as affected by method.

Method		Specific Gravity	Weight	Volume	Specific Volume
A	Muffin	0.944^{a*}	150.2^{a}	309.7^{a}	2.06^{bc}
B	Cake	0.880	130.4^{c}	250.3	1.948^{c}
C	Biscuit	0.964^{a}	146.5^{ab}	325.7^{a}	2.216^{a}
D	Pastry	0.937^{a}	139.1^{bc}	316.1^{a}	2.269^{a}
E	Quick	0.957^{a}	154.4^{a}	304.3^{a}	2.071^{b}

* Superscript indicates difference by Fisher's LSD at the 5% level.

with a higher specific gravity. Muffins made from Formula I weighed less when compared with those made with the same method and Formula II; muffins from Formula I generally had a larger volume than those muffins made with Formula II.

With the exception of Method B, the lighter muffins were larger in volume. Method B should have produced muffins that weighed the least and also had the greatest volume. The muffins made using Method B weighed the least but also had the poorest volume. In general, the muffin batter with the lower specific gravity produced muffins with the larger volume. Method B did not follow this pattern indicating that the specific gravities may have been too low. These results suggested that there may be a minimum value for specific gravity of muffin batters.

Specific volumes for muffins made with Formula I were greater when compared with the specific volume of muffins made from the same method and Formula II. The opposite results were expected as the rich formula should have produced muffins with the greatest specific volume. Methods C (Biscuit) and D (Pastry) produced the greatest specific volume while Method B unexpectedly produced the lowest. Complete data for specific gravity, weight, volume, and specific volume are in Table 9 (Appendix, p. 43).

Muffin qualities (Table 10, Appendix, p. 44) evaluated by the panel were analyzed for the effect of method, formula, and panelist (Table 7). Method significantly affected the most qualities which included top crust color, size, grain, over-all physical qualities, and over-all eating quality. A comparison of the mean values of these qualities (Table 8) indicated that Methods D and C produced the best muffins while Method B produced the poorest.

Table 7. Summary of analysis of variance for muffin qualities.

		F - Ratios									
										Over-all Qualities	
Source	DF	Shape	Top	Top Crust Color	Size	Grain	Break	Texture	Crumb Color	Physical	Eating
Method	4	0.093	1.339	2.717*	14.513*	3.336*	0.683	1.388	1.717	6.861*	2.464*
Formula	1	0.055	1.656	3.830	0.425	3.035	3.567	0.134	1.355	1.860	29.078*
Panelist	3	10.217*	4.798*	1.736	1.570	0.944	0.676	2.564	2.758*	1.791	6.156*
Error	130	0.211+	0.201+	0.188+	0.169+	0.467+	0.039+	0.202+	0.201+	0.294+	0.410+

* Significant at the 5% level

\+ Error mean square from least squares analysis of variance

Table 8. Mean values of muffin qualities affected by method.

Method	Top Crust Color	Size	Grain	Over-all Qualities Physical	Over-all Qualities Eating
A	1.756[ab*]	1.994[ab]	1.791[b]	2.076[ab]	2.181[a]
B	1.544[b]	1.336	2.320[a]	1.549	1.700[c]
C	1.805[a]	2.104[ab]	2.033[ab]	2.181[a]	2.143[a]
D	1.836[a]	2.123[a]	2.242[a]	2.298[a]	2.082[ab]
E	1.524[b]	1.923[b]	1.790[b]	1.866[b]	1.850[bc]

* Superscript indicates difference by Fisher's LSD at the 5% level.

The only quality significantly affected by formula was the over-all eating quality of the muffins. Usually formula affects other qualities such as size, grain, and texture. Difference in over-all eating quality as affected by formula was anticipated because Formula II produced muffins richer and sweeter than muffins made with Formula I.

Variations in the panel evaluation significantly affected the mean values for shape, top, crumb color, and over-all eating quality. Panel members each had a guide sheet for reference during the evaluation; therefore, shape and top were evaluated using the same standards. The difference in scores for shape and top could be attributable to variations within the same batch caused by the technique used to dip the batter.

Differences in crumb color while significantly affected only by panelist also should have been affected by method. For both formulas, muffins made by Methods C and D have the highest mean values for crumb color indicating that these methods more thoroughly mixed the muffin batter than the other methods. Method A (Muffin) produced the lowest scores from crumb color.

The panel rated the over-all eating qualities of muffins made from Formula II over the muffins made with Formula I. This indicated the panel's preference for a sweet rich muffin, a fact, as stated above, had been anticipated.

An informal ranking of the mean values (Table 10) for Treatments 1 through 5 compared favorably with the ranking for Treatments 6 through 10 for most qualities. Over-all, Methods D and C produced muffins with the highest quality, Methods A and E ranked next, and Method B was the poorest. This ranking demonstrated that the effect of method is the same no matter which type formula was used. Based on this evidence, it should be possible to standardize a procedure for mixing muffins without sacrificing quality.

Two reasons are offered for the relatively high ranking of Methods C and D. Both methods called for solid shortening which was thoroughly dispersed throughout the dry ingredients. This procedure coated the flour particles helping to deter gluten formation after the liquid ingredients were added. If Methods A and E had more thoroughly dispersed their liquid shortening with the dry ingredients first, they might have scored higher as gluten formation would have been more effectively prevented.

CONCLUSIONS

Under the conditions of this study, the following conclusions may be drawn:

1. Specific gravity of muffin batter is affected by both formula and method. It is possible that there is an optimum range of specific gravity for muffins.
2. Muffins made from a lean formula will have a greater specific volume than muffins made with a rich formula.
3. Differences caused by method indicate that:
    a. The effect of method has more influence on muffin quality than the formula.
    b. The most popular methods used for mixing muffins, the Muffin Method and the Cake Method, may not be the best methods.
    c. The Biscuit Method and the Pastry Method produce the best over-all muffins.
4. The muffin formula has the greatest effect on eating quality and a sweet, rich formula is preferred over a plain formula.

5. No matter which type of formula is used, the method of mixing muffins can be standardized.

SUMMARY

This comparison of several methods of mixing muffins and their effect on quality was undertaken to determine if it is possible to standardize the procedure for mixing muffins. Preliminary to the reported study six formulas were tested using different methods of mixing. Two formulas (one rich and one lean) and five methods were selected for this study and classified according to treatments making a total of 10 treatments.

During each of 10 baking periods, four treatments (batches) of muffins were made. Ingredients were pre-weighed and stored at room temperature, except for the frozen eggs which were refrigerated and weighed one hour before the start of the baking period. After controlled mixing procedures, the batters were tested for specific gravity before being scaled into muffin tins and baked in a reel oven at 400°F for 20 minutes.

A panel of four judges evaluated the freshly baked muffins for external and internal factors. Six muffins from each batch were weighed three at a time and then measured for volume by rape seed displacement. Specific volume was calculated from the weight and volume of three muffins.

Data were subjected to an analysis of variance to determine the effect of method and formula on the specific gravity of the batter, the specific volume of the muffins, and the evaluation by the panel members.

Specific gravity of the batter was significantly affected by method and formula. Those treatments with Formula I produced lower specific gravities than when the same methods were used with Formula II. The Cake Method

produced significantly lower specific gravities no matter which formula was used.

Muffins made with Formula I had greater specific volume than those made with the same method and Formula II. The Biscuit Method and Pastry Method produced the best specific volume while the Cake Method was significantly less.

The scores from the panel reports tended to rate the muffins over a narrow range. Method significantly affected scores for top crust color, size, grain, over-all physical quality, and over-all eating quality. Formula significantly affected only eating quality scores. While the degree of variation in panelists' reports was a significant factor for shape, top, crumb color, and eating quality, this could be due to a variation within the same batch of muffins.

Based on the conditions of this study, a standardized procedure for making muffins is possible. The Biscuit Method and Pastry Method rated the highest, and standardization should be developed using either of these methods.

RECOMMENDATIONS FOR FURTHER WORK

A standardized method of preparation should be developed using either the Biscuit or Pastry Method. Using either of these methods has several advantages: time is saved in preparation because shortening does not have to be melted and then cooled, muffin formulas do not have to be enriched with shortening and sugar to prevent over-mixing, and the resulting muffins have good quality. Before standardization is undertaken, the methods used for this study should be tested using larger quantities of batter.

The effect of specific gravity on muffin quality should be further studied. A predictable correlation between specific gravity of muffin batter and the specific volume of the muffins from that batter may be developed with further work. The fact that a lean formula produced a greater specific volume than the rich formula also deserves more attention.

ACKNOWLEDGMENTS

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The author is grateful to Mrs. Vadaline Strohm for her assistance with the evaluation panel, and to the panel members: Mary Baggan, Judy Frederick, Julian Morris, and Allene Vaden for their cooperation.

A very special thanks is due my wife, Marilynn, for her patience, encouragement, and understanding during this year of study.

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THIS BOOK CONTAINS NUMEROUS PAGES THAT WERE BOUND WITHOUT PAGE NUMBERS.

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APPENDIX

2	1	1
2	1	1
1	2	1
3	2	1

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2		1	
1		2	
2	1	1	

1	2	3
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1	2	3
1	2	3
1	2	3

3	2	1
3	2	1

Name:____________________ Date:____________

Baking Period:____________ Treatment:__________ Sample:__________

MUFFINS

Circle the term that applies.

Do Not Mark This Column

External Characteristics:

Shape:	Symmetrical	Lopsided	Other__________
Top:	Round	Flat	Peaked
Top Color:	Dark Brown	Medium Brown	Light Brown
Size:	Large	Medium	Small

Internal Characteristics:

Grain:	Tunnels	Medium Fine	Fine	Open
Break:	Breaks Easily		Does not break easily	
Texture:	Crumbly		Not Crumbly	
Crumb Color:	Even	Streaky	Spotty	

Eating Quality: Place a check mark in the appropriate column if it applies.

	Slightly	Moderately	Very
Warm			
Moist			
Tender			
Sweet			
Salty			
Baking Powdery			
Flat Flavor			
Sustained Flavor			

Over-all Rating as a Muffin:

Physical Characteristics:	Good	Fair	Poor
Eating Quality:	Good	Fair	Poor

Is there anything else we should know about?

Instructions to the Panel Members and an Explanation of the Evaluation Sheet

Panel members were instructed to evaluate the muffins based on pre-determined characteristics. The following is an explanation of the characteristics judged and the methods the panel was instructed to use for judging each characteristic.

<u>External Characteristics</u> - These are judged looking at the whole muffin.

Shape - Refer to guide sheet. The muffin should be symmetrical in shape.

Top - Refer to guide sheet. The shape of the top of the muffin should be round.

Top Color - The top crust should be judged. It should be a golden (medium) brown.

Size - Refer to guide sheet.

<u>Internal Characteristics</u> - These are judged by cutting the muffin in half. Use a serated edge knife.

Grain - Refer to guide sheet. The grain should be medium fine.

Break - Hold a muffin, cut side away from the body, by placing the thumbs on top and the index fingers along the cut side and touching the thumbs. Gently apply pressure. A muffin should break easily.

Texture - Once the muffin is broken, it should not crumble.

Crumb Color - The crumb should be even throughout the muffin.

Eating Quality - Take small thumb-nail size bites taking part of the crust and interior with the same bite. Indicate the degree to which each of the following characteristics is perceived.

Warm - Did the muffin feel warm?

Moist - Was the muffin moist?

Tender - Was the muffin tender?

Sweet - Was the muffin sweet?

Salty - Was the muffin salty?

Baking Powdery - Could you taste baking powder?

Flat Flavor - Did the flavor disappear quickly?

Sustained Flavor - Did the flavor linger?

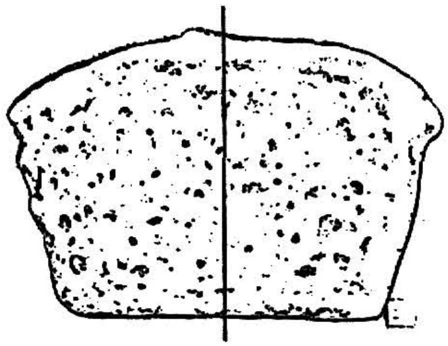
Over-all Rating - Consider all the qualities listed in the evaluation sheet.

Physical Characteristics - Considering only the internal and external characteristics, how well did the muffin measure up to a quality muffin?

Eating Quality - How good was the eating quality of this muffin?

Is there anything else we should know about? Use this space for any comments you wish to make. If you are ill or have a cold, indicate this.

Guide sheet used by panelists to evaluate muffins.



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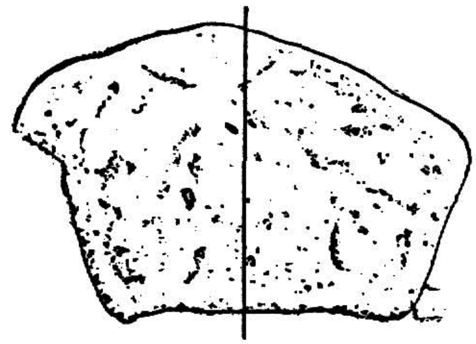

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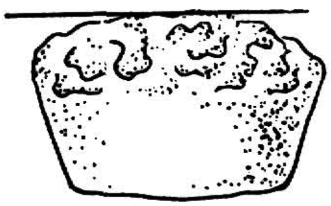

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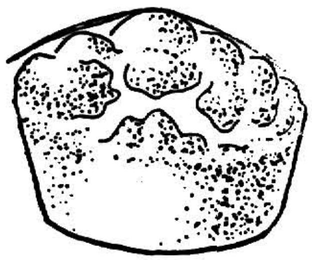

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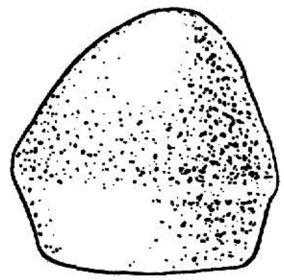

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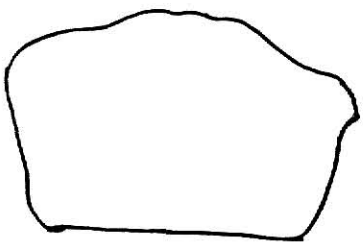

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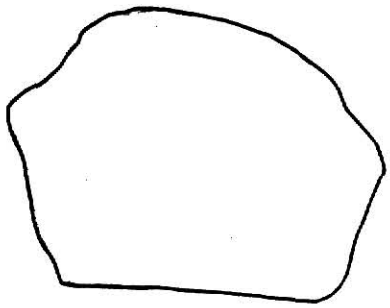

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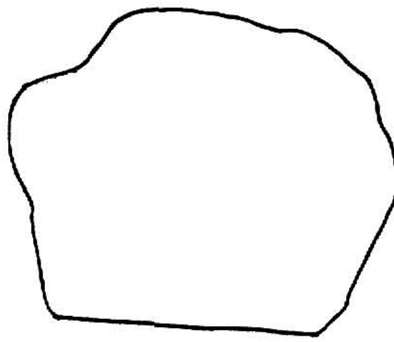

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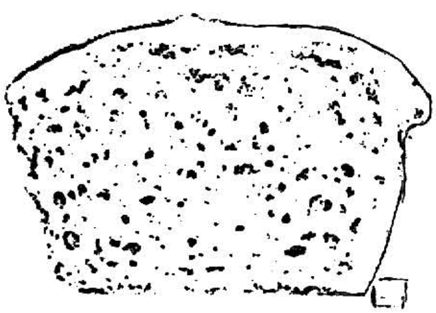


MEDIUM FINE

TUNNELS

Table 9. Average measurement of the specific gravity of the batter and the weight, volume, and specific volume of three muffins.

Treatment	Specific Gravity	Weight (g)	Volume (ml)	Specific Volume (ml/g)
1	0.90	138	295	2.13
2	0.86	130	264	2.04
3	0.92	143	328	2.29
4	0.90	139	319	2.30
5	0.88	142	310	2.18
6	1.00	164	323	1.98
7	0.90	135	254	1.88
8	1.00	150	322	2.15
9	0.98	140	315	2.24
10	1.00	158	285	1.94

Table 10. Mean square differences of panel scores as affected by method and formula.

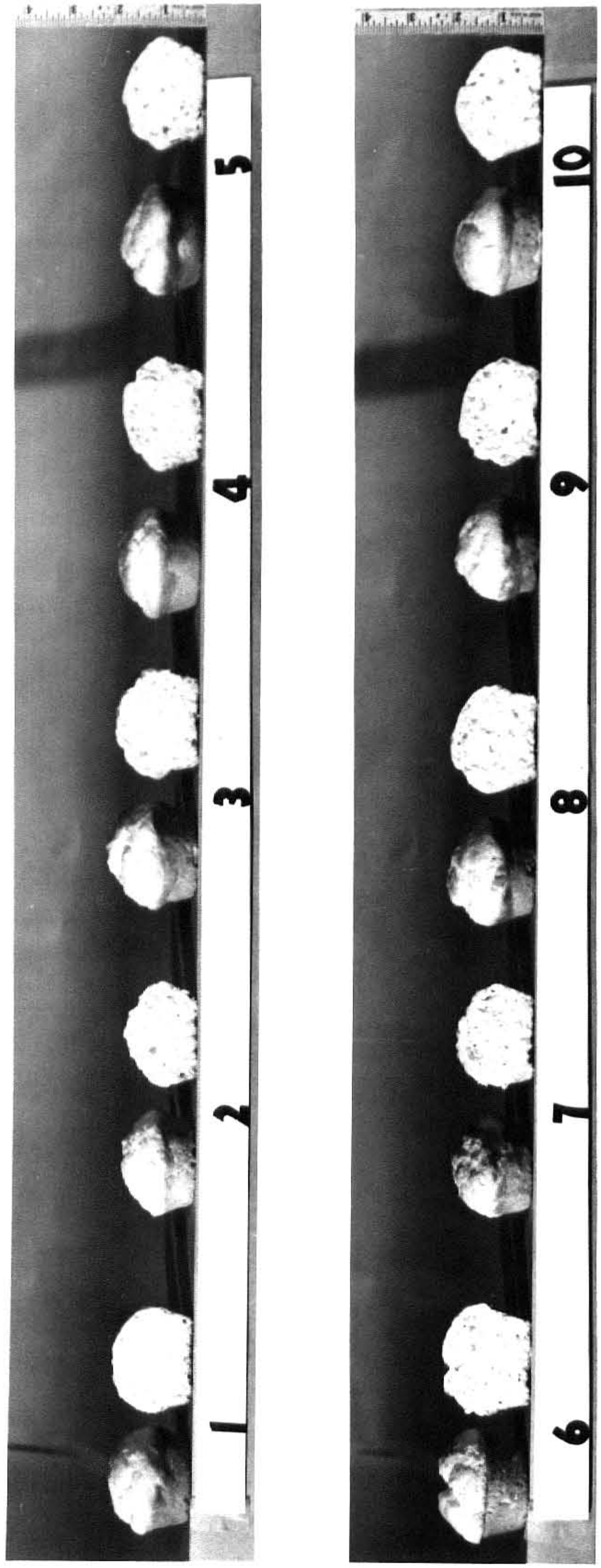
Treat-ment	Shape	Top	Top Crust Color	Size	Grain	Break	Texture	Crumb Color	Over-all Qualities	
									Physical	Eating
1	1.55	1.68	1.82	1.98	1.90	1.92	1.74	1.70	2.13	1.87
2	1.53	1.51	1.62	1.33	2.43	1.88	1.62	1.78	1.61	1.40
3	1.51	1.80	1.87	2.09	2.14	1.93	1.76	1.97	2.24	1.84
4	1.50	1.66	1.90	2.11	2.35	1.97	1.68	1.96	2.35	1.78
5	1.48	1.61	1.59	1.89	2.16	1.95	1.90	1.81	1.93	1.56
6	1.57	1.78	1.68	2.02	1.70	1.98	1.72	1.60	2.01	2.47
7	1.54	1.61	1.48	1.47	2.22	1.94	1.60	1.68	1.49	2.00
8	1.53	1.90	1.80	2.13	1.94	2.02	1.74	1.87	2.12	2.44
9	1.52	1.76	1.83	2.15	2.15	2.03	1.66	1.86	2.23	2.38
10	1.49	1.70	1.45	1.93	1.70	2.01	1.88	1.71	1.81	2.16
Highest Possible Score	2.00	2.00	2.00	3.00	3.00	2.00	2.00	2.00	3.00	3.00

EXPLANATION OF PLATE I

A sample of muffins prepared from each treatment.

Treatment	Formula	Method
1	Lean	Muffin
2	Lean	Cake
3	Lean	Biscuit
4	Lean	Pastry
5	Lean	Quick
6	Rich	Muffin
7	Rich	Cake
8	Rich	Biscuit
9	Rich	Pastry
10	Rich	Quick

PLATE I



A COMPARISON OF MIXING METHODS FOR MUFFINS

by

IRA MARC WALMAN

B. S., Kansas State University, 1967

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

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Manhattan, Kansas

1972

The purpose of this study was to compare five methods of mixing muffins using two different formulas and determine if it was possible to standardize the procedure for mixing muffins. Formula I was a typical plain muffin formula and Formula II was a rich type muffin high in sugar and shortening. The methods of mixing used were the Muffin Method, Cake Method, Biscuit Method, Pastry Method and Quick Method.

Each formula and method of mixing was classified as a treatment making a total of 10 different treatments. The experiment was designed with 10 baking periods in a partially incomplete block design. During each baking period, four different treatments (batches) were tested.

Ingredients were weighed and stored at room temperature the day before baking, except for the frozen eggs which were refrigerated at approximately 36°-38°F and weighed one hour before the start of the baking period. After controlled mixing procedures the specific gravity of the batter was taken. The muffin batter was scaled into teflon coated muffin tins with a No. 20 ice cream dipper. The batter was baked in a reel oven for 20 minutes at 400°F.

A panel of four judges rated the muffins for external and internal factors. Six muffins from each batch were weighed in two groups of three each. The volume of each group was taken using rape seed displacement. The weight and volume of three muffins was used to calculate the specific volume.

Analysis of variance were run to determine the effect of the treatments on the specific gravity of the batter, the specific volume of the muffins, and the panel's evaluation of the muffins. Significant differences at the 0.05 level were found among specific gravity and specific volume and these are attributed to the method and formula. The characteristics evaluated by the panel demonstrated significant differences for all characteristics except texture. Method affected crust color, size, grain, over-all physical qualities, and over-all eating quality. The formula affected only eating quality. The panelist was a significant factor for shape, top, crumb color, and eating quality but this could be attributed to a variation within the same batch of muffins.

Based on the conditions of this study the Biscuit Method and Pastry Method are the most desirable to use for making muffins. A standardized procedure for making muffins should be developed using either of these methods.