# A Micro Method for Cake Baking (High Ratio, White Layer)[1]

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**ABSTRACT**

A micro method for baking high-ratio white layer cakes requiring only 5 g of flour was developed to test small quantities of experimental ingredients. Optimum mixing time, mixing speed, mixer design, and baking temperature were determined for the micro method. Among all the conditions tested, three mixing stages (4+2+2 min) at 670 rpm speed, using a flat paddle, and baking at 191°C produced cake properties similar to those produced by using the AACC method 10-90. These are similar conditions to those used in AACC method 10-90, which uses 200 g of flour instead of 5 g. The 5- and 200-g cake-baking methods were compared by using different levels of spray-dried egg whites and bovine blood plasma (0, 25, 50, 75, and 100% of the normal level of egg white protein). Although only one cake flour was used, correlation coefficients between the 5- and 200-g cake-baking methods for specific gravity, cake volume, and symmetry index measurements were 0.80, 0.99, and 0.98, respectively, for egg whites and 0.84, 0.99, and 0.99, respectively, for blood plasma.

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The standard AACC baking methods (AACC 1983) have limited applications because of the relatively large quantity of ingredients required. Thus, micro baking procedures have been developed for use when limited amounts of experimental materials are to be evaluated. For example, Finney et al (1950) described a micro cookie-baking procedure to evaluate the quality of flour obtained from experimental varieties developed in wheat breeding programs. A micro method for breadmaking, using 10 g of flour, was developed by Shogren et al (1969) and improved by Shogren and Finney (1984) for wheat fractionation and reconstitution studies. However, a micro method for cake baking has not been described.

We plan to evaluate purified fractions of egg whites and bovine blood plasma as substitutes for egg ingredients in cakes. Because these fractions are currently expensive or difficult to prepare in quantities sufficient for the AACC method, a micro procedure for cake baking using a high-ratio, white layer-cake formulation is needed. This article describes such a procedure. In the first part of this study, we used different mixing and baking conditions, including those of AACC 10-90, to determine the optimum conditions for a micro test for cakes. The second part compares this micro procedure with the widely used AACC method 10-90.

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## MATERIALS AND METHODS

### Materials

Cake ingredients and their sources were: cake flour (Super Cake Flour; moisture 13.6%, protein 7.5%, and ash 0.4% on an as-is basis; Mennel Milling Co., Fostoria, OH); spray-dried egg whites (type p-110; Henningsen Foods, Inc., Omaha, NE); spray-dried beef blood plasma (AMPC, Inc., Ames, IA); and emulsified (mono- and diglycerides) shortening (Betrkake; Durkee Industrial Foods Corp., Cleveland, OH). The remaining ingredients, powdered sugar 6X, dry milk solids, double-acting baking powder, and salt were all local retail products.

Samples were analyzed by standard procedures for moisture, protein, and ash (AOAC 1984). Protein contents of samples were estimated using the nitrogen-to-protein conversion factor of 5.7 for flour and 6.25 for egg whites and plasma.

### Equipment

The mixing equipment used for micro preparation of cake batter is shown in Figure 1. A 50-ml beaker (Fig. 1A), used as the mixing bowl, was modified so that the bottom was round like a bowl. A bowl holder (Fig. 1B) was designed to prevent heat transfer from hands through the glass bowl to the batter during mixing and to provide more uniform mixing of the batter by allowing the bowl to turn during mixing. A miniature flat mixing paddle (Fig. 1C) was fabricated from stainless steel to have the same edge design and the same general shape as a regular cake paddle. A miniature whisk (Fig. 1D) was purchased from a local department store. A laboratory stirrer (model SL 600; Fisher Scientific Co., Itasca, IL) was used to mix the batter (not shown). Nonstick surface muffin pans (Fig. 1E) (cup size 7.6 × 3.2 cm, bottom diameter 5.2 cm) were used as baking pans.

### Cake Preparation

To determine the optimum conditions, three mixing times, each consisting of three mixing stages (3+1+1, 4+2+2, and 5+3+3 min); two different speeds (518 and 670 rpm); two types of paddles (flat and whisk); and three baking temperatures (177°C [350°F], 191°C [375°F], and 204°C [400°F]) were tested in a split-plot experimental design. Baking temperatures were assigned at random to the whole plots. Paddle type, mixing speed, and mixing time (12 combinations) were assigned at random to subplots within each whole plot. The three baking temperatures resulted in 36 (12 × 3) cakes per replicate. The experiment was replicated three times.

*Procedure.* The batter formula for the AACC method 10-90 was used, except that the amounts of ingredients were reduced by a factor of 40 (Table I). All dry ingredients were weighed, sifted, and transferred into the mixing bowl and then shortening was added. Mixing and water additions were completed in three stages as in the AACC standard method. The ingredients and 60% of the water (4 ml) were mixed at the lowest speed for 40 sec; thereafter, the batter was mixed at a specified speed (518 or 670 rpm) for a specified time (3, 4, or 5 min). After the first half (1.4 ml) of the remaining water was added, the batter was mixed at the lowest speed for 20 sec and then mixed again at either 518 or 670 rpm for a specified time (1, 2, or 3 min). Finally, the remaining water (1.3 ml) was added and the batter was mixed at the lowest speed for 20 sec, then mixing continued for 1, 2, or 3 min at either 518 or 670 rpm. The specific gravity of each batter was then determined as the ratio of the weight of a standard container filled with batter to that of the same container filled with water.

Cake batter (17.5 g) was transferred to a greased and parchment paper-lined pan and baked at 177, 191, or 204°C for 16.5, 13.5, or 10.5 min (until done). Parchment paper lining was required despite the use of nonsticking pans because cakes made without added egg white or plasma were so fragile that they could not be tested for volume without the liner for support.

*Cake Comparison.* Cakes were prepared by using either the AACC method 10-90 (AACC 1983) or the micro method for cake baking previously described. We determined that acceptable cakes were produced by three stages of mixing (4+2+2 min) at 670 rpm speed and using a flat paddle. We used these conditions to prepare the micro cakes for the comparison study. The formulations used for both methods are given in Table I. AACC cake batter (425 g) was transferred into each of two 20.3-cm (8-in.) diameter cake pans and baked at 191°C for 25 min in an electric oven. AACC baking trials were replicated two times. Micro cakes were baked at 191°C for 13.5 min and replicated three times.

To determine the correlations of physical properties between the micro and AACC methods, cakes were prepared with spray-dried egg whites and blood plasma at 0, 25, 50, 75, and 100% of the normal level of egg-white protein. The amount of water added in the first mixing stage was adjusted to compensate for the different moisture contents of blood plasma and egg whites.

### Physical Evaluation of Cakes

The volumes of the micro cakes were determined by amaranth seed displacement after cooling the cakes for 1.5 hr at room temperature. The micro cakes were stored in plastic bags overnight at 4°C and evaluated the next day for symmetry index (profile), crust color, and texture of the crumb. Volumes of the AACC cakes were determined by rapeseed displacement 2 hr after the cakes were removed from the oven. Symmetry index and height were measured by using the layer cake measuring template as described in AACC method 10-91 (AACC 1983). For our micro cakes, the layer-cake measuring template was reduced to one fourth of its original size. Crust colors of cakes were measured with a Hunterlab Labscan Spectro colorimeter (model LS-5100, Hunter Associates Laboratory, Reston, VA). $L$ (lightness), $a$ (red), and $b$ (yellow) values were obtained after calibrating the instrument by using a white tile with standard values of $X = 78.46$, $Y = 83.14$, and $Z = 85.53$. Fluorescent light was used to illuminate the sample.

### Statistical Analyses

Statistical analyses were performed by using the Statistical Analysis System (SAS 1990). Multiple comparisons were per-

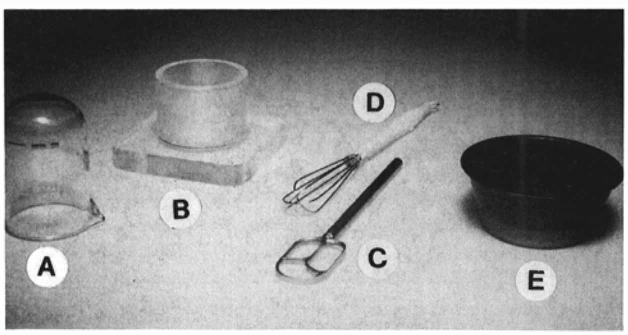


**Fig. 1.** Mixing equipment for micro cake baking. A, mixing bowl; B, bowl holder; C, flat paddle; D, whisk; and E, baking pan.

**TABLE I**
**High-Ratio White Layer-Cake Formulations for AACC and Micro Cake-Baking Methods[a]**

| Ingredients | AACC Method | Micro Method |
|---|---|---|
| Cake flour | 200 | 5.00 |
| Sugar | 280 | 7.00 |
| Shortening | 100 | 2.50 |
| Nonfat dry milk | 24 | 0.60 |
| Dried egg whites | 18 | 0.45 |
| Salt | 6 | 0.15 |
| Baking powder | 10 | 0.25 |
| Water | 270 | 6.70 |
| Stage 1 | 162 | 4.00 |
| Stage 2 | 54 | 1.40 |
| Stage 3 | 54 | 1.30 |

[a] All values are in grams.

formed after a preliminary $F$ test. When the $F$ test was significant at the 0.05 or 0.01 levels. Means were compared by the least significant difference (LSD) test. Correlation coefficients among cake measurements and between the two methods for cake measurements were calculated by using the PROC CORR procedure.

## RESULTS AND DISCUSSION

### Effects of Mixing and Baking Conditions on Micro Cakes

Batter specific gravity was significantly affected ($P < 0.01$) by paddle type, mixing time, and mixing speed (Table II). The whisk produced batters with lower specific gravities (0.804 g/cm$^3$) than did the flat paddle (0.825 g/cm$^3$). The shortest mixing time (3+1+1) produced the highest specific gravity (0.838 g/cm$^3$). Specific gravities of the other two mixing times (4+2+2 and 5+3+3) were not significantly different (0.803 g/cm$^3$). Mixing at 518 rpm also produced batters with higher specific gravities (0.825 g/cm$^3$) than mixing at 670 rpm (0.804 g/cm$^3$). These results indicated that the whisk, higher mixing speed, and longer mixing times incorporated more air into the batter during mixing.

There were also mixing time × paddle type, mixing time × speed, and paddle type × speed interactions on batter specific gravity (Table II). Differences between the mean values for the two paddle types decreased with increasing mixing time. At 5+3+3 min of mixing, both the flat paddle and the whisk gave almost the same batter specific gravity. The influence of mixing speed with mixing time also followed the same trend. Speed had greater effect on the ability of the whisk to incorporate air into the batter than on the flat paddle.

**TABLE II**
**Analysis of Variance for Properties of Micro Cakes Prepared with Different Mixing and Baking Conditions**

| | | *F*-Values[a] | | | |
|---|---|---|---|---|---|
| Source | df[b] | Specific Gravity | Volume | Symmetry Index | Height |
| Replicate (REP) | 2 | 17.94** | 3.86* | ns | ns |
| Temperature (TEMP) | 2 | ns | ns | 31.14** | 30.25** |
| REP × TEMP (error A) | 4 | | | | |
| Paddle type (PTY) | 1 | 29.54** | 17.26** | ns | ns |
| Mixing time (MTM) | 2 | 36.05** | 86.99** | 13.34** | 26.30** |
| PTY × MTM | 2 | 4.71* | ns | ns | ns |
| Speed (SP) | 1 | 28.83** | 63.09** | ns | 11.97** |
| PTY × SP | 1 | 4.32* | ns | ns | ns |
| MTM × SP | 2 | 5.43** | ns | ns | ns |
| PTY × MTM × SP | 2 | ns | ns | ns | ns |
| TEMP × PTY | 2 | ns | ns | ns | ns |
| TEMP × MTM | 4 | ns | ns | ns | ns |
| TEMP × PTY × MTM | 4 | ns | 2.77* | ns | ns |
| TEMP × SP | 2 | ns | ns | ns | ns |
| TEMP × PTY × SP | 2 | ns | ns | ns | ns |
| TEMP × MTM × SP | 4 | ns | ns | ns | ns |
| TEMP × PTY × MTM × SP | 4 | ns | ns | ns | ns |
| Error B | 66 | | | | |

[a]* and ** significant at $P < 0.05$ and $P < 0.01$, respectively. ns = Not significant at $P > 0.05$.
[b]Degrees of freedom.

As with batter specific gravity, cake volume was also significantly affected ($P < 0.01$) by paddle type, mixing time, and mixing speed (Table II). Volume significantly increased with increasing mixing time. The whisk produced higher cake volumes (45.6 cm$^3$) than did the flat paddle (45.1 cm$^3$). Volumes of the cakes (45.8 cm$^3$) prepared at the higher speed were larger than those of the cakes (44.9 cm$^3$) prepared at the lower speed. Although the $F$ test was not significant for baking temperature, the greatest volume was obtained when cakes were baked at 191°C; the next greatest volume was obtained at 204°C.

Cake height and symmetry index (crowning profile) significantly increased as baking temperature and mixing time increased (Table II). Mixing speed also significantly affected cake height; cakes mixed at 670 rpm were higher than cakes mixed at 518 rpm. From observations, cakes mixed for 3+1+1 min gave coarse and dense crumb structure. Cakes mixed for 4+2+2 min and 5+3+3 min were similar, having fine and light crumb cell structures.

Correlation coefficients ($r$) among cake measurements were calculated for each baking temperature and for the composite data over all baking temperatures (Table III). As expected, based on experience with the AACC cake method, the specific gravity of the micro cake batter was significantly and negatively correlated with cake volume and height. An inverse relationship between specific gravity and volume has also been observed by Dunn and White (1939) and Ellinger and Shappeck (1963) for standard-size cakes. Strong positive correlation coefficients among cake volume, symmetry index, and height (at the center) were observed in our micro cake trials.

### Selection of Optimum Mixing and Baking Conditions for Micro Cakes

Three sets of mixing and baking combinations (4+2+2 min, whisk, 670 rpm, 177°C; 4+2+2 min, flat, 670 rpm, 191°C; and 5+3+3 min, whisk, 670 rpm, 191°C) were chosen as potential optimum micro cake conditions and tested further (Table IV). This time, cakes were prepared with egg whites, blood plasma, or without any added protein to see which of these micro mixing and baking combinations would give results similar to those of AACC method 10-90.

In all three mixing and baking combinations, volumes of the cakes prepared without added protein (for egg white substitution) were significantly lower than those in which egg whites or blood plasma were used. There were no significant differences between egg whites and blood plasma cakes. However, the volumes of the egg white cakes mixed with the flat paddle tended to be higher (but not significantly) than those made with blood plasma. Because the flat paddle produced results similar to those of AACC method 10-90, the flat paddle was chosen for use in the subsequent comparison study.

### Comparison of the Micro Method with AACC Method 10-90

Comparisons of the methods were made by preparing cakes with spray-dried egg whites and bovine blood plasma at levels of 0, 25, 50, 75, and 100% of the normal level of egg white protein in the formula. Specific gravities of the batters, and volumes and symmetry indices of the cakes prepared by using the AACC and micro cake-baking methods are shown in Table V. Specific gravities of the cake batters tended slightly toward lower values as

**TABLE III**
**Correlation Coefficients Among Micro Cake Measurements Within Baking Temperature and for Composite Data (All Temperatures)**

| | 171°C[b] | | | 191°C[b] | | | 204°C[b] | | | Composite Data[c] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variables[a] | VOL | SYM | HT | VOL | SYM | HT | VOL | SYM | HT | VOL | SYM | HT |
| SPGR | −0.68**[d] | −0.27 | −0.42* | −0.83** | −0.42* | −0.47** | −0.73** | −0.22 | −0.34* | −0.71** | −0.15 | −0.27** |
| VOL | | 0.45** | 0.63** | | 0.49** | 0.67** | | 0.40* | 0.50** | | 0.33** | 0.49** |
| SYM | | | 0.88** | | | 0.82** | | | 0.90** | | | 0.92** |

[a]SPGR = specific gravity; VOL = volume; SYM = symmetry index; HT = height at the center.
[b]$n = 36$.
[c]$n = 108$.
[d]* and ** significant at $P < 0.05$ and $P < 0.01$, respectively.

the levels of egg whites and blood plasma proteins increased, but these differences were not significant in either the AACC method or in the micro method for egg white or blood plasma cakes. This may be because air is largely incorporated in the fat phase during the mixing process (Carlin 1944, Bell et al 1975). Wootton et al (1967) reported soluble proteins are directly involved in air incorporation only when the batter contains fluid shortenings.

For both methods, cake volumes increased as the levels of spray-dried egg whites and blood plasma increased (Table V, Figs. 2 and 3). Reducing the egg white level from the 100% to the 75% level did not significantly reduce cake volumes in either method. Likewise, the 75% egg white level produced cake volumes similar to that of the 50% egg white level in both methods. The volumes of the plasma cakes at the 100 and 75% levels were not significantly different when prepared by the AACC method, but they were significantly different when prepared by the micro method.

The symmetry index (crown or profile) increased in both the AACC and micro methods as the level of spray-dried egg whites and blood plasma increased (Table V and Figs. 2 and 3). In both methods, the crowning profiles of egg white cakes gradually increased as the level of protein increased 25–100% (Table V), whereas the crowning profile of the blood plasma cakes increased significantly at 25–50%, and then remained similar thereafter in

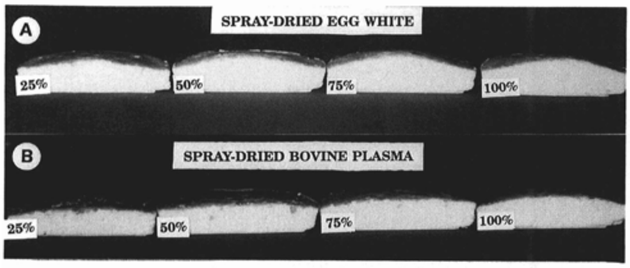


**Fig. 2.** Cakes baked with AACC method 10-90 using different levels of spray-dried egg whites (A) and bovine blood plasma (B) proteins.

**TABLE IV**
**Effect of Preparation Conditions on Volume of Micro Cakes**[a]

| Mixing Time (min) | Paddle Type | Mixing Speed (rpm) | Baking Temperature (°C) | Protein Used | Volume ($cm^3$) |
|---|---|---|---|---|---|
| 4+2+2 | Whisk | 670 | 177 | None | 42.5 b |
| 4+2+2 | Whisk | 670 | 177 | Plasma | 46.3 a |
| 4+2+2 | Whisk | 670 | 177 | Egg whites | 46.2 a |
| 4+2+2 | Flat | 670 | 191 | None | 42.1 b |
| 4+2+2 | Flat | 670 | 191 | Plasma | 46.4 a |
| 4+2+2 | Flat | 670 | 191 | Egg whites | 47.4 a |
| 5+3+3 | Whisk | 670 | 191 | None | 42.4 b |
| 5+3+3 | Whisk | 670 | 191 | Plasma | 48.7 a |
| 5+3+3 | Whisk | 670 | 191 | Egg whites | 48.3 a |

[a] Means with the same letter within the same mixing and baking conditions are not significantly different at $P < 0.05$.

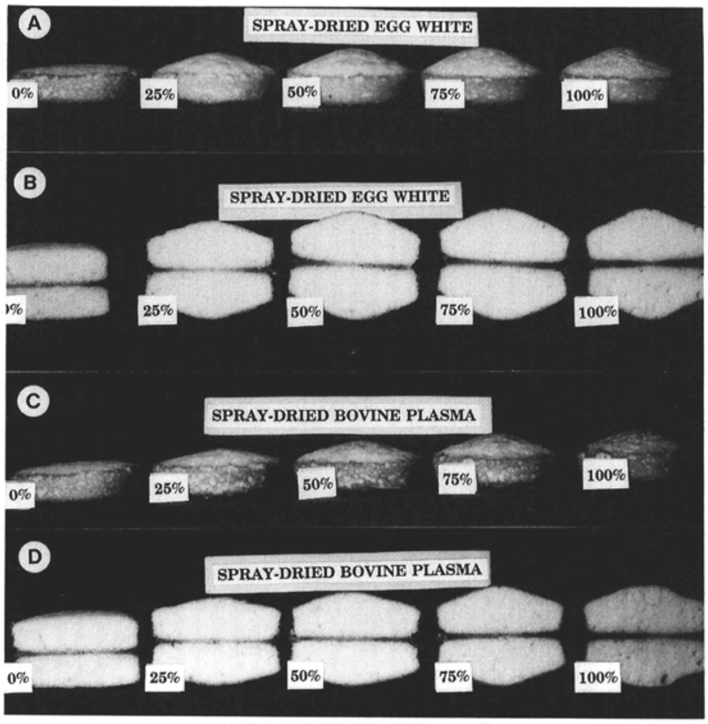


**Fig. 3.** Cakes prepared using the micro cake-baking method and different levels of spray-dried egg whites (A, B) and bovine blood plasma (C, D) proteins.

**TABLE V**
**Properties of Cakes Prepared with Different Levels of Spray-Dried Egg Whites and Bovine Blood Plasma Using AACC and Micro Methods**[a]

| Test and Protein Level (%) | Egg Whites | | Blood Plasma | |
|---|---|---|---|---|
| | AACC | Micro | AACC | Micro |
| Specific gravity $(g/cm)^3$ | | | | |
| 0 | 0.803 ± 0.016 a | 0.801 ± 0.036 a | 0.803 ± 0.016 a | 0.801 ± 0.036 a |
| 25 | 0.806 ± 0.005 a | 0.815 ± 0.031 a | 0.802 ± 0.000 a | 0.789 ± 0.025 a |
| 50 | 0.789 ± 0.023 a | 0.798 ± 0.054 a | 0.782 ± 0.023 ab | 0.772 ± 0.019 a |
| 75 | 0.789 ± 0.013 a | 0.805 ± 0.015 a | 0.778 ± 0.006 ab | 0.782 ± 0.024 a |
| 100 | 0.780 ± 0.029 a | 0.775 ± 0.030 a | 0.765 ± 0.017 b | 0.774 ± 0.027 a |
| LSD ($P < 0.05$)[b] | 0.049 | 0.064 | 0.038 | 0.049 |
| Volume ($cm^3$) | | | | |
| 0 | 854 ± 34 a | 40.3 ± 0.6 a | 854 ± 34 a | 40.3 ± 0.6 a |
| 25 | 979 ± 7 b | 43.5 ± 0.6 b | 916 ± 13 b | 42.4 ± 1.0 b |
| 50 | 1,029 ± 10 c | 45.6 ± 0.5 c | 969 ± 11 c | 43.9 ± 0.9 c |
| 75 | 1,035 ± 4 cd | 46.1 ± 0.2 cd | 1,013 ± 2 d | 44.7 ± 0.5 c |
| 100 | 1,079 ± 22 d | 47.1 ± 0.6 d | 1,048 ± 1 d | 46.1 ± 0.4 d |
| LSD ($P < 0.05$) | 48 | 1.0 | 44 | 1.3 |
| Profile (mm) | | | | |
| 0 | 0.5 ± 0.7 a | 3.9 ± 1.2 a | 0.5 ± 0.7 a | 3.9 ± 1.2 a |
| 25 | 14.0 ± 0.2 b | 8.8 ± 1.2 b | 4.4 ± 0.6 a | 6.4 ± 2.1 b |
| 50 | 15.5 ± 0.4 bc | 10.1 ± 0.8 bc | 7.6 ± 0.9 c | 9.9 ± 1.0 c |
| 75 | 17.0 ± 0.7 bc | 11.2 ± 0.6 cd | 8.1 ± 0.1 c | 9.6 ± 0.4 c |
| 100 | 17.3 ± 2.5 c | 12.0 ± 0.8 d | 8.6 ± 0.2 c | 10.0 ± 0.6 c |
| LSD ($P < 0.05$) | 3.1 | 1.7 | 1.5 | 2.2 |

[a] Means ± one standard deviation with the same letter within the same subcolumn are not significantly different at $P < 0.05$.
[b] Least significant difference.

either method.

Figure 4 shows the relationships between the specific gravities, cake volumes, and symmetry indices (profiles) for batters and cakes prepared with egg whites and blood plasma by using the AACC standard method and the micro method. Highly significant correlation coefficients ($P < 0.01$) between cake volumes ($r = 0.99$) and profiles ($r = 0.98$ and 0.99) for the two methods suggest that the micro method provides a simple and reliable alternative to the AACC method.

### Comparison of Egg White and Plasma Cakes

Egg white and plasma proteins were compared in both methods to see whether we would come to the same conclusions about the cake-baking properties of each protein source, irrespective of the method used. When cakes were prepared by using the AACC method, volumes of the plasma cakes at the 100% protein level were about 3% lower than those of the egg white cakes at the same level, but this difference was not significant. This was less than the 7% reduction in cake volume previously reported by Lee et al (1991). Volumes of the cakes containing 100% blood plasma were not significantly different from cakes containing 50–75% egg whites (Table VI). Likewise, at 75% of the normal egg white level, plasma cakes were not significantly different from cakes made with 25–75% egg whites. These results confirm that blood plasma protein is slightly less effective than egg white protein.

When cakes were prepared by using the micro method, blood plasma protein at the 100% level produced about the same volume as did egg white protein. As with AACC method 10-90, the volumes of blood plasma cakes at the 100% level were not significantly different from the volumes of egg white cakes at the 50–75% levels (Table VI). Cakes made with blood plasma protein at the 75 and 50% levels were equivalent to cakes made with egg white protein at the 50 and 25% levels, respectively. The micro baking results also show that blood plasma protein was less efficient than egg white protein at the same levels as was shown when using the AACC method 10-90. In both methods, egg whites gave more highly crowned profiles than did blood plasma at the same protein levels. However, blood plasma cakes prepared by the micro method produced more highly crowned profiles than did blood plasma cakes prepared with the AACC method.

Crust colors of blood plasma cakes were significantly darker than those of egg white cakes prepared by either method (Table VII). Because crust colors of the micro cakes were lighter than those of the standard cakes, another experiment was undertaken to determine a baking time for micro cake baking that would give similar crust colors to the standard cakes. Cakes were prepared with 100% egg whites and baked at 191°C for 13.5, 14.5, 15.0, 15.5, 16.0, 16.5, and 17.0 min. Cake volumes and crust colors were determined. In general, cake volume decreased with longer baking times, but the differences were not significant. Crust colors similar to that of the standard cake were obtained when micro cakes were baked for 15.5 min.

## CONCLUSIONS

A micro method for cake baking using a high-ratio white layer-cake formulation was developed to test expensive experimental

**TABLE VI**
**Effects of Different Levels of Egg Whites and Bovine Blood Plasma on Cake Volumes[a]**

| Method | Protein Level (%) | Volume (cm³) Egg Whites | Plasma |
|---|---|---|---|
| AACC 10-90 | 0 | 854 a | 854 a |
| | 25 | 979 cd | 916 b |
| | 50 | 1,029 ef | 969 c |
| | 75 | 1,035 ef | 1,013 de |
| | 100 | 1,079 g | 1,048 fg |
| | LSD ($P < 0.05$)[b] | 34 | 34 |
| Micro method | 0 | 40.3 a | 40.3 a |
| | 25 | 43.5 c | 42.4 b |
| | 50 | 45.6 ef | 43.9 cd |
| | 75 | 46.1 fg | 44.7 de |
| | 100 | 47.1 g | 46.2 fg |
| | LSD ($P < 0.05$) | 1.1 | 1.1 |

[a] Means within each section followed by the same letter are not significantly different at $P < 0.05$.
[b] Least significant difference.

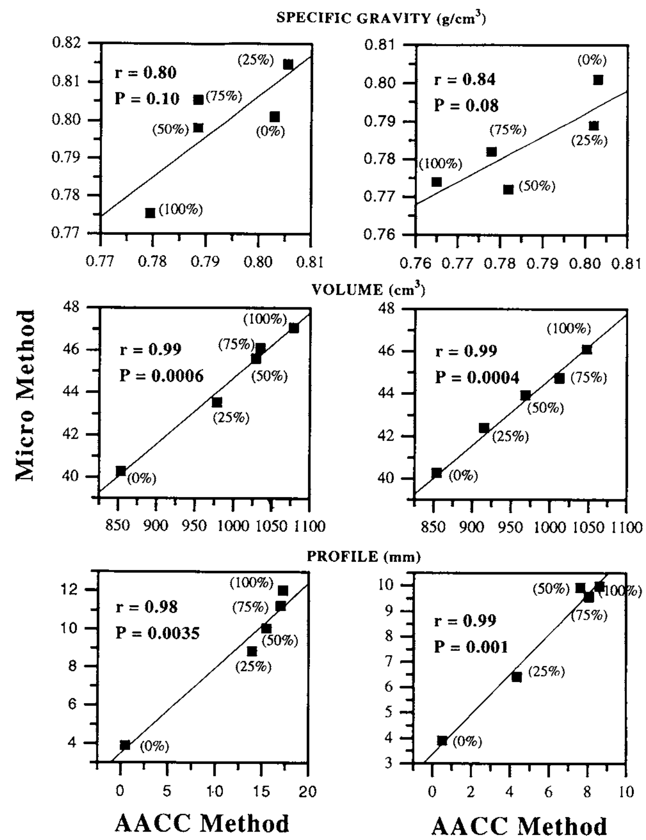


**Fig. 4.** Relationships between batter specific gravity (top), cake volume (middle), and cake profile (bottom) determined by using AACC method 10-90 or the micro method with egg whites (left) and blood plasma (right).

**TABLE VII**
**Crust Colors of Cakes Baked with AACC and Micro Cake-Baking Methods Using Different Levels of Egg Whites and Blood Plasma[a,b]**

| Protein and Level | AACC Cake-Baking Method *L* | *a* | *b* | Micro-Cake-Baking Method *L* | *a* | *b* |
|---|---|---|---|---|---|---|
| None (0%) | 67.4 ± 0.2 a | 9.5 ± 0.3 b | 25.5 ± 0.5 ab | 81.2 ± 0.1 a | 4.6 ± 0.3 d | 26.7 ± 0.0 b |
| Egg whites (50%) | 66.9 ± 3.3 a | 10.5 ± 0.7 b | 26.9 ± 1.0 a | 74.7 ± 0.8 b | 8.4 ± 1.2 c | 28.2 ± 0.8 a |
| Egg whites (100%) | 65.4 ± 2.0 a | 12.0 ± 0.7 a | 27.4 ± 0.3 a | 70.9 ± 0.1 c | 10.6 ± 0.7 b | 28.6 ± 0.1 a |
| Blood plasma (50%) | 58.5 ± 1.6 b | 12.2 ± 0.2 a | 23.4 ± 1.5 bc | 61.6 ± 0.6 d | 12.9 ± 0.1 a | 25.4 ± 0.6 c |
| Blood plasma (100%) | 52.3 ± 0.5 c | 13.4 ± 0.6 a | 22.1 ± 1.1 c | 58.4 ± 1.2 e | 13.9 ± 0.0 a | 24.4 ± 0.4 c |

[a] Mean values of two replicates, ± one standard deviation. Means with the same letter within a column are not significantly different at $P < 0.05$.
[b] Crust color was measured using a Hunterlab colorimeter. $L$ = lightness (100 white, 0 black); $a$ = +red, −green; $b$ = +yellow, −blue.

ingredients. Acceptable cakes were produced by using three-stage mixing (4+2+2 min) at 670 rpm mixing speed, using a flat paddle, and baking at 191°C. Although only one cake flour was considered, the cake properties obtained using the micro method were highly correlated with those obtained by using AACC method 10-90. The micro method reduced the amount of ingredients to 1/40th of that required by the AACC standard method. Therefore, the micro method for cake baking is applicable for many in situations in which there are only limited amounts of ingredients available, offering a convenient, simple, and rapid alternative to the AACC standard method for ingredient evaluation in high ratio, white layer cakes.

## LITERATURE CITED


AMERICAN ASSOCIATION OF CEREAL CHEMISTS. 1983. Approved Methods of the AACC, 8th ed. Method 10-90, approved October 1976, revised October 1982; Method 10-91, approved April 1968, reviewed October 1982. The Association: St. Paul, MN.

AOAC. 1984. Official Methods of Analysis, 14th ed. Association of Official Analytical Chemists: Arlington, VA.

BELL, A. V., BERGER, K. G., RUSSO, J. V., WHITE, G. W., and WEATHERS, T. L. 1975. A study of the micro-baking of sponges and cakes using cine and television microscopy. J. Food Technol. 10:147.

CARLIN, G. T. 1944. A microscopic study of the behavior of fats in cake batters. Cereal Chem. 21:189.

DUNN, J. A., and WHITE, J. R. 1939. The leavening action of air included in cake batter. Cereal Chem. 14:93.

ELLINGER, R. H., and SHAPPECK, F. J. 1963. The relation of batter specific gravity to cake quality. Baker's Dig. 37(6):52

FINNEY, K. F., MORRIS, V. H., and YAMAZAKI, W. T. 1950. Micro versus macro cookie baking procedures for evaluating the cookie quality of wheat varieties. Cereal Chem. 27:42

LEE, C. C., JOHNSON, L. A., LOVE, J. A., and JOHNSON, S. 1991. Effects of processing usage level on performance of bovine plasma as an egg white substitute in cakes. Cereal Chem. 68:100

SAS. 1990. SAS/STAT User's Guide: Statistics. SAS Institute, Inc.: Cary, NC.

SHOGREN, M. D., FINNEY, K. F., and HOSENEY, R. C. 1969. Functional (breadmaking) and biochemical properties of wheat flour components. I. Solubilizing gluten and flour protein. Cereal Chem. 46:93.

SHOGREN, M. D., and FINNEY, K. F. 1984. Bread making test for 10 grams of flour. Cereal Chem. 61:418

WOOTTON, J. C., HOWARD, N. B., MARTIN, J. B., McOSKER, D. E., and HOLME, J. 1967. The role of emulsifiers in the incorporation of air into layer cake batter systems. Cereal Chem. 44:333.


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