Edible Beef Tallow Substitution in White Layer Cakes[1]

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ABSTRACT

Cereal Chem. 58(3):213–216

The functional use of edible beef tallow fractions (25°C solid and 35°C olein) with and without added emulsifiers was determined in white layer cakes prepared by AACC method 10-90. Denser, less viscous batters were produced by the nonemulsified tallow fractions. Viscosities of the emulsified tallow fraction batters were significantly lower than the control batter viscosity, although viscosity of the solid fraction batter was greater than viscosity of the olein fraction batter. These factors corresponded to lower volumes for cakes prepared with nonemulsified tallow than for those with emulsified tallow. Although no significant differences were found in tenderness, the emulsified tallow produced a softer cake. An eight-member taste panel scored both emulsified tallow fraction cakes higher than the cakes prepared with the olein tallow fraction without added emulsifier.

The production of beef tallow in the United States approximates 5.5 billion pounds annually, of which over 50% is exported. Less than 10% of the total amount is used for edible products (Taylor et al 1976). The use of edible beef tallow in this country has been limited to shortenings and spreads. The low production cost of edible beef tallow makes its use favorable as an inexpensive substitute for more costly imported fats and oils (USDA 1977). Fractionated beef tallow has also been reported to be similar or superior to imported fats and oils (Burnham 1978, Taylor et al 1976).

This research investigated the use of beef tallow with and without an emulsifying agent as the shortening ingredient in white layer cakes. In the cake system, fat acts primarily to increase the amount of air incorporated into the batter. Finely dispersed fat globules allow smaller and more numerous air cells to be incorporated. Moncrieff (1970) reported that emulsifiers aid in batter aeration by uniformly dispersing small fat globules and thereby increasing the number of small air bubbles incorporated, which corresponds to an increase in volume in the baked product. If a surfactant is used, the source of fat probably has less effect than if a surfactant is not used. Prior investigations (Del Vecchio 1975, Guy and Vettel 1973, MacDonald 1968) have shown that emulsifiers significantly increase cake volume in various cake systems using different fats.

[1]Published as Michigan Agricultural Experiment Station Journal Article 9603. Research was supported by a grant from the Fat and Proteins Research Foundation, Inc.

0009-0352/81/03021304/$03.00/0
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MATERIALS AND METHODS

Preparation of Samples

Four tallow fractions were used for this study: one olein and one solid, obtained by detergent (sodium dodecyl sulfate) fractionation of tallow at controlled temperatures, 25°C for solid and 35°C for olein (Evans et al 1980), and each of the tallow fractions plus 3% (flour basis) commercial emulsifier. This emulsifier, Vanall (Patco Products), was a hydrated blend of sorbitan monostearate, glycerol monostearate, and polysorbate 60, with propylene glycol, lactic acid, and sodium propionate included as preservatives. A commercial hydrogenated vegetable shortening, Crisco (Procter and Gamble), containing monoglycerides and diglycerides was used as a comparison standard.

During preliminary experiments the concentration of emulsifier used was determined by its performance according to the AACC method for Baking Quality of Cake Flour, 10-90 (AACC 1967). Cakes prepared with emulsifier added to the tallow at the 3 and 2% (flour basis) level were compared to a control cake. The cake with tallow and 3% added emulsifier had a greater volume than did the cake with tallow and 2% added emulsifier or the control cake. No apparent differences were observed for symmetry, uniformity, or tenderness between the two emulsified tallow cakes and the control cake. Thus the 3% emulsifier added to the tallow was based on these preliminary results and on commercial specifications.

AACC method 10-90 was followed to prepare all experimental cakes for five replications. The formula was reduced to 87.5% of the recipe to allow the use of 7-in. baking pans.

Measurements of Quality

Batter specific gravity was determined gravimetrically. Viscosity was measured using the Brookfield viscometer (model RVT) with spindle 6 at 10 rpm. Tenderness and compressibility of baked cakes were determined using an Allo-Kramer shear press. The plastic template included with AACC method 10-90 was converted for use with a 7-in. cake and used to measure shrinkage, volume index, symmetry index, and uniformity index. Volume was also determined by rapeseed displacement using the National loaf volumeter. A trained eight-member taste panel evaluated the internal factors according to the scale provided with AACC method 10-90. Tasting was performed in individual booths in a controlled atmosphere.

Analyses of variance and Duncan's multiple range tests (Duncan 1957) were performed on the five replications to identify significant differences at the 0.05 level of probability.

RESULTS AND DISCUSSION

Effect of Type of Fat

Physical characteristics of the cakes are shown in Table I. The two batters prepared using beef tallow without emulsification had significantly greater specific gravities than did the batter made with hydrogenated vegetable shortening (control). Viscosities of both tallow batters were significantly less than the control batter viscosity. These two factors indicated that less air was incorporated into the batters containing fractionated beef tallow. This corresponds to the lower volume evident in the baked product. Both the volume by rapeseed displacement and the volume index by the AACC method 10-90 template indicated that significantly lower volumes were obtained in the two tallow cakes than in the control. No significant difference was observed for symmetry index, uniformity index, or shrinkage. However, cakes with the olein tallow fraction exhibited slightly sunken centers (Fig. 1).

Cake tenderness is affected by the presence of fat, which acts as a lubricant to enable gluten strands to slide across one another. Fat also inhibits extensive gluten formation by physically interfering with gluten strand development (Bennion 1972). The cakes prepared with beef tallow showed no significant difference from the control in the amount of force needed to shear the cake samples. This indicates that beef tallow has tenderizing effects in white cakes similar to that of hydrogenated vegetable shortening. Compressibility readings show that significantly more force was needed to compress the solid tallow fraction cake sample than was needed to compress the control. These factors indicate that the solid tallow fraction produced firmer yet equally tender white cakes than did hydrogenated vegetable shortening.

Sensory evaluation results (Table II) revealed that major differences occurred mainly for the olein tallow fraction cake. Significantly lower scores were obtained for grain, moistness, tenderness, softness, crumb color, and total score. Crumb color for the solid tallow fraction cake was also ranked significantly lower than that of the control. No significant difference in cell uniformity and size or in flavor were found.

This study revealed that cakes prepared using less expensive beef tallow as the source of fat were of inferior quality. Objective tests showed that poor quality cakes resulted from the use of solid and olein tallow fractions, and sensory results indicated that olein tallow cakes were below standard.

Effect of Emulsifier

Physical measurements are shown in Table I. The batters prepared using beef tallow plus emulsifier had significantly

TABLE I
Physical Characteristics[a] of AACC White Layer Cakes Prepared with Commercial Shortening,[b] Two Tallow Fractions, and Two Tallow Fractions with Added Emulsifier[c]

		Tallow Fractions[d]			
		Without Emulsifier		With Emulsifier	
Characteristics	Commercial Shortening[d]	Solid[e]	Olein[e]	Solid	Olein
Batter					
Specific gravity	0.722 a ± 0.022	0.895 b ± 0.104	0.939 b ± 0.078	0.749 a ± 0.055	0.787 a ± 0.042
Viscosity (poise)	41.4 a ± 4.2	21.5 c ± 9.0	14.5 c ± 2.8	30.8 b ± 8.6	15.6 c ± 2.8
Cake					
Volume (cm^3)	1004 a ± 38	891 b ± 62	884 b ± 69	989 a ± 27	1005 a ± 39
Tenderness (lb/g)	1.58 ± 0.50	1.73 ± 0.63	1.96 ± 0.59	1.70 ± 0.59	1.66 ± 0.75
Compressibility (lb/cm comp)	4.99 bc ± 0.73	5.99 a ± 1.37	5.90 ab ± 1.19	4.65 c ± 1.42	4.76 c ± 1.42
Volume index (cm)	11.40 a ± 0.21	9.64 b ± 0.26	9.50 b ± 0.52	11.34 a ± 0.42	11.62 a ± 0.54
Symmetry index (cm)	0.30 ± 0.42	0.08 ± 0.25	0.16 ± 0.62	0.36 ± 0.51	0.74 ± 0.53
Uniformity index (cm)	0.02 ± 0.11	0.00 ± 0.14	0.12 ± 0.34	0.04 ± 0.21	0.02 ± 0.16
Shrinkage (cm)	1.00 ± 0.20	0.86 ± 0.30	0.74 ± 0.05	1.06 ± 0.25	0.78 ± 0.45

[a] Based on five replications.
[b] Crisco, hydrogenated vegetable shortening (Procter and Gamble).
[c] Vanall (Patco Products, Kansas City) added at 3% fat basis.
[d] Means followed by the same letter showed no significant difference ($P<0.05$).
[e] Fractionation at 25°C for solid fraction, 35°C for olein.

($P<0.05$) lower specific gravities than did the batters made with tallow without added emulsifier but were comparable to the control. The viscosities of the tallow plus emulsifier batters were significantly ($P<0.05$) less than that of the control, although that of the solid fraction batter was greater than that of the olein fraction batter. The viscosity of the olein fraction plus emulsifier batter was similar to those of the nonemulsified tallow batters. These factors indicated that more air was incorporated into the tallow plus emulsifier batters, especially the one with the solid fraction, in agreement with Moncrieff's (1970) finding that emulsifiers aid in batter aeration.

Both volume by rapeseed displacement and volume index indicated a significant increase in volume of emulsified tallow cakes (both fractions) over nonemulsified tallow cakes (both fractions). The volume measurements from both methods also indicated that emulsified tallow yielded cakes with volume comparable to that of cakes prepared with hydrogenated vegetable shortening. No significant differences were observed for symmetry index,

TABLE II
Internal Factors[a] of AACC White Layer Cakes Prepared with Commercial Shortening[b], Two Tallow Fractions, and Two Tallow Fractions with Added Emulsifier[c]

		Tallow Fractions[d]			
	Commercial	Without Emulsifier		With Emulsifier	
Characteristics	Shortening[d]	Solid[e]	Olein[e]	Solid	Olein
Cells					
Uniformity	6.8 ± 0.8	8.3 ± 1.1	7.4 ± 2.1	6.6 ± 0.5	6.7 ± 0.7
Size	7.9 d ± 0.5	8.4 ± 0.7	7.4 ± 1.1	7.9 ± 0.4	8.0 ± 0.9
Thickness of walls	8.2 a ± 0.3	8.5 a ± 1.0	6.8 b ± 0.8	8.0 a ± 0.1	8.0 a ± 0.8
Grain	14.0 a ± 0.6	12.5 ab ± 1.5	11.4 b ± 0.9	13.9 a ± 0.6	13.3 a ± 1.6
Texture					
Moistness	8.7 a ± 0.3	8.3 a ± 0.6	7.3 b ± 0.6	8.5 a ± 0.5	8.9 a ± 0.9
Tenderness	12.1 a ± 0.4	11.7 a ± 0.6	9.3 b ± 1.6	12.5 a ± 0.5	12.0 a ± 2.2
Softness	8.9 a ± 0.5	8.3 ab ± 0.7	7.0 b ± 0.9	9.3 a ± 0.7	9.0 a ± 1.7
Crumb color	9.4 a ± 0.3	8.7 b ± 0.2	8.3 b ± 0.2	9.4 a ± 0.2	9.3 a ± 0.5
Flavor	8.7 ± 0.5	8.5 ± 0.7	7.4 ± 0.7	8.9 ± 1.1	8.1 ± 0.9
Total	84.5 a ± 2.9	83.6 a ± 5.9	72.0 b ± 7.4	85.6 a ± 1.6	82.6 a ± 9.8

[a] Based on AACC method 10-90 scale for five replications; eight taste panel members.
[b] Crisco, hydrogenated vegetable shortening (Procter and Gamble).
[c] Vanall (Patco Products, Kansas City) added at 3% flour basis.
[d] Means followed by the same letter showed no significant difference ($P<0.05$).
[e] Fractionation at 25°C for solid fraction, 35°C for olein.

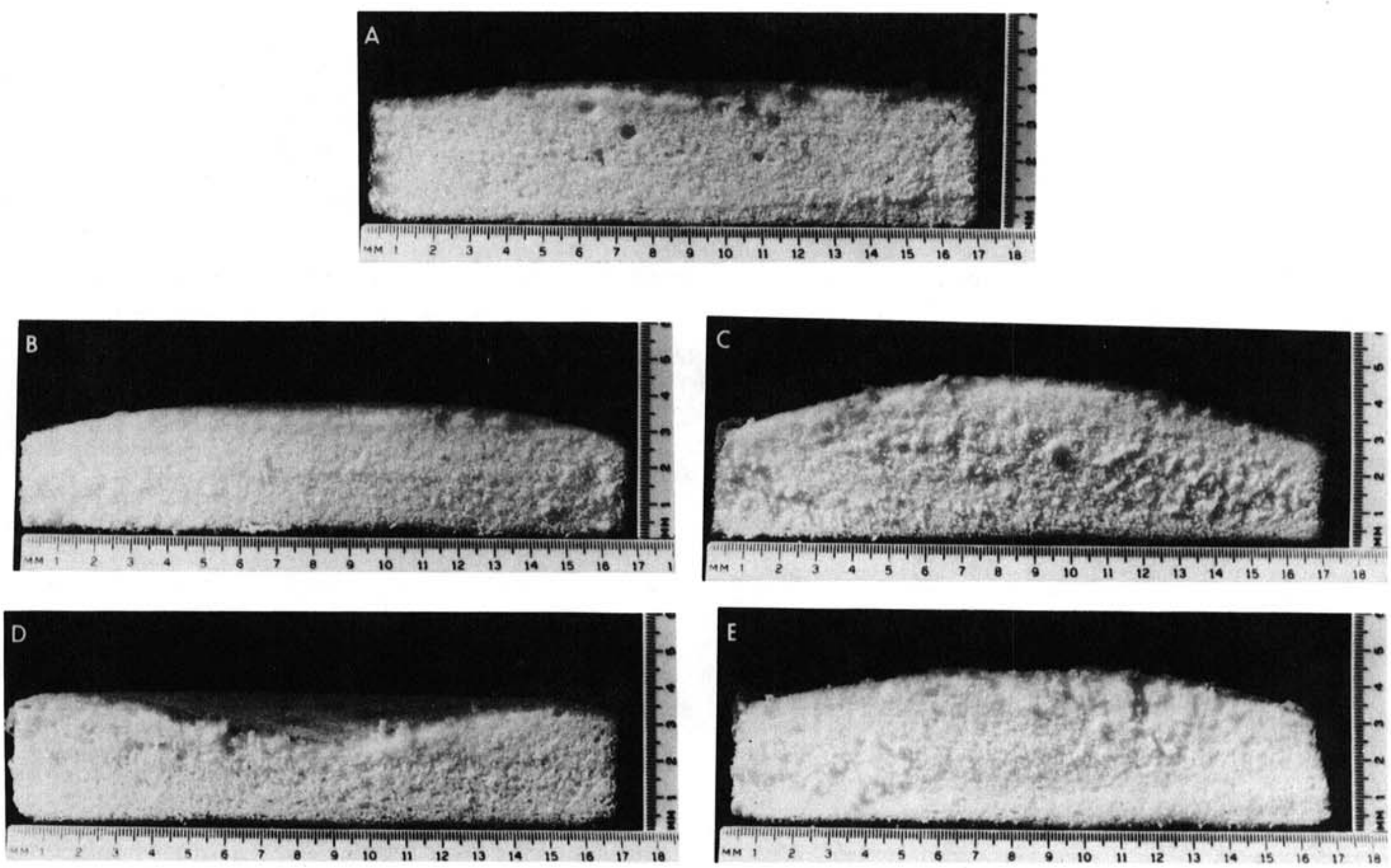

Fig. 1. Cross section of cakes made with: **A,** a commercial shortening; **B,** a 25°C solid tallow fraction; **C,** 25°C solid tallow fraction plus emulsifier; **D,** a 35°C olein tallow fraction; and **E,** a 35°C olein tallow fraction plus emulsifier.

uniformity index, or shrinkage for any of the treatment levels. Therefore the emulsified and nonemulsified tallow cakes yielded products comparable to the control according to indices measured by the AACC template method, with the exception of the volume index for the two nonemulsified tallow cakes. The improvement in cake volume and structure when emulsifiers were included in the formula is shown in Fig. 1.

Tenderizing effects in white cakes were similar for emulsified tallow, nonemulsified tallow, and hydrogenated vegetable shortening. This was indicated by no significant difference in the amount of force required to shear the cake samples. Compressibility readings, on the other hand, revealed that significantly less force was required to compress the emulsified tallow cakes than the nonemulsified tallow cakes yet was comparable to the force required for the control cakes. Thus emulsified tallow yielded cakes that were softer but as tender as nonemulsified tallow cakes.

Sensory evaluation results (Table II) show that taste panelists preferred both cakes with emulsified tallow fractions over the cake with the olein fraction without added emulsifier. This was indicated by significantly higher ratings obtained for cell wall thickness, grain, moistness, tenderness, softness, crumb color, and total score. Cakes with either emulsified fraction were also scored significantly higher for crumb color than was the cake with the solid fraction without added emulsifier. No significant differences were observed between the two emulsified tallow cakes and the control cake for any of the sensory evaluation criteria.

This investigation revealed that more economical beef tallow plus emulsifier may be substituted for vegetable shortenings in white layer cakes without adverse effects. No significant differences were found for volume, compressibility, tenderness, and sensory evaluation between cakes prepared with the tallow fractions and cakes prepared with commercial shortening. However, on the average, the use of nonemulsified tallow yielded white layer cakes of inferior quality. Significant differences were found for crumb color, volume, and compressibility between cakes with both tallow fractions and the control. The scores for texture, grain, cell wall thickness, and total sensory evaluation given the cake with the olein fraction were significantly lower than those given all other cakes.

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[Received September 5, 1980. Accepted October 16, 1980]