Use of Frozen, Foam-Spray-Dried, Freeze-Dried, and Spray-Dried Whole Eggs in Yellow Layer Cakes[1]

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ABSTRACT

This study compared the performance of frozen, foam-spray-, freeze-, and spray-dried eggs in cakes containing fat and prepared by the long, multi-stage, conventional method. No significant differences were noted in specific gravities of cake batters. Ranked in order of decreasing viscosity were batters prepared with spray-, foam-spray-, freeze-dried, and frozen eggs. Nevertheless, a highly significant negative correlation coefficient between batter stability, as indicated by drainage, and batter viscosity indicated thinnest batters were most stable. Objective measurements of volume indices, compressibility, tenderness, and Hunter L and a_L values showed no significant differences attributable to egg processes; however, cakes prepared with spray-dried eggs appeared more yellow as indicated by b_L values than cakes prepared with other types of eggs ($P < 0.05$). No significant differences attributable to egg processes were found in sensory evaluations of crust texture, interior color, cell size, cell distribution, tenderness, crumb, and flavor. All cakes were judged acceptable.

New and/or improved methods for processing eggs have been developed in recent years. The functional performance of some types of processed eggs, such as spray-dried, has been studied while other types, such as foam-spray-dried and freeze-dried, have received limited investigation. In an early study, Grover and Hawthorne (1) found a positive correlation between baking quality and solubility of spray-dried whole eggs. Tinklin and Vail (2) reported similar results. Investigating the effect of storage on spray-dried eggs, Schlosser et al. (3) found egg solids of good initial quality made acceptable cakes. The performance of foam-spray-, freeze-, and spray-dried eggs varied when sponge and chiffon cakes or cream puffs were used as test products (4,5).

The purpose of this study was to compare the performance of frozen, foam-spray-, freeze-, and spray-dried eggs in cakes containing fat. In their investigation of the effect of mixing method on the quality of the finished cake, Tinklin and Vail (6) found, in general, very quick methods of mixing gave inferior cakes. Therefore, the long, multi-stage, conventional method of mixing was used to prepare the six replications of cakes from each of the four types of processed eggs.

METHODS

Cake Preparation

Eggs from a common source were processed, packaged, and stored as outlined by Funk et al. (5). Also, repackaging into amounts needed for one replication followed the same procedure described by these investigators. All eggs were stored at -23°C.

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Ingredients were each from a common lot. Sugar and whole milk powder as well as the combined flour, baking powder, and salt were weighed into amounts appropriate for one replication prior to data collection. The milk powder was packaged in heat-sealable pouches and stored at 5°C., whereas other ingredients were put into polyethylene bags, closed, and stored at room temperature.

Frozen eggs were thawed at 2° to 4°C. for 24 hr. while dried eggs were defrosted at room temperature for 15 to 20 min. All dried eggs were reconstituted as described by Funk et al. (5). Dried milk was reconstituted by sprinkling the powder onto the surface of distilled water and then stirring with a wire whip. Both the reconstituted milk and eggs stood undisturbed at room temperature for 15 min. to aid in rehydration. Hydrogenated vegetable shortening containing only the additive, methyl silicone, was weighed just prior to preparation.

The long, multi-stage, conventional method was used to combine the weighed or measured ingredients (Table I). Using a 5-qt. bowl for a KitchenAid mixer, Model K5-A, equipped with a batter-beater attachment, the fat was creamed for 2 min. at speed 4 (132 r.p.m.) before the sugar was added over a 1-min. period. After addition of the unbeaten eggs and vanilla, mixing was continued for 30 sec. at speed 2 (92 r.p.m.). The beater and bowl were then scraped and mixing was continued for 7.5 min. at speed 4. Using speed 1 (56 r.p.m.) the sifted dry ingredients were added in three aliquots intermittently with the reconstituted milk which had been divided into two equal portions. The batter was then blended for 15 sec. at speed 2. Total mixing time after the addition of the flour began was 2 min. 10 sec.; the over-all mixing time was 13 min. 10 sec.

Three hundred grams of cake batter was poured into each of four 8-in. aluminum layer-cake pans which had previously been oiled and lined with oiled waxed paper. The four cakes, comprising one replication, were baked simultaneously in a Hotpoint roasting and baking oven, Model HJ225, preheated to and maintained at 177°C. ± 2° with the grids set on medium and the damper half open. Cakes designated for specific objective measurements or sensory evaluation were placed in the oven according to a previously developed rotation plan designed to negate any effects of oven position.

TABLE I. CAKE FORMULA FOR ONE REPLICATION[a]

Ingredients	Amount	Percentage of Flour
Shortening	188.0 g.	49.0
Sugar	400 g.	104.2
Vanilla	10 ml.	2.6
Eggs[b]	213.0 g.	55.5
Flour, cake	384 g.	...
Baking powder, SAS type	15.4 g.	4.0
Salt	6.4 g.	1.7
Milk[c]	480.0 g.	125.0

[a]Batter for four 8-in. layers and objective measurements.

[b]75.0, 73.5, and 75.0 g. of foam-spray-, freeze-, and spray-dried eggs reconstituted with 138.0, 139.5, and 138.0 g. of distilled water, respectively.

[c]Dried milk solids (52.5 g.) and distilled water (427.5 g.).

Cakes were removed from the oven after 25 min. and allowed to cool on wire racks for 15 min. before they were removed from the pans. After an additional cooling period of approximately 1 hr., the cakes were wrapped in plastic food wrap, placed on cardboard trays, labeled, put into polyethylene bags, and frozen at -23°C.

Objective Measurements

Specific gravity of cake batter was determined as outlined by Brown and Zabik (7). Using a No. 5 spindle at a speed of 20 r.p.m., the batter viscosity was determined with a Brookfield viscometer, Model RVF, as described by Matthews and Dawson (8). Percentages of moisture lost during baking were calculated from the before- and after-baking weight of one specifically designated cake from each replication.

To test emulsion stability, 12 ml. of batter was put into each of two 15-ml. calibrated centrifuge tubes. After covering with Parafilm, the filled tubes were set in a 30°C. water bath for approximately 20 hr. Emulsion stability was indicated by separation of oil from batter.

Tenderness and compressibility of designated cake samples were measured with an Allo-Kramer shear press, Model SP-12, equipped with an E2EZ electronic recorder by the methods outlined by Funk et al. (9). A 100-lb. proving ring, 25 lb. of pressure, and a range of 50% were used for all measurements. Tenderness was expressed as maximum force and area-under-the-curve indices by the method outlined by Franks et al. (10) to calculate the former, and methods described by Funk et al. (9) to calculate the latter. However, a conversion factor of 175.2 was used.

Color of designated cake samples was determined using a Hunter Color-Difference meter, Model D-25, standardized with a yellow tile covered with an optical lens (L, 82.8; a_L, -3.5; b_L, +26.2). The crust was cut from duplicate cake samples, the cut surface was covered with an optical lens, and two sets of readings were obtained by rotating each sample one-quarter of a turn. For each replication, the mean color values were calculated from the four readings.

As an index to volume, the height of the cake designated for color determinations was measured to the nearest 0.01 cm. with a vernier caliper after the cake had been cut in half. Five measurements, at the edges, center, and equal distances from the edges and center, were averaged and the value expressed as an index to volume for each replication.

Sensory Evaluation

Cake samples, 5.08 cm. in diameter, were cut from the designated frozen cake, wrapped in plastic food film, placed on coded paper plates, and allowed to thaw at room temperature for 1 hr. A six-member taste panel scored samples for crust texture, interior color, cell size, cell distribution, tenderness, mouth-feel, and flavor using a 1-to-5-to-1-point scale. An attribute of excellent quality was given a score of 5 with continuums on either side to permit assessments of two equally undesirable characteristics of each as shown in Fig. 1. This descriptive separation of characteristics allowed the researchers opportunity to better determine the type of deviation from the standard even though both descriptions with the same number were analyzed as one. Judges, evaluating one sample from each of three variables at

Attribute	1	2	3	4	5	4	3	2	1
CRUST TEXTURE	Extremely pebbly and coarse	Very pebbly	Moderately pebbly	Slightly pebbly	Very slightly pebbly	Slightly smooth	Moderately smooth	Smooth and shiny	Very smooth and shiny. Cracked
INTERIOR COLOR	Too pale. Off-white	Off-white with yellow flecks	Yellowish white with yellow flecks	Yellowish creamy white	Creamy yellow	Very slight brownish cast	Slight brownish cast	Moderate brownish cast	Brownish cast
CELL SIZE	Extremely small and compact	Very small and compact	Slightly small	Very slightly small	Small, uniform size	Very slightly large and uniform	Slightly large and slightly irregular	Moderately large and irregular	Large irregular size
CELL DISBRIBUTION	Not distinguishable	Almost indistinguishable			Uniform grain	Slightly irregular	Moderately irregular	Very irregular	Extremely irregular
TENDERNESS	Extremely tender and crumbled	Moderate tendency to crumble	Slight tendency to crumble	Very slight tendency to crumble	Tender when bitten or cut	Slightly tough	Moderately tough	Very tough	Extremely tough
CRUMB OR MOUTH FEEL	Too moist and gummy	Moderately gummy	Slightly gummy	Very slightly gummy	Velvety resilient or elastic	Very slightly dry	Slightly dry and coarse	Moderately dry and coarse	Extremely dry and coarse
FLAVOR	Imperceptible	Very slightly perceptible	Slightly perceptible	Moderately perceptible	Delicate sweet evenly blended	Slightly dominate off-flavor	Moderately dominate off-flavor	Strong dominate off-flavor	Very strong dominate off-flavor

Fig. 1. Scorecard used to evaluate cake samples.

each session, were asked to describe any off-flavors detected. A randomized pattern of variable selection was used for the evaluation sessions.

RESULTS AND DISCUSSION

Objective Measurements

Means, standard deviations, and statistical analyses of objective measurements are presented in Table II. Specific gravities of all cake batters were similar, thus no significant differences were noted. Ranked in order of decreasing viscosity were cake batters prepared with spray-, foam-spray-, freeze-dried, and frozen eggs. Funk et al. (5) suggested differences in the viscosity of cream puff batters prepared with the same types of processed eggs were due to variances in the emulsifying properties of the eggs. However, Lowe (12) indicated batters of various degrees of viscosity can be produced from the same proportions of the same ingredients and the high standard deviations of this study tend to support this observation.

All cake batters appeared smooth and glossy when mixing was completed. Very little separation, as indicated by drainage, occurred when batters stood undisturbed. Nevertheless, batters prepared with frozen and freeze-dried eggs were more stable than those prepared with foam-spray-dried and spray-dried eggs ($P < 0.05$). The negative correlation coefficient ($r = -0.53$,**) between batter stability and viscosity indicated thinnest batters were most stable.

Cakes prepared with frozen and foam-spray-dried eggs lost less moisture during baking than cakes prepared with freeze-dried ($P < 0.05$) and spray-dried egg. No significant differences were noted in the index to volume measurements of the cakes prepared with the four types of eggs.

Shear press measurements of compressibility and tenderness showed no differences attributable to egg process. Agreement between the two types of

TABLE II. MEANS, STANDARD DEVIATIONS, AND STATISTICAL ANALYSES OF OBJECTIVE MEASUREMENTS OF FAT-CONTAINING CAKES PREPARED WITH FOUR TYPES OF PROCESSED EGGS

Measurement	Egg Process: Frozen Fr	Foam-Spray-Dried FSD	Freeze-Dried FD	Spray-Dried SD	Statistical Significance[a]: P<0.01	P<0.05
Batter:						
Specific gravity	0.70±0.01	0.70±0.01	0.70±0.01	0.71±0.02	n.s.	
Viscosity (cp.)	10000±558.6	11100±613.2	10500±1143.7	11450±454.9	Fr<FSD.SD	FD<SD
Stability (ml. drainage)	0.03±0.01	0.02±0.01	0.03±0.01	0.02±0.01		Fr,FD>FSD,SD
Moisture lost during baking (%)	7.9±0.3	7.9±0.5	8.6±0.7	8.5±0.4		Fr,FSD<FD
Index of volume (cm.)	2.59±0.14	2.60±0.21	2.67±0.28	2.64±0.14	n.s.	
Compressibility Maximum force (lb. force)	5.21±1.50	5.94±1.80	5.86±0.51	5.08±0.56	n.s.	
Tenderness Maximum force (lb. force/g.)	0.98±0.22	0.97±0.17	0.99±0.19	1.02±0.08	n.s.	
Area-under-curve ($cm.^2$)	6.33±1.79	6.25±0.90	6.93±1.48	6.65±0.68	n.s.	
Color differences						
L values	83.6±0.6	83.1±0.6	83.8±0.7	83.4±0.4	n.s.	
a_L values	1.6±0.5	1.5±0.5	1.9±0.5	1.9±0.4	n.s.	
b_L values	20.8±0.3	20.4±0.2	20.6±0.2	21.5±0.6	Fr,FSD,FD<SD	

[a]Values underscored by the same line are not significantly different (11).

TABLE III. MEANS[a] AND STANDARD DEVIATIONS OF SENSORY EVALUATIONS OF PLAIN CAKES PREPARED WITH FOUR TYPES OF PROCESSED EGGS

Attribute	Egg Process			
	Frozen	Foam-Spray-Dried	Freeze-Dried	Spray-Dried
Crust texture	3.9±0.2	3.5±0.5	4.0±0.2	3.8±0.4
Interior color	4.3±0.1	4.2±0.3	4.4±0.2	4.5±0.2
Cell size	3.9±0.5	3.7±0.4	3.8±0.3	3.9±0.2
Cell distribution	4.1±0.3	4.0±0.3	4.0±0.2	4.0±0.2
Tenderness	4.0±0.3	4.2±0.3	4.0±0.4	4.1±0.1
Crumb	4.1±0.2	4.2±0.3	4.1±0.3	4.1±0.2
Flavor	4.6±0.3	4.3±0.2	4.4±0.2	4.6±0.2

[a]Mean of six replications by six judges.

measurements is indicated, however, by the positive correlation between the two (r = 0.63,**).

Hunter values indicated no differences in L values (lightness) and a_L values (greenness). However, cakes prepared with spray-dried eggs appeared more yellow than cakes prepared with other types of eggs ($P < 0.05$). Whole egg and yolk sponge cakes prepared with eggs processed in a similar manner exhibited similar trends (4).

Sensory Evaluations

Means and standard deviations for the sensory evaluations are presented in Table III. No significant differences attributable to the egg processes were noted. Thus, cakes prepared with frozen eggs were most frequently described as having crusts which were very slightly smooth; a yellowish, creamy white color; very slightly large air cells which were slightly irregular in their distribution; a very slight tendency to crumble although it was very slightly gummy in mouth-feel; and a moderately perceptible, sweet, and delicate flavor. Cakes prepared with foam-spray-dried eggs most frequently had very slightly pebbled crusts; small, uniform cells although their distribution was slightly irregular; and interior color, tenderness, crumb, and flavor as described for the cakes prepared with frozen eggs.

When prepared with freeze-dried eggs, cakes were most frequently described as having slightly smooth crusts; a creamy, yellow color; small uniform cells which were slightly irregular in distribution; a tender, velvety, resilient crumb; and a delicately sweet flavor. Cakes prepared with spray-dried eggs most frequently had very slightly pebbled crusts; interior color, cell size, cell distribution, crumb, and flavor as described for cakes prepared with freeze-dried eggs; and tenderness as described for cakes prepared with frozen eggs.

Cell size and cell distribution showed a positive correlation (r = 0.75, **) indicating any irregularities in the size of the cells was accompanied with uneven distribution of the cells. Cell size and tenderness scores showed a positive correlation (r = 0.42, *) as did cell distribution and tenderness scores (r = 0.44, *). Also, tenderness scores were significantly correlated with crumb scores (r = 0.70, **) showing that as tenderness scores deviated from the high-quality product, so did crumb scores.

Interior color scores were correlated with color difference values. Correlations between the scores and L values and a_L values were not significant; however, a positive correlation existed between scores and b_L values indicating agreement between the objective measurement of yellowness and the sensory evaluations.

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