Cream Puffs Prepared with Frozen, Foam-Spray-Dried, Freeze-Dried, and Spray-Dried Eggs[1]

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ABSTRACT

Cream puffs were prepared with frozen, foam-spray-dried, freeze-dried, and spray-dried eggs containing corn syrup solids to compare emulsifying and extensible properties as well as palatability of processed eggs. Ranked in order of increasing viscosity were batters prepared with foam-spray-dried, frozen, spray-dried, and freeze-dried eggs, the various viscosities suggesting differences in emulsifying properties of the eggs. Cream puffs prepared with freeze-dried eggs contained more ($P<0.05$) moisture than those prepared with other types of eggs. Percentages of moisture lost during baking, and linear and volume measurements, did not differ significantly among egg processes. Shear press measurements of tenderness expressed as maximum force and area-under-the-curve indicated that cream puffs prepared with foam-spray-dried eggs were tougher ($P<0.05$ and $P<0.01$, respectively) than those prepared with other types of eggs. All cream puffs scored fair to good in shape, exterior appearance, shell thickness, interior appearance, interior moistness, and flavor; in cavity size and tenderness they scored poor to fair. Those prepared with spray-dried eggs were toughest ($P<0.05$); those prepared with foam-spray-dried eggs had the largest cavities ($P<0.05$).

Increased interest in improving the palatability characteristics and functional properties of dehydrated eggs has prompted research with new or improved processing methods, or both. Spray-drying is the most commonly used method of drying eggs; however, foam-spray-drying and freeze-drying have been used to a limited extent. This study was undertaken to investigate the emulsifying and extensible properties as well as palatability characteristics of eggs processed by foam-spray-drying, freeze-drying, and spray-drying. Because a high proportion of fat must be emulsified in the batter and the protein matrix of the batter must be extended during baking, cream puffs were selected as the test product to compare the performance of the dried eggs with that of frozen eggs obtained from the same common lot.

In an early investigation, Nason (1) compared cream puffs made with albumen with those made with yolk and showed that combined yolk and albumen were necessary for fat emulsification and extension of the protein matrix during baking. Watts and Elliott (2) combined each of three types of dried albumen and fresh albumen with egg yolks for cream puff preparation. Their results showed that cream puffs prepared with Chinese fermented and acid-treated spray-dried albumen had less than two-thirds the volume of cream puffs prepared with untreated vacuum-dried and fresh albumen; this suggested that extensible protein had been damaged during two of the drying processes.

Using simple oil-in-water systems to evaluate emulsifying properties of frozen,

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foam-spray-dried, freeze-dried, and spray-dried whole eggs, Zabik (3) reported that spray-dried egg emulsions were less stable than those prepared with other types of processed eggs. In a later study, Zabik (unpublished data) found that mayonnaise prepared from whole eggs and yolks processed by the same four methods was acceptable. Chapin (4) reported that spray-drying whole eggs increased the emulsifying ability of their proteins and lipoproteins. In contrast, Rolfes et al. (5) found that spray-dried and freeze-dried yolks produced less stable emulsions than either fresh or frozen yolks.

The volume of baked products has been used to measure the effectiveness of emulsifying agents (6,7). Matthews and Dawson (8) reported greatest viscosity in cake batters when fats with added emulsifiers were used, and concluded that batter viscosity was a good method of assessing performance of fats in cakes. Therefore, these objective measurements were used to assess emulsifying properties of the processed eggs.

MATERIALS AND METHODS

Processing of Eggs

Grade A to C shell eggs from a common source were purchased from a commercial processor, machine-broken under USDA supervision, strained through stainless-steel screens with 0.014-in. perforations, and churned to produce homogeneity. Corn syrup solids and salt were added on the basis of 31.5 ± 0.5% carbohydrate and 1.5 ± 0.25% salt. After pasteurization at 60° to 61°C. for 3.5 to 4 min., the eggs were frozen in 30-lb. containers and held at -30°C. until further processing.

For foam-spray-drying, the eggs were thawed under running tap water for 24 hr. and then heated to 54°C. in a water bath. Immediately prior to drying, nitrogen gas under pressure of 950 p.s.i. was injected into the eggs. With the use of a cocurrent horizontal inverted tear-drop dryer equipped with two No. 62 nozzles and No. 20 spindles, the eggs were sprayed under an atomization pressure of 850 p.s.i. Inlet temperature was 116°C. and exhaust temperature was approximately 79°C.

Eggs, thawed as described above, were placed in trays of a Stokes freeze-dryer, Lab. 2003F2. The 0.75-in. layers of eggs were frozen at -22°C. and vacuum-dried at approximately 200 μ of mercury for 24 hr. with a plate temperature of 45°C. The freeze-dried eggs were then pulverized in a Fitzmill, Model D, comminuting machine equipped with a 0.05-in. sieve.

A pilot-plant spray-dryer under an atomizing pressure of 2,000 lb. with an intake temperature ranging from 149° to 163°C. and exhaust temperatures varying from 66° to 71°C. was used to spray-dry the previously thawed eggs. The egg solids were then passed through 16-mesh USBS screens. All processed eggs were packaged and stored as outlined by Franks et al. (9).

Cream Puff Preparation

Prior to collection of data, portions of dried eggs adequate for one replication were heat-sealed into plastic pouches. A 30-lb. can of frozen eggs was partially thawed at 2° to 4°C. and portions were weighed into plastic bags which were then closed and placed in plastic-coated paper containers. All eggs were stored at -23°C.

All-purpose flour, obtained from a common source, was weighed to the nearest g., prepackaged, and stored at room temperature until needed. Refrigerated hydrogenated vegetable shortening containing methyl silicone, from a common lot, was weighed to the nearest g. on preparation days.

Cream puffs were prepared according to Lowe's formula (10), adjusted to compensate for corn syrup solids added to the eggs prior to processing. Therefore, quantities of 222 g. distilled water, 112 g. shortening, 112 g. flour, and 231 g. eggs were used for each of the six replications prepared with the four types of processed eggs. The weight of dried eggs used depended on their moisture content; hence, 154, 156, and 154 g. of foam-spray-dried, freeze-dried, and spray-dried eggs, respectively, were reconstituted with appropriate quantities of water to make the needed 231 g.

Frozen eggs were thawed at 2° to 4°C. for approximately 21 hr. prior to use, and dried eggs were reconstituted just prior to preparation. With the whip attachment to a Kitchen Aid mixer, Model K5-A, one-half of the water was mixed with the dried eggs at speed 1 (108 r.p.m.) for 30 sec. After the remaining water was added, mixing was continued for 30 sec. before the reconstituted eggs were strained to ensure complete reconstitution.

For batter preparation, fat and water were heated in a covered mixer bowl to 99°C. ± 1° as recorded by a potentiometer lead from a Brown electronic high-speed recorder. Using the batter-beater attachment of the K5-A mixer, the flour was combined with the water-fat mixture for 15 sec. at speed 2 (132 r.p.m.); the sides of the bowl were scraped, and mixing was continued at the same speed for 45 sec. The temperature of the resulting water-fat-flour mixture was 51°C. ± 1°.

One-half of the eggs was then added and the mixture was beaten for 2.5 min. at speed 1. After scraping of the bowl, the remainder of the eggs was added and mixing was continued at the same speed for 2.5 min. The batter was then mixed for 5 min. at speed 4.

With a No. 40 dipper, the batter was portioned onto lecithin-sprayed aluminum baking sheets (16½ by 24½ in.). To determine weight losses during baking, three dippers of batter were placed on a presprayed baking sheet (13 by 16 3/4 in.), which was weighed after each addition of batter. Cream puffs were baked in a preheated Hotpoint oven, Model HJ 225, regulated at 227°C. ± 2° with a Versatronik controller. During the first 20 min. of the baking the top oven grid was on low and the bottom grid turned off, and the damper was closed. The oven heat was turned off and the damper opened for the remaining 25 min. of baking.

Viscosity of the batter was measured with a Brookfield Synchro-Lectric viscometer, Model RVT, mounted on a Helipath stand. A 58.4-g. weight was attached to the shaft of the viscometer to prevent swaying of the No. B spindle as it rotated at 5 r.p.m. Readings at revolutions 5, 6, 7, and 8 were averaged and converted to poises.

To determine emulsion stability, three No. 40 dippers of batter were put into 250-ml. graduated beakers. The beakers were covered with Parafilm and then placed in a controlled-temperature water bath at 30°C. Observations to determine oil separation were made at 30-min. intervals for a 3-hr. period.

Percentages of moisture lost during baking were calculated from the difference in weights before and after three previously designated cream puffs were baked. Percentages of moisture in the baked cream puffs were determined in triplicate by drying halved cream puffs for 4 hr. at 60° to 70°C. and 28 to 30 in. of Hg. The percentages of the three cream puffs were then averaged.

Linear measurements and volume were determined for three cream puffs from predetermined baking positions with the use of a vernier caliper and a modified 1-lb.-size National Loaf volumeter, respectively. The maximum height of each of the three cream puffs was recorded and two measurements of the width were taken at right angles and averaged. A false bottom was installed in the sample box of the volumeter to reduce the height of the interior to 3¼ in. Approximately 3/4 in. of seeds were allowed to fall into the box; three cream puffs were placed in the box simultaneously to minimize errors in obtaining accurate readings when individual cream puffs were measured.

Tenderness was measured as described by Funk et al. (11) with the standard shear compression cell for an Allo-Kramer shear press, Model SP12, equipped with a Varian electronic recorder, Model E2EZ. A 3,000-lb. proving ring, 10-lb. range, 25-lb. pressure, and a 30-sec. downstroke were used for the three cream puffs from each replication of batter. Readings, expressed as maximum force and area-under-the-curve, were calculated and averaged for each replication. A conversion factor of 174.2 was used to convert the weight under each graphed curve to sq.cm. as outlined by Funk et al. (11).

The shape, exterior appearance, cavity size, shell thickness, interior appearance, interior moistness, tenderness, and flavor of cream puffs were evaluated by a seven-member trained panel using a five-point rating scale designated with appropriate descriptive terms. A score of 5 indicated a very good evaluation of the attribute; a score of 1 indicated very poor quality. Two cream puffs were independently rated at each session.

The data were analyzed for variance by Duncan's multiple range test (12) to pinpoint significant differences. Correlation coefficients were calculated for appropriate combinations of the data.

RESULTS AND DISCUSSION

Cream Puff Batter

Smooth, viscous batters were prepared with all types of processed eggs. However, the batter prepared with foam-spray-dried eggs was thinner ($P<0.01$) than batters prepared with frozen and spray-dried eggs, and these batters were in turn thinner ($P<0.01$) than batters prepared with freeze-dried eggs (Table I). These data suggest differences in the emulsifying properties of eggs processed by the four methods because, according to Lowe (10), an emulsion becomes stiffer and more viscous as increased amounts of oil are emulsified and the increased viscosity contributes to the stability of the emulsion. Somewhat in contradiction, Zabik (unpublished data) found no significant differences in the viscosities of mayonnaises prepared with eggs processed by the same methods, although the viscosity of mayonnaise prepared with foam-spray-dried eggs was lower than that of mayonnaise prepared with the other types of eggs. The data for frozen and spray-dried eggs show the same trend as reported by Chapin (4); however, the results reported by Rolfes et al. (5) are in disagreement with the findings of this study.

When the batters stood undisturbed at a constant temperature of 30°C., oil droplets appeared only on the surfaces of batters prepared with foam-spray-dried

TABLE I. AVERAGES, STANDARD DEVIATIONS, AND STATISTICAL ANALYSES OF MEASUREMENTS OF VISCOSITY, MOISTURE, LINEAR MEASUREMENTS, VOLUME, AND TENDERNESS OF CREAM PUFFS PREPARED FROM FOUR TYPES OF PROCESSED EGGS

Measurements	Frozen Eggs (F)	Foam-Spray-Dried Eggs (FSD)	Freeze-Dried Eggs (FD)	Spray-Dried Eggs (SD)	Statistical Analyses[a] 1% Level	Statistical Analyses[a] 5% Level
Viscosity (poises)	2,425 ± 125[b]	2,246 ± 148	2,579 ± 155	2,442 ± 100	FSD F SD FD	
Moisture lost during baking (%)	49.4 ± 1.4	48.8 ± 3.1	47.8 ± 1.1	48.5 ± 1.7	None	
Moisture in baked c. puffs (%)	13.1 ± 0.9	13.4 ± 0.8	14.6 ± 1.0	13.7 ± 0.5		F FSD SD FD
Max. width (cm.)	5.58 ± 0.10	5.51 ± 0.12	5.53 ± 0.12	5.67 ± 0.11	None	
Max. height (cm.)	4.03 ± 0.15	3.99 ± 0.10	3.98 ± 0.11	3.96 ± 0.10	None	
Volume (cc.)	58.3 ± 5.3	61.1 ± 4.3	58.3 ± 0.0	62.5 ± 4.6	None	
Tenderness:						
Max. force (lb. force/g.)	11.13 ± 0.77	11.97 ± 0.85	10.89 ± 0.46	10.77 ± 0.65		SD FD F FSD
Area-under-curve (sq.cm.)	3.36 ± 0.13	3.84 ± 0.13	3.38 ± 0.19	3.37 ± 0.18	F SD FD FSD	

[a]Values underscored by the same line are not significantly different (see ref. 12). [b]Standard deviation.

TABLE II. AVERAGE SCORES[a], STANDARD DEVIATIONS, AND STATISTICAL DIFFERENCES FOR SENSORY EVALUATIONS OF CREAM PUFFS PREPARED WITH FOUR TYPES OF PROCESSED EGGS

Characteristic	Frozen Eggs (F)	Foam-Spray-Dried Eggs (FSD)	Freeze-Dried Eggs (FD)	Spray-Dried Eggs (SD)	Statistical Differences[b] (5% level)
Shape	3.4 ± 0.4[c]	3.6 ± 0.3	3.6 ± 0.4	3.5 ± 0.6	None
Exterior appearance	3.7 ± 0.2	3.7 ± 0.2	3.8 ± 0.2	3.6 ± 0.3	None
Cavity size	2.7 ± 0.3	3.1 ± 0.5	2.4 ± 0.3	2.5 ± 0.4	FD SD F FSD
Shell thickness	3.5 ± 0.2	3.2 ± 0.4	3.3 ± 0.3	3.0 ± 0.3	None
Interior appearance	3.0 ± 0.2	3.2 ± 0.3	3.2 ± 0.2	3.1 ± 0.2	None
Interior moistness	3.4 ± 0.2	3.6 ± 0.1	3.4 ± 0.3	3.4 ± 0.2	None
Tenderness	3.6 ± 0.1	3.5 ± 0.3	3.4 ± 0.3	3.2 ± 0.2	SD FD FSD F
Flavor	3.5 ± 0.1	3.4 ± 0.2	3.3 ± 0.4	3.3 ± 0.2	None

[a]Scores based on scale of 5 = very good, 4 = good, 3 = fair, 2 = poor, 1 = very poor. [c]Standard deviation.
[b]Values underscored by the same line are not significantly different (see ref. 12).

eggs. The oil droplets were noted after 1 hr. of standing and appeared to increase in size during the following 2 hr.

Objective Measurements of Baked Cream Puffs

Percentages of moisture lost during baking showed no significant differences among cream puffs prepared with all types of eggs (Table I). The moisture content of baked cream puffs prepared with freeze-dried eggs was higher ($P<0.05$) than the moisture content of cream puffs prepared with the other three types of eggs (Table I). However, when the averages of the two moisture determinations were combined for each type of egg, all cream puffs lost the same amount of moisture during baking and the subsequent drying process.

No significant differences existed among the cream puffs prepared from all types of processed eggs in measurements of maximum width and height (Table I). Maximum widths ranged from 5.51 to 5.67 cm. and maximum heights from 3.96 to 4.03 cm.

In addition to their emulsifying role, eggs help form extensible coagulable material for the crust of the cream puffs (10). Cream puffs prepared with spray-dried eggs had the largest volume; those prepared with foam-spray-dried eggs were next. However, the volume of these cream puffs was not significantly different from that of cream puffs prepared with frozen and freeze-dried eggs with the same average volume (Table I). Therefore, these data indicate that the four methods of processing did not significantly affect the extensible properties of the eggs. The linear measurement data support the volume measurement data.

Volume measurements of cakes have been used to measure the effectiveness of emulsifying agents (6,7). However, in the present study volume data are not in agreement with batter viscosity or stability data; this suggests that cream-puff volume may not be a measure of the emulsifying properties of eggs.

Ranked in order of decreasing tenderness, as shown by maximum force values, were cream puffs prepared with spray-dried, freeze-dried, frozen, and foam-spray-dried eggs. When tenderness was expressed as area-under-the-curve, cream puffs prepared with frozen, spray-dried, and freeze-dried eggs showed no significant differences; however, the foam-spray-dried eggs produced cream puffs tougher ($P<0.01$) than those prepared with other types of eggs. A highly significant correlation coefficient ($r=0.69$) between maximum force values and area-under-the-curve values indicated the close relationship between the two.

Tenderness, expressed as maximum force, was correlated with percentages of moisture in the baked cream puffs, and a highly significant negative correlation coefficient ($r= -0.60$) showed cream puffs containing the most moisture were most tender. Tenderness, expressed as area-under-the-curve, showed a highly significant negative relationship ($r= -0.55$) to batter viscosity; this suggests that the thinnest batter produced the toughest cream puffs.

Sensory Evaluations of Cream Puffs

No significant differences were found among egg processes for sensory evaluations of shape, exterior appearance, shell thickness, interior appearance, interior moistness, and flavor (Table II). The cream puffs scored fair to good in shape and according to judges' comments; some of the cream puffs appeared flat.

Perhaps the comments can be attributed to the method and equipment used to portion the batter, which resulted in cream puffs different in shape from the subjective standards of the judges.

Because of the corn syrup solids added to the eggs during processing, the cream puffs were well browned. Hence, some cream puffs received low scores for the dark brown color of the surface. According to Amerine et al. (13), deviations from expected color standards may decrease the acceptability of a food.

The shells of the cream puffs prepared with all types of eggs were scored as fair, and comments by the judges indicated that some of the shell walls were too thick in proportion to over-all size and somewhat irregular in thickness. The interior appearance of cream puffs was also scored as fair. Irregularities in shell thickness caused differences in interior color, in that thin shell walls resulted in a browned appearance within the cream puff. Judges indicated that some oil droplets were present on the moist webs within some of the cream puffs, suggesting a break in parts of the film formed by the emulsifying agent before the egg was heat-coagulated during baking. For the attribute of interior moistness, cream puffs were scored as fair. Flavor scores were fair to good for cream puffs prepared with all types of eggs. Some judges objected to the flavor of the well-browned surface of the cream puffs.

An ideal cream puff was defined as having one large cavity with a few small cells around the outside wall. Cream puffs did not score high in this attribute, although standard deviations indicate that cream puffs varied greatly within each batch. Ranked in order of decreasing scores of 3.1, 2.7, 2.5, and 2.4 for cavity size were cream puffs prepared with foam-spray-dried, frozen, spray-dried, and freeze-dried eggs, respectively. The differences ($P<0.05$) of the scores indicated that the cells of the cream puffs varied in size or number, or both. No discernible pattern was noted which might explain the differences.

Ranked in order of decreasing tenderness were cream puffs prepared with frozen, foam-spray-dried, freeze-dried, and spray-dried eggs with average scores of 3.6, 3.5, 3.4, and 3.2, respectively. The scores showed that cream puffs prepared with spray-dried eggs were tougher ($P<0.05$) than those prepared with each of the other three types of eggs. Comments indicated that cream puffs prepared with spray-dried eggs lacked crispness. Sensory evaluations of tenderness were not significantly correlated with shear press measurements of tenderness, percentages of moisture lost during baking, or moisture in the baked cream puffs.

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