Soybean Oil in Dried Egg Mixes[1]

C.D. EVANS, K. WARNER, K. BOUNDY, G.R. LIST, J.C. COWAN, and J. DIZIKES[2],
Northern Regional Research Laboratory[3], Peoria, Illinois 61604

ABSTRACT

Dried egg mixes prepared commercially with hydrogenated-winterized soybean, corn, or cottonseed oils were evaluated for initial flavor and for flavor storage stability. Quality evaluations were made on products from two processing plants; flavor, color, stability, and mix volumes were determined periodically during storage at 100 F for 1 year. All mixes contained 15% of the specified oil and were air-packaged in 6 oz laminated foil pouches. Replicated triangle flavor tests on reconstituted dried eggs (scrambled) indicated that neither an analytical-type taste panel nor a palatability panel could distinguish between the mixes containing the different vegetable oils. All samples, regardless of oil component, deteriorated at ca. the same rate when stored at elevated temperatures. Minor differences in flavor scores, color indices, and mix volumes were noted in samples stored at 100 F for 9 or 12 months. A dried egg mix made with hydrogenated-winterized soybean oil could not be distiguished, after 4 months' aging at 100 F, from a fresh (unaged) mix made with corn oil. After 6 months' storage at 100 F all aged mixes, regardless of the vegetable oil used in their preparation, could be distinguished from the fresh corn oil mix.

INTRODUCTION

Dried egg mixes are purchased extensively by the Federal Government and are distributed widely to the armed services and through the food assistance programs. Although the added vegetable oil makes up only 15% of the product, the oil component has been considered an important factor controlling the stability and quality of a dried egg mix. The sharp increase in the price of corn oil since 1971 made it necessary that other vegetable oils be investigated as replacements. Previous to our work, only corn oil was permitted under government purchase specifications.

In reviewing the literature before 1970, Tuomy and Walker (1) found that data developed with spray-dried whole eggs are not applicable to a spray-dried scrambled egg mix. Dried egg products have been reviewed extensively by Lightbody and Fevold (2) and by Bergquist (3).

An improved scrambled egg mix containing 4.8% corn oil and 30% condensed skimmed milk was developed in the 1960s. Stability factors and quality attributes of this product were studied extensively (1). Moisture level was the most crucial factor in deterioration of both flavor and texture. Oxygen played only a minor role compared to moisture in the deterioration of flavor, color, and texture of the product. A color change was the first storage effect to be observed, and it was the controlling organoleptic attribute. The changes in color of dehydrated eggs during storage were studied spectrometrically by Dutton and Edwards (4). Earlier, Edwards and Dutton (5) had presented evidence that the brown material in dehydrated eggs was a reaction product of cephalin and aldehydes.

Kline, et al., (6) indicated a glucose-lipid interaction as the cause of flavor deterioration of whole egg powders. Lorenz and Maga (7) followed the change in the fatty acid composition of whole dried eggs under elevated temperature storage and reported an increase in unsaturated fatty acid content of all samples, including the controls that had been stored at 5 C. The effect of neutral fats (triglycerides) in the deterioration of dried egg mixes is not so clear but more suspect in nature. Early workers had indicated that gas-packaging improved the mix and that fats were a possible source of aldehydes through oxidation. Fevold, et al., (8) continued to study the influence of phospholipids (cephalin) and reported that isolated egg lipids, free of phosphatides, did develop marked rancidity on storage. Dawson, et al., (9) replaced the lipids of dehydrated eggs by corn oil and reported satisfactory flavor, storage stability, and emulsifying action in baked goods. However, the foaming properties of their product were poor.

Our investigation was initiated to determine the suitability of hydrogenated-winterized (specially processed) soybean salad oil and cottonseed salad oil as replacements for corn oil in the formulation of dried egg mixes. Results are based upon the organoleptic evaluation of scrambled eggs prepared with different oils from mixes processed commercially.

MATERIALS AND METHODS

All ingredients used in formulating the various mixes were commercially available products that were processed and spray-dried under the operating conditions of two different commercial dried egg mix plants. In plant A, two experimental runs of ca. 500 lbs each were formulated with hydrogenated-winterized soybean salad oil and with cottonseed salad oil. The commercial mix being formulated at this time with corn oil served as control. In plant B, both the run with hydrogenated-winterized soybean oil and the run with corn oil were full-scale commercial operations. Although processing conditions and ingredients were not disclosed, the products met USDA specifications for dried egg mixes (Announcement no. PY-53, December 1970).

This specification, subsequently modified in April 1972 to include other vegetable oils, requires that an egg mix will consist of not less than 51% whole egg solids, 30% nonfat milk solids, 15% corn oil, and not more than 1% salt. The spray-dried product will have less than 3% moisture and pass standard plate count and coliform count tests. The palatability score will be at least 7, as determined by the USDA, Dairy Division Laboratory, Chicago, Ill. At the Chicago laboratory, qualified judges use an 11 point scoring scale from a low of 0, up to a score of 8, which is comparable to high quality fresh shell eggs. A score of 7-1/2 indicates very slight off-flavor; 7, slight but no unpleasant off-flavor; 6-1/2, definite but not unpleasant off-flavor; and, below this figure, samples are scored in whole numbers according to the degree of unpleasantness. All vegetable oils used in the formulations were stabilized with a mixed antioxidant (0.0625%) containing butylated hydroxyanisole, butylated hydroxytoluene, propyl gallate, and citric acid. The dried egg mixes from both plants were air-packaged in heat-sealed 6 oz laminated foil pouches.

For evaluation at the Northern Laboratory, the dried egg mixes were hydrated in a 2:1 ratio (wt/wt) of water to powder (usually 50 g egg mix) as recommended in the package directions. The slurry was mixed at no. 6 speed, for 2 min, in a Hobart Kitchen Aid mixer (model K4B) with a

[1] Presented at AOCS Meeting, Mexico City, April 1974.
[2] Dairy Division Laboratory, AMS, USDA, Chicago, Ill.
[3] ARS, USDA.

TABLE I

Composition of Vegetable Oils Used by Plant A to Formulate Dried Egg Mixes

Fatty acid component	Composition, %		
	Soybean[a]	Corn	Cottonseed
Myristate	---	---	0.9
Palmitate	8.8	11.2	18.6
Palmito-oleate	---	---	0.7
Stearate	4.6	2.0	2.8
Oleate	41.0	24.7	17.3
Linoleate	38.6	60.1	55.3
Linolenate	4.3	1.3	0.1
Unknowns and traces	2.7	0.7	4.3
Iodine value (calculated)	113.4	128.7	111.0

[a]Hydrogenated-winterized (specially processed).

wire whip attachment. Volumes of the slurried mixtures were measured immediately in 250 ml graduated cylinders. The egg mixtures were cooked for ca. 5 min with continuous stirring in ceramic pans over direct heat (glass-ceramic stove top). Neither seasonings nor extra shortening was used.

Flavor evaluation was to determine whether or not aged egg mixes prepared with cottonseed or soybean oil could be distinguished from aged mixes made with corn oil. The scrambled eggs were evaluated by the triangle test method with three samples, e.g. two corn and one soybean or two soybean and one corn, being presented simultaneously to each taster. Replicate tests were made for all samples. Panel members were instructed to judge samples for flavor difference only. Red fluorescent lights in the taste panel rooms disguised any color differences among the samples. Triangle testing was also used to compare both fresh (samples stored at -20 F) soybean and fresh corn oil dried egg mixes against their aged counterparts to determine when deterioration became significant during storage at 100 F.

Structure of the dried egg mix powders was investigated by scanning electron microscopy according to the technique described by Wolf and Baker (10).

TABLE II

Triangle Taste Tests on Dried Egg Mixes

Samples stored at 100 F, months	Number of tasters	Correct selection, %	Significance[a]
Soybean vs corn oil formulation–plant A			
0	39	39	NS
2	22	60	*
4	30	44	NS
6	33	45	NS
9	32	38	NS
12	31	39	NS
Corn vs cottonseed oil formulation–plant A			
0	39	34	NS
2	24	29	NS
4	25	24	NS
6	34	44	NS
9	32	37	NS
12	29	39	NS
Soybean vs corn oil formulation–plant B			
0	27	41	NS
1	30	48	NS
4	26	43	NS
6	30	49	NS
Corn oil fresh vs stored soybean, cottonseed and corn oil mixes–plant A			
4 (Soy)	29	52	NS
4 (Cotton)	22	73	**
6 (Soy)	32	76	**
6 (Cotton)	35	69	**
6 (Corn)	34	56	**
Soybean oil: fresh vs stored samples–plant B			
1	32	44	NS
2	29	62	**
3	31	48	*
5	27	48	*
Corn oil: fresh vs stored samples–plant B			
1	30	37	NS
2	32	50	*
3	29	62	**
5	31	81	**

[a]NS = not significant, * = significant at the 5% level, and ** = highly significant at the 1% level.

RESULTS AND DISCUSSION

Composition of the salad oils used in plant A for the formulation of dried egg mixes is listed in Table I. These are typical values as determined by gas liquid chromatography (GLC) for refined and winterized salad oils. Usually, linolenate values at these low levels are higher when determined by GLC than by alkali isomerization. Normally, corn oil has less than 1% and hydrogenated-winterized soybean oil ca. 3.5-4.0% linolenic acid. The iodine values are typical for these salad oils.

Organoleptic evaluations and comparisons of the various dried egg mixes are given in Table II. The tasters were unable to select identical samples in any of the triangle testing of either the fresh or aged samples. One exception occurred in the 2 month aging comparison of the soybean vs corn oils. Some tasters consistently could identify corn oil mixes by a sweetness attribute. This attribute does not detract from the quality or desirability of the product, nor does it indicate that one product is more acceptable than the other; but it does enable some tasters to identify the identical pair under such an evalution system.

Since consistent statistical differences between samples could not be established by the taste panel, it was concluded that mixes prepared with soybean, cottonseed, or corn oil were equally acceptable. It also must be inferred that the rate of deterioration of all samples was ca. the same, because significant differences did not appear under elevated storage conditions. In the middle section of Table II, data are given for the comparison of fresh corn oil mix (plant A) against the aged mixes of the three different oils made in plant A. The stability of soybean mixes for 4 months indicates that the mixes from plant A were considerably more stable than the mixes from plant B. Both aged soybean and corn oil mixes from plant B could be distinguished from fresh mixes within 2 months, while samples from plant A required ca. 4 months. The difference in storage stability of mixes from plants A and B also is indicated by the palatability scores, which will be discussed later.

In the last section of Table II, fresh vs aged comparisons were made for soybean and corn oil dried egg mixes from plant B. The results indicate the similarity of the two mixes made with different oils. Both formulations showed the same rate of deterioration, and, after 2 months' storage, the taste panel could distinguish fresh samples from aged.

Products from plant A were not compared organoleptically with those from plant B. No apparent difference in the products was discernible or reported by the taste panel when different lots were investigated. Palatability scores from Dairy Division Laboratory for the dried egg mixes prepared in both processing plants are given in Table III. Scores for mixes prepared with the three different oils in plant A were almost identical for all samples over the 12 month storage period. Only at the 10 month evaluation period was the score for soybean oil mix slightly lower than the mixes prepared with corn and cottonseed oil. At the 12 month evaluation, for the three different mixes, all scores

TABLE III

Palatability Scores of Dried Egg Mixes

Samples stored at 100 F, months	Dried mix formulation		
	Soybean	Corn	Cottonseed
	Plant A		
0	7.5	7.5	7.5
2	7.0	7.0	7.0
4	6.5	6.5	6.5
6	6.5	6.5	6.5
10	6.0	6.5	6.5
12	5.0	5.0	5.0
	Plant B		
0	7.5	7.5	---
2	6.5	6.5	---
4	6.5	6.0	---
6	4.0	6.0	---

TABLE IV

Slurry Volume of Dried Egg Mixes

Samples stored at 100 F, months	Volume of mix, ml		
	Soybean	Corn	Cottonseed
	Plant A		
0	218	252	248
6	199	233	230
12	171	220	219
12 (room temperature)	206	252	228
	Plant B		
0	235	206	---
1	213	183	---
2	221	171	---
3	191	175	---
5	199	155	---
6	185	155	---

were the same, and all samples were judged to have an unpleasant off-flavor. As is indicated by the palatability scores, dried egg mix samples from plant B deteriorated under storage at 100 F at a much faster rate.

When scrambled eggs were prepared for the taste panel, differences were observed in the slurry volume of different mixes. Preparation of the slurry was identical for all mixes, and this slurry volume was exactly reproducible for each dried egg mix (Table IV). Slurry volume standard deviations for corn and soybean oil mixes from plant A were 6.6 ml and 7.6 ml, respectively. Mixes from plant A show that initial slurry volumes of samples formulated with soybean oil were 13% lower than those of corn oil. However, in the mixes from plant B, the corn oil slurry was 12% lower than that of soybean oil.

It is not logical to attribute these differences in slurry volumes to the oil component. Many unknown factors contribute to slurry volume, and these would be expected to arise mostly from the egg and milk ingredients, as well as from the formulating and spray-drying conditions used in the two plants. A progressive decrease in slurry volume was observed for all samples as the length of storage increased. Samples from plant A decreased on 12 months' storage by 21, 13, and 12%, for soybean, corn, and cottonseed oil mixes, respectively. After 6 months' storage, plant B products showed a decrease in slurry volume of 21% for soybean and 25% for corn oil mixes.

Investigations were not undertaken to correlate the slurry volume test with the flavor, texture, and appearance of baked goods. Although dried egg mixes are used primarily for scrambled eggs, commercial producers issue recipes incorporating the mix in cakes, muffins, and pancakes. Then, slurry volume might be an index of leavening, thickening, and emulsifying properties of the mix when used in baked goods.

The addition of a yellow coloring agent to dried egg mixes is permitted by law because the natural color of the egg yolk varies. A uniform color of nos. 2-3 yellow (National Egg Processors Association color numbers) (11) is, thus, obtained by all processors of dried egg mixes. Any change in color of a dried egg mix under elevated storage temperatures might be associated with oil oxidation (carotene destruction) of the various mixes. Color determinations were made periodically for all samples under storage. Changes in yellow color intensity for the three different mixes from plant A are plotted in Figure 1. A consistent decrease in yellowness (+b) values as determined by the Hunter color difference meter is evident. During 12 months' storage, all samples uniformly decreased in yellowness and changed only slightly in lightness. Cottonseed mixes increased in grayness between 9 and 12 months. Color data for the soybean and corn mixes from plant B appear in Table V. Since color changes were small and progressive, the data for intermediate times are not given. Color data on the stored mixes from both plants are similar.

The visual appearance of dried egg mix powders, slurries, and the cooked scrambled eggs for mixes produced in plant B is presented in Table VI. When judged at the time of cooking, no color change is apparent in soybean products after 6 months' storage. However, for this lot of samples, the corn oil mixes developed a slight caramel color after 6 months' storage. The increase in +a values (redness) and the decrease in +b values (yellowness) in Table V for the 6 months' aged corn samples corresponds to the slight caramel color observed visually.

Color differences were evident in the different oil mixes (plant A) stored at elevated temperatures for 6 months or more. Differences appeared in the dried powdered mixes and in the cooked scrambled eggs. Corn oil mixes retained the original bright yellow color, and soybean oil mixes took on a light caramel color, while cottonseed mixes assumed a dull grayish caramel appearance. All three dried egg mixes produced in plant A had annatto added (artificial color) during their formulation.

Small differences between mixes prepared with different oils were observed for products from each commercial plant. However, equal or greater differences were observed between mixes made with the same oil in different plants. The appearance of a caramel color on storage and a maximum slurry volume for corn and soybean oil mixes practically are reversed in the respective products of the two plants. Conditions of plant formulation and drying are indicated as important variables in evaluating storage stability of this product. To determine physical differences in particles of the spray-dried products, they were examined with a scanning electron microscope. Figure 2 presents

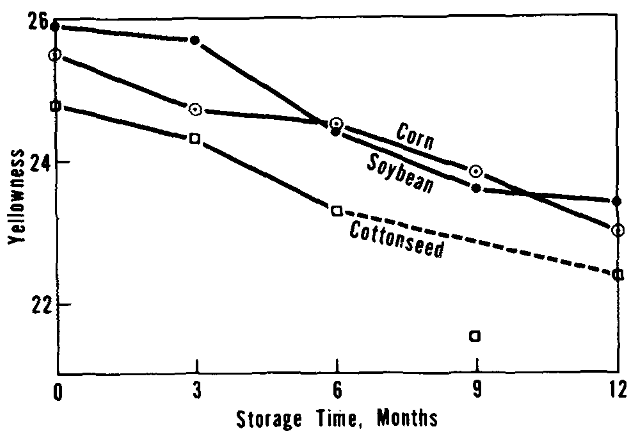

FIG. 1. Changes in color intensity of three dried egg mixes from plant A during 12 months' storage at 100 F. (Hunter color difference meter readings +b).

TABLE V

Hunter Differential Color Values of Dried Egg Mixes (Plant B)

Sample mix	Storage at 100 F, months	Color[a]		
		L	+a	+b
Soybean	0	86.4	−0.4	26.1
Corn	0	85.9	+0.5	26.6
Soybean	3	86.7	−0.1	26.0
Corn	3	85.3	+0.8	25.3
Soybean	6	86.6	0.0	25.0
Corn	6	85.3	+1.0	23.9

[a]L = lightness, +a = redness, and +b = yellowness.

TABLE VI

Visual Appearance of Powders, Slurries, and Cooked Dried Egg Mixes (Plant B)

Samples	Storage conditions months at F	Color of		
		Powder	Slurry	Cooked
Soybean oil	6, -20 F	Bright yellow	Medium yellow	Bright yellow
	1, 100 F	Bright yellow	Medium yellow	Bright yellow
	6, 100 F	Bright yellow	Medium yellow	Bright yellow
Corn oil	6, -20 F	Light yellow	Medium yellow	Bright yellow
	1, 100 F	Light yellow	Medium yellow	Bright yellow
	6, 100 F	Slight caramel	Medium caramel	Medium caramel

photomicrographs at 500X obtained on corn and soybean oil dried egg mixes from the two plants. Figures 2A and 2B show the convoluted and inward shrunken spheres of all the mixes from plant A. Even the smaller spheres have this shrunken and indented configuration. This appearance probably results from a rapid drying rate and loss of moisture from the inside of the sphere causing numerous areas of collapse. The surface of the particles apparently does not case harden sufficiently to dry as spheres.

Perhaps not all of the sunken or collapsed areas can be attributed to diminished internal stress. Collision with other particles may also have caused some of these depressions. (See particularly the photomicrographs of products from plant B, Figs. 2C and D.) However, our interpretation of the photomicrographs is that most of the depressions in plant A particles result from implosions. Apparently, rapid drying results in a thinner shell on the sphere, because more fragmentation of the spheres occurred in products from plant A.

Particle size of all the dried egg mixes varies from a few μ across to ca. 75-100 μ. In Figure 2A, the large cupped particle at left center is ca. 75 μ wide. Those particles within the cup vary from 1 to several μ in diameter. The large fragmented particle at left center in Figure 2B is ca. 55 μ wide and has a shell wall thickness of ca. 10% of its total diameter.

In Figures 2C and D, the spray-dried particles are smoother and more spherical (plant B) but again with an extremely wide range in size. The number and extent of the depressions on these spheres are fewer and much shallower than those seen for the plant A mix. Many of the impacted spheres remain fused. When they are broken apart, part of the impacted sphere remains fused at the point of contact. Some of the collisions probably occurred early in the drying stage, as many of the particles are fused completely and welded together. Structures of this type indicate a comparatively slower drying rate in the spray dryer at plant B and at a rate that prolongs the plastic and adhesive state allowing fusion of any impacted spheres.

Figure 3 shows a ruptured sphere at 1000X taken from a corn oil mix prepared at plant B. In this photograph, the estimated particle wall thickness is greater than 10% of the particle diameter. The products from plant A generally were regarded as having greater stability, and the rapid spray-drying and cooling of the product immediately after drying may account for the superior quality of these samples. Spray-drying conditions that affect shelf life of the dried egg mix were not part of this study. Our comments are based upon the examination of one set of samples from each processor and must be so qualified.

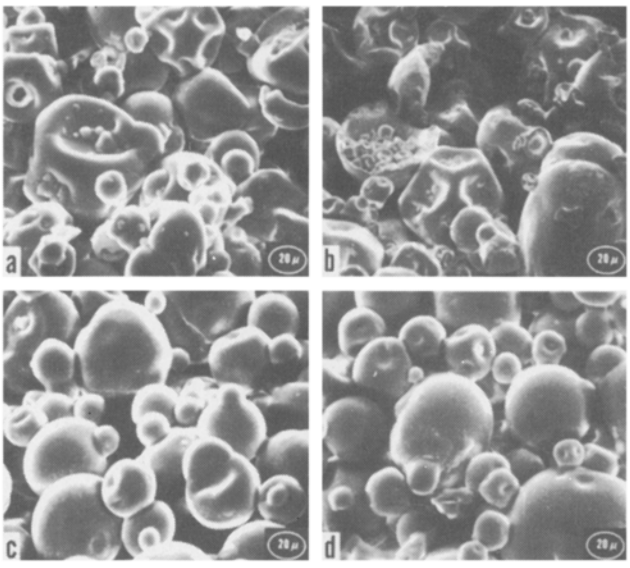

FIG. 2. Scanning electron micrographs (500X) of dried egg mixes produced: in plant A with (A) corn oil and (B) hydrogenated-winterized soybean oil and produced in plant B with (C) corn oil and (D) hydrogenated-winterized soybean oil.

ACKNOWLEDGMENTS

F.L. Baker performed the scanning electron microscopic examination and members of the organoleptic panels provided assistance throughout these tests.

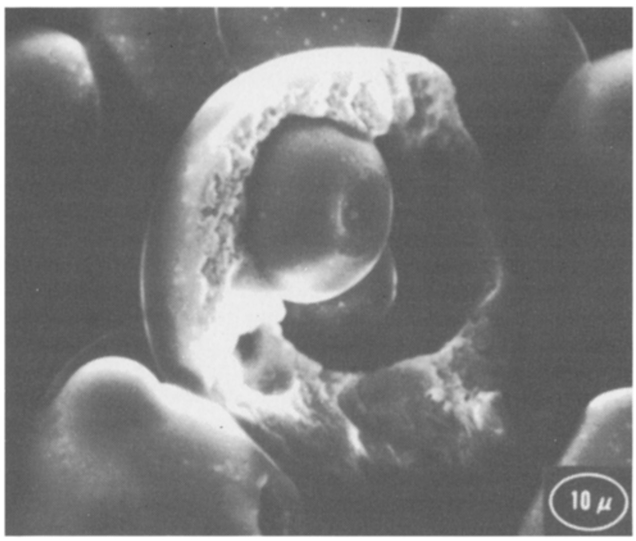

FIG. 3. Scanning electron micrograph (1000X) of a fractured particle in the corn oil dried egg mix prepared in plant B.

REFERENCES

1. Tuomy, J.M., and G.C. Walker, Food Technol. 24:99 (1970).
2. Lightbody, H.D., and H.L. Fevold, Advan. Food Res. 1:149 (1948).
3. Bergquist, D.H. in "Food Dehydration," Vol. 2, Edited by W. van Arsdel and M.J. Copley, Avi Publishing, Westport, Conn., 1964, pp. 652-693.
4. Dutton, H.J., and B.G. Edwards, Ind. Eng. Chem. 38:347 (1946).
5. Edwards, B.G., and H.J. Dutton, Ibid. 37:1121 (1945).
6. Kline, L., J.E. Gegg, and T.T. Sonoda, Food Technol. 5:181 (1951).
7. Lorenz, K., and J. Maga, J. Food Sci. 36:936 (1971).
8. Fevold, H.L., B.C. Edwards, A.I. Dimick, and M.M. Boggs, Ind. Eng. Chem. 38:1079 (1946).
9. Dawson, L.E., M. Gomez, K. Funk, and M.E. Zabik, Paper presented at the Institute of Food Technologists Meeting, Miami Beach, June 1973.
10. Wolf, W.J., and F.L. Baker, Cereal Sci. Today 17:124 (1972).
11. U.S. Department of Agriculture, "USDA Laboratory Methods for Egg Products," (C&MS PY Notice, No. 150), U.S. Department of Agriculture, Washington, D.C., March 15, 1965.

[Received July 3, 1974]