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THE VITAMIN CONTENT OF EGGS AS AFFECTED BY  
DEHYDRATION AND STORAGE

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### SUMMARY

The vitamin A, thiamine, and riboflavin content of fresh egg pulp, freshly dehydrated eggs, and dehydrated eggs stored at 35-40°, 70°, and 100-105°F. for 3, 6, and 12 months were determined.

The vitamin content per gram of sample was as follows: vitamin A, 60 and 66 I.U.; thiamine, 4.6 and 4.7 mcg.; riboflavin, 12.0 and 12.1 mcg. for fresh egg pulp and for freshly dehydrated eggs, respectively. This indicates that no destruction of these vitamins occurred during the process of dehydration.

Storage caused a marked destruction of vitamin A. Based on the amount of vitamin A present in the freshly dehydrated eggs (66 I.U. per gm.) the per cent retained after 12 months storage was 53, 30, and 11 for 35-40°, 70°, and 100-105°F., respectively.

Only a limited amount of destruction of thiamine occurred at 35-40°F., however, after 12 months storage at 100-105°F. 57 per cent of the amount of thiamine present in the freshly dehydrated eggs, was lost.

The riboflavin content of the egg samples remained approximately the same throughout the entire period of observation.

Dehydrated eggs are an excellent source of riboflavin. If properly handled they also supply thiamine and vitamin A in appreciable quantities.

# THE VITAMIN CONTENT OF EGGS AS AFFECTED BY DEHYDRATION AND STORAGE<sup>1</sup>

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## INTRODUCTION

Any product which has had so much adverse criticism as dehydrated eggs must of necessity be improved to the highest quality of excellence in all respects before it will assume its rightful place among other food commodities on a peace-time market. To date, remarkable improvements have been made in the quality of dehydrated eggs which are available. Special attention has been given to sanitation measures, to the treatment of the egg pulp before and during the drying process, to the perfection of the drying equipment, and to packaging as well as to the proper storage of the dried product. There is every reason to believe that dehydrated eggs will eventually prove to be as important to the poultry industry as dried milk now is to the dairy industry.

Many of the criticisms of dehydrated eggs, no doubt, could have been avoided had the industry grown gradually under normal conditions. Instead, in 1939, the relatively inexperienced industry was suddenly faced with the tremendous responsibility of helping to supply food to our soldiers and allies. Eggs, in a form which could be shipped abroad economically and carried along easily by a moving army, were in great demand. As a result, the industry expanded rapidly. The number of dehydrating plants increased from 16 in 1939 to 117 in 1945, and during this period the amount of dehydrated eggs produced in one year rose from 10 million to 320 million pounds (Leimert, 1945). It is not surprising that under such conditions, the most rigorous to which a perishable food could be subjected, prejudices were built up against dehydrated eggs which are stamped indelibly upon the minds of many veterans of World War II.

In spite of the adverse criticism of dehydrated eggs, the essential role played by this food during the war has been recognized. Illustrating the importance of dehydrated eggs in supplying more adequate nutrition to a vast population during strenuous times is this statement by Lord Woolton, the

<sup>1</sup> This report includes data from theses submitted by Corinne Whitford, Carmel Pickering and Katheryn Summers in partial fulfillment of the requirements for the degree of Master of Arts in the Graduate School of the University of Missouri.

former British Minister of Food: "The supplies of milk and eggs arriving in this country in dehydrated form have helped maintain a standard of feeding impossible in the last war" (Vickery, 1945).

Recently the dehydrating industry has proved its value in helping to make it possible for the government to carry out its program of egg-price stabilization. It could serve also to help minimize fluctuations in egg prices due to seasonal variation, since it affords one of the most efficient methods of preserving eggs during periods of heavy production for use during periods of minimum production.

While Stewart (1948) has predicted that the dried egg business is here to stay on the domestic market, it is doubtful that dehydrated eggs will give much competition to frozen liquid or storage shell eggs in industries such as baking or ice-cream manufacturing. There does appear to be an excellent outlet for dried eggs, with no competition whatsoever from liquid eggs, in the preparation of dry mixes—products which are gaining rapidly in popularity. They, no doubt, would also be used in considerable quantities by housewives if the product were packaged in family size amounts and regularly available at the grocery store. This would be expected to be true, especially if consumers were educated in regard to the advantages of dehydrated eggs and ways in which they can be used. Such information for consumer education has been published by the Bureau of Human Nutrition and Home Economics (1945) and is also brought out by Stewart (1948) in the article, "There's a Future for Good Dried Eggs."

Questions in regard to the nutritive value of a food product usually parallel its development. This has been the case for dehydrated eggs. A review of the literature indicates that studies have been made on the vitamin content of dehydrated eggs by several groups of investigators, some of which are: Hauge and Zscheile (1942); Klose, Jones and Fevold (1943); Schrenk, Chapin and Conrad (1944); and Olsen, Weybrew and Conrad (1948).

The object of the present investigation was to determine the vitamin A, thiamine, and riboflavin content of eggs as affected by dehydration and by storage for 3, 6, and 12 months at temperatures of 35-40°, 70°, and 100-105° Fahrenheit.

## EXPERIMENTAL PROCEDURE

### The Sample

**Source.** The fresh liquid eggs and the dehydrated eggs used in this study were supplied by the F. M. Stamper Company, Moberly, Missouri.\*

**Treatment at the Dehydrating Plant.** The eggs, which had been candled and washed, were broken out of the shells, inspected to insure a product of

\* The authors gratefully acknowledge the interest and cooperation of the F. M. Stamper Company in this investigation.

first class quality, placed in the collecting line, and piped to a large vat. Here they were mixed by a slowly revolving coil and were held in the vat at 38°F. until a sufficient quantity had accumulated for the dehydrating operation. When the dehydrating process was begun, the egg pulp was allowed to pass through the warming coils, where it reached a temperature of approximately 70°F. Following this, it was forced to the drying chamber and spray-dried at temperatures between 280 and 300°F. The dried material was discharged from the conical bottom of the dryer, where the temperature was about 140°F. It was then cooled to 80°F. and sifted into appropriate containers.

**Collection and Treatment of the Samples.** In order to minimize the sampling error, 15 cumulative fresh liquid samples were removed from the vat at 15-minute intervals. The composite was kept at 38-40°F. during the time it was being collected and transported to the laboratory. After this, it was divided into 50 ml. portions, stored in glass jars with screw tops, and held at 15°F. until assayed.

The dried egg samples, one-half pound each, were collected five minutes after the liquid sample was taken from the vat. The composite egg samples were thoroughly blended to insure an homogenous mixture and packaged in 35-gram portions in cellophane bags. After sealing the bags with heat, they were placed in paste-board cartons, which in turn were wrapped in wax paper and sealed with paraffin. The sealed cartons were divided into 4 lots: two being stored in a refrigerator at a temperature between 35-40°F.; one in a constant temperature oven at 70°F.; and one in a drying oven maintained at a temperature of 100 to 105°F. Such temperatures were chosen to correspond to storage temperatures in household refrigerators, to ordinary room temperature, and to room temperature during hot summer months.

### Vitamin Assays

The vitamin A, thiamine, and riboflavin values of the samples were determined for (1) fresh liquid eggs, (2) freshly dehydrated eggs, and (3) dehydrated eggs stored at 35-40°, 70°, and 100-105°F. for 3, 6, and 12 months.

**Vitamin A.** A modification of the Sherman and Munsell (1925) method was used to establish the reference growth curve\* and to measure the amount of vitamin A in the egg samples.

**Thiamine.** The biological rat-growth method as described by Erdsiek *et al.* (1951) was followed.

**Riboflavin.** Three methods of assay were used: (1) a modification of the biological rat-growth method of Bourquin and Sherman (1931), (2) the microbiological method of Strong and Carpenter (1942), a modification of the Snell and Strong (1939) procedure, and (3) an adaptation of the fluorometric method described by the Association of Vitamin Chemists (1947).

\* U.S.P. Reference Cod Liver Oil was used as the standard.

Biological rat-growth method. The basal diet used in this assay consisted of:

	Per cent
Casein (Vitamin B-free).....	18
Sucrose .....	70
Salt Mixture (Osborne and Mendel, 1919).....	4
Solka Flock*.....	4
Hydrogenated Fat**.....	4
Cod Liver Oil***.....	2

\* From: The Brown Company, Berlin, New Hampshire.

\*\* Crisco.

\*\*\* Parke-Davis, Standardized Cod Liver Oil containing 2000 U.S.P. units vitamin A, and 250 U.S.P. units vitamin D per gram.

The basal diet was supplemented with the necessary known B-vitamins, other than riboflavin, by feeding each rat 2 ml. of the following solution three times per week.

	Wt. per liter of solution
Labco Rice Polish Concentrate II†.....	116.66 gm.
Vitamin B <sub>6</sub> †† .....	11.66 mg.
Pantothenic Acid††.....	58.33 mg.
Thiamine†† .....	23.33 mg.

† From: The Borden Company, 350 Madison Avenue, New York 17, N. Y.

†† From: Merck and Company, Rahway, N. J.

Care of the rats used in the assay, the construction of the riboflavin reference curve, the feeding of a measured quantity of the material to be assayed, and the calculation of the riboflavin content of the sample were done in a manner similar to that described by Erdsiek *et al.* (1951) for the biological assay of thiamine in chicken tissues.

## RESULTS AND DISCUSSION

Values obtained for the vitamin A, thiamine, and riboflavin content of the fresh egg pulp (white and yolk), the freshly dehydrated eggs, and the dehydrated eggs stored at 35-40°, 70°, and 100-105°F. for 3, 6, and 12 months, are given in Table 1. They are in accord with results reported by Klose, Jones and Fevold (1943), and Hague and Zscheile (1942), and show that the dehydrating process caused no destruction of these vitamins. Storage, especially at the higher temperatures, caused a marked destruction of Vitamin A; thiamine, also, was unstable; but the riboflavin content of the samples remained the same throughout the entire period of observation.

TABLE 1--Vitamin A, Thiamine, and Riboflavin Content of Eggs  
As Affected by Dehydration and by Storage

Kind	Egg Sample*		Vitamin, Assay Method, and Amount of Vitamin				
	Storage		Vitamin A	Thiamine	Riboflavin		
	Time months	Temper- ature °F.	Biological I.U./gm.	Biological mcg./gm.	Biological mcg./gm.	Micro- biological mcg./gm.	Fluoro- metric mcg./gm.
Fresh	0	15	60**	4.6**	14.1	12.0**	----
Dried	0	35-40	66	4.7	14.7	12.1	----
Dried	3	35-40	38	4.0	10.5	12.3	11.7
Dried	3	70	---	3.7	13.6	11.5	10.6
Dried	3	100-105	---	2.6	8.9	12.5	9.6
Dried	6	35-40	38	4.2	11.1	12.6	12.2
Dried	6	70	28	4.2	12.8	12.5	12.0
Dried	6	100-105	11	2.4	12.8	12.3	12.2
Dried	12	35-40	35	4.2	12.3	12.4	12.5
Dried	12	70	20	3.7	11.1	12.3	12.6
Dried	12	100-105	7	2.0	14.6	12.4	12.7

\*Whole egg

\*\*Dry weight basis

#### Vitamin Content of Fresh Eggs and of Dehydrated Eggs

**Vitamin A.** The vitamin A content, determined by the biological (rat-growth) method, was 60 I.U. per gram (dry basis) for the fresh egg pulp, and 66 I.U. per gram for the freshly dehydrated eggs (Table 1). Compared to results obtained by other investigators, using the bioassay method, these values agree well with the upper limit of the ranges 37 to 60 I.U. per gram of emulsified whole egg (Klose, Jones and Fevold, 1943) and 31.6 to 58.5 I.U. per gram of dehydrated eggs (Schrenk, Chapin and Conrad, 1944). Hauge and Zscheile (1942) reported that dehydrated eggs contained approximately 44 I.U. of vitamin A per gram, while Klose, Jones and Fevold (1943), who assayed 5 samples of dehydrated eggs, found a range of 32 to 53 with an average of 39 I.U. per gram.

**Thiamine.** Results of the biological assay showed that the fresh egg pulp contained 4.6 mcg. of thiamine per gram (dry basis) while the dehydrated sample contained 4.7 mcg. of thiamine per gram (Table 1). These results are higher than the average values obtained by the thiochrome method as reported in the literature—3.9 mcg. of thiamine per gram (dry weight) of emulsified whole egg, 3.8 mcg. per gram of dehydrated eggs (Klose *et al.*, 1943); and 3.0 mcg. per gram of dehydrated eggs (Cruickshank, Kodicek and Wang, 1945). The latter investigators report that Copping, who used the biological assay method, found dehydrated eggs to contain 4.4 mcg. of thiamine per gram.

The higher value obtained by Copping, as well as the higher value found in this study, supply more evidence that the biological method gives higher results for the thiamine content of some foods than the thiochrome method.



Such differences have been observed by Lane, Johnson and Williams (1942); Brown, Hamm and Harrison (1943); Jentsch and Morgan (1949); Fardig, Guerrant and Dutcher (1951); and Erdsiek *et al.* (1951). Fardig, Guerrant and Dutcher (1951) state that the difference in the values obtained by the two methods is especially pronounced when foods high in protein are assayed for thiamine.

**Riboflavin.** Values given in Table 1 indicate that of the three methods used to determine the riboflavin content of these samples, the micro-biological method gave the most consistent results. Since the results of all methods showed that after 12 months storage even at 100-105°F., the riboflavin content of the sample was slightly higher than for the fresh or freshly dehydrated product, it is apparent that this vitamin is very stable. Therefore, it was permissible to determine and compare the average riboflavin value obtained by each method during the entire period. These averages, expressed in mcg. per gram (dry basis) were as follows: 12.4, 12.3, and 11.8 when assayed by the biological, microbiological, and fluorometric methods, respectively.

Klose *et al.* (1943) reported riboflavin values of 8 to 13 with an average of 9.8 mcg. per gram for emulsified whole egg (dry weight), and 8 to 13 with an average of 11.2 mcg. per gram for the dehydrated sample. According to Cruickshank *et al.* (1945) the riboflavin content of the dehydrated eggs used in their study ranged from 12.0 to 17.7 with an average of 15.5 mcg. per gram. Both groups of investigators, cited here, used the fluorometric method of assay.

The values for the vitamin A, thiamine, and riboflavin content of dehydrated eggs, obtained in the present investigation, agree favorably with those reported in the literature. Even if experimental error were ruled out, some variations would be expected from sample to sample, since the egg itself is a variable product and the amount of the various constituents which it contains are related to the composition of the ration consumed by the hen.

### Effect of Storage

**Vitamin A.** The vitamin A content of the dehydrated eggs, expressed in I.U. per gram was 38 at 35-40°; 28 at 70°; and 11 at 100-105°F. after 6 months storage. It decreased to 35 at 35-40°; 20 at 70°; and 7 at 100-105°F. after 12 months storage (Table 1 and Figure 1). Based on the amount of vitamin A present in the freshly dehydrated eggs (66 I.U. per gm.), the per cent retained after 12 months storage was 53, 30, and 11 for storage temperatures of 35-40°, 70°, and 100-105°F., respectively. These results are in good agreement with those of Klose *et al.* (1943) who observed the effect of comparable storage time and temperature on the retention of vitamin A in dehydrated eggs.

**Thiamine.** Thiamine was also destroyed in these samples but to a lesser



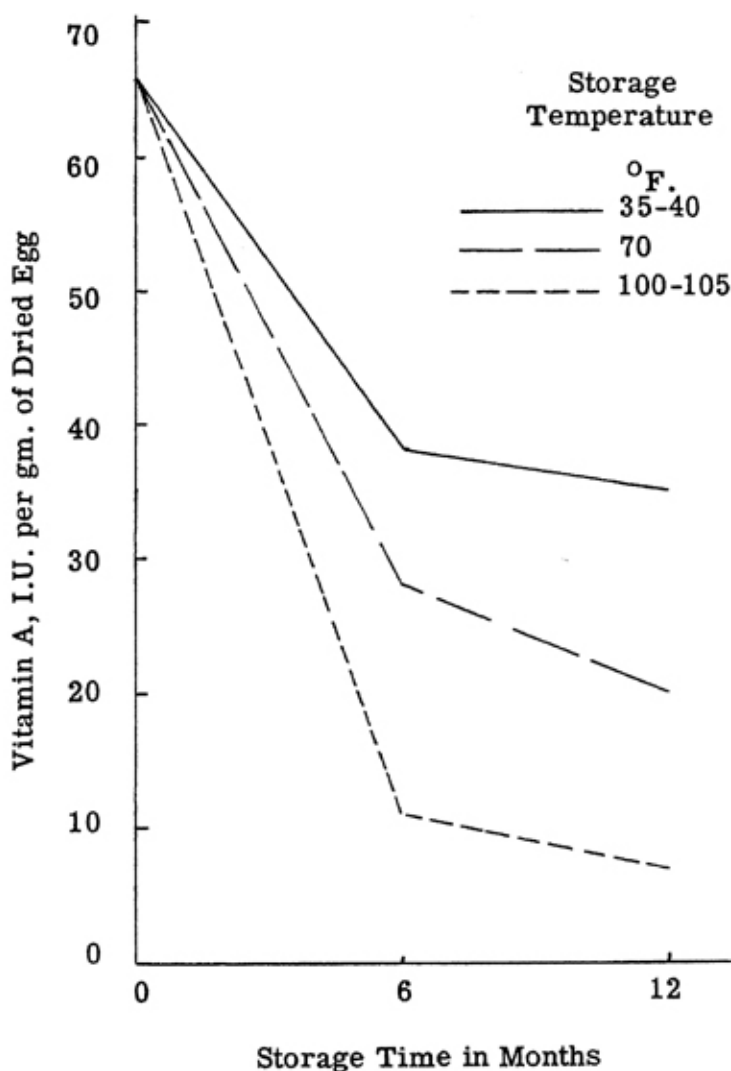


Figure 1.—Vitamin A content of dehydrated eggs as affected by storage time and temperature.

degree than vitamin A (Table 1 and Figure 2). The per cent of thiamine retained during storage, when based on the value 4.7 mcg. per gram of freshly dehydrated eggs, was as follows: 3 months—85 at 35-40°, 79 at 70°, 55 at 100-105°F.; 6 months—89 at 35-40°, and at 70°, 51 at 100-105°F.; 12 months—89 at 35-40°, 79 at 70°, and 43 at 100-105°F.

Klose *et al.* (1943) reported that very little thiamine was destroyed at 15°F. but only about 50 per cent of the original amount of thiamine (2.8 mcg. per gm.) remained in the dried eggs when they were stored for 9 months at 98.6°F.

Olsen, Weybrew and Conrad (1948) gave evidence to show that destruction of thiamine in dehydrated eggs varies inversely with the moisture content of the sample. Loss of thiamine in the samples stored at 98.6°F. for 57 weeks

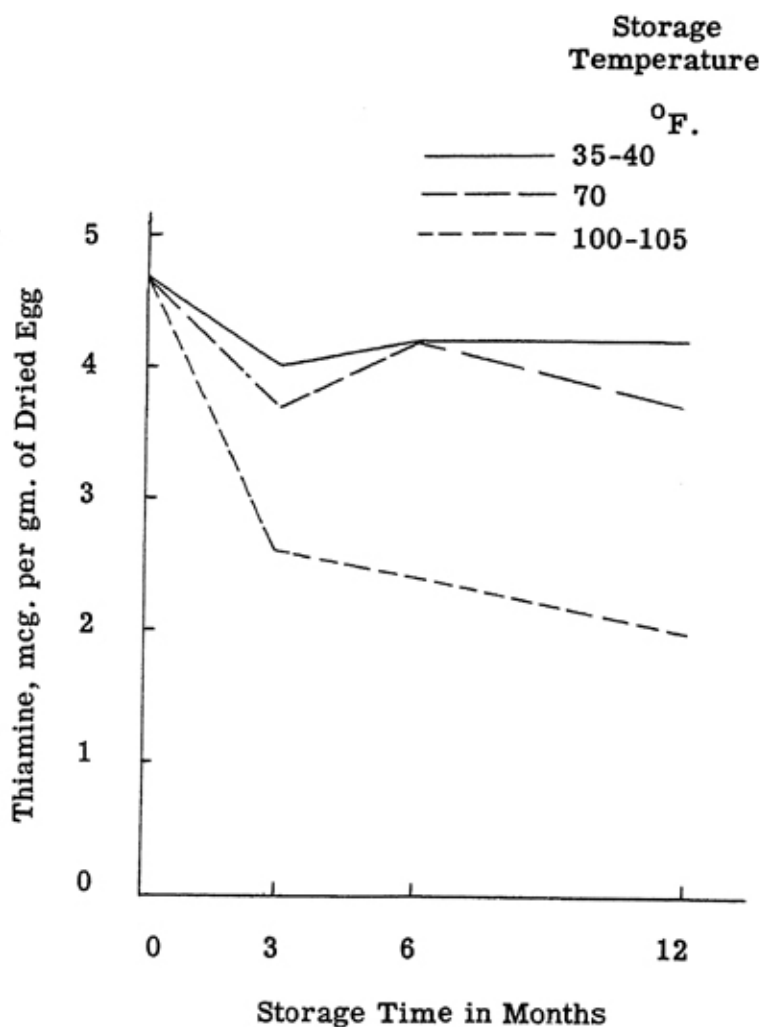


Figure 2.—Thiamine content of dehydrated eggs as affected by storage time and temperature.

was 70 per cent when it contained 3.53 per cent moisture; and 41 per cent when it contained 1.66 per cent moisture. Their control sample which was stored in the refrigerator contained 2.55 per cent moisture, and 3.7 mcg. of thiamine per gram.

Results (Table 1 and Figure 2) show that these samples which contained approximately 2 per cent moisture, lost 57 per cent of the amount of thiamine present in the freshly dehydrated eggs, after they had been stored at 100-105°F. for 12 months. This agrees favorably with the results reported by Olsen *et al.* (1948) and by Klose *et al.* (1943).

Cruickshank *et al.* (1945) observed that samples of dehydrated eggs with a relatively high moisture content (8.4 and 11.0 per cent) when stored in air at 37°C. (98.6°F.) lost almost all of their thiamine potency after 9 months. In identical samples stored at -20°C. for 9 months very little if any destruction of thiamine occurred. They state, "It is evident, therefore, that under certain

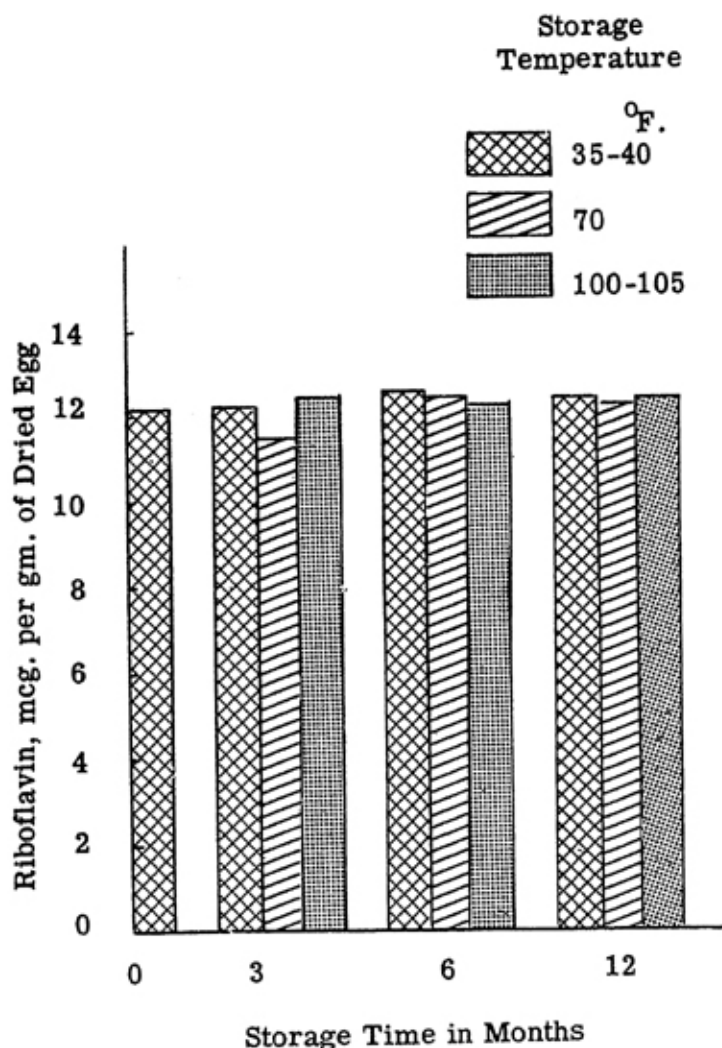


Figure 3.—Riboflavin content of dehydrated eggs as affected by storage time and temperature.

conditions a high temperature during storage is very detrimental to vitamin-B<sub>2</sub> retention. A high water content, however, if combined with a low storage temperature, appears to have very little or no effect.”

**Riboflavin.** As stated previously, the riboflavin content of these samples remained approximately the same (12 mcg. per gm.) under all conditions during the entire period of observation. The column diagram, Figure 3, illustrates graphically the constancy of the assay values given in Table 1.

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