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Stability of Vitamin A in Mixed Feeds

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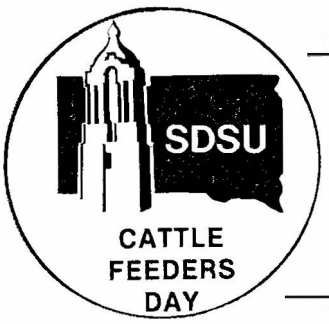

STABILITY OF VITAMIN A IN MIXED FEEDS

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Summary

Feed mixtures as ground corn, minerals and a cattle supplement fortified with vitamin A acetate were stored for 24 weeks under conventional warehouse and cold storage conditions. Vitamin A activity was relatively stable with the ground corn mixture under either method of storage. Vitamin A activity was rapidly destroyed in mineral mixtures regardless of storage conditions. Under warehouse storage, over 50% of the vitamin A activity in the mineral feed was lost after 9 weeks and about 80% after 24 weeks. Destruction of vitamin A in the cattle supplement under warehouse storage was gradual and amounted to about 44% over the 24-week study. Cold storage retarded vitamin A destruction with the ground corn and supplement feeds but not with the mineral mixtures. These studies indicate that feed mixtures containing mineral elements and fortified with vitamin A should be supplied to cattle freshly mixed and at frequent intervals during a feeding period.

Introduction

Vitamin A and carotene are readily susceptible to oxidation and ultra-violet light with resulting loss of biological activity. Minerals such as copper, cobalt, manganese, iron, zinc and iodine have been shown to catalyze oxidative destruction of vitamin A and carotene in mixed feeds. The environmental temperature and humidity are important factors in rate and degree of destruction. These climatic factors together with the destructive effect of minerals have an important bearing on the biological stability of vitamin A in livestock feeds stored over an extended period.

Early studies with cod liver oil as a source of vitamin A provided ample proof of its instability in feeds. Vitamin A supplement manufacturers have recognized the stability problem and have developed various stabilized vitamin A products. Synthetic vitamin A products of the acetate and palmitate ester form have been widely used in the feed industry. Recently, vitamin A acetate has had widespread acceptance in livestock feeds manufactured for commercial use.

The factors which retard or prevent destruction of vitamin A have not been adequately investigated under present methods of storage and when livestock feeds are stored for varying periods of time. The study reported here was conducted to determine how different types of feed mixtures and storage conditions affect the biological activity of vitamin A acetate. The study was initiated June 19, 1978, continued through the summer months and completed January 9, 1979.

Procedures

Three feed mixtures were prepared by mixing various feed ingredients with a vitamin A premix in a small, stainless steel batch mixer. A vitamin A premix was obtained fresh from a commercial vitamin manufacturer for addition to the mixtures. The premix contained 30,000 International Units (IU) per gram. The composition of the feed mixtures is shown in table 1.

Table 1. Composition of Feed Mixtures, %

Ingredient	Ground corn	Minerals	Cattle supplement
Ground yellow corn	99.63	--	33.48
Soybean oil meal	--	--	46.20
Urea	--	--	3.00
Trace mineral salt	--	49.81	3.00
Dicalcium phosphate	--	24.91	2.00
Ground limestone	--	24.91	6.00
Potassium chloride	--	--	3.00
Sodium sulfate	--	--	2.40
Antibiotic premix[a]	--	--	0.35
Vitamin E premix[b]	--	--	0.20
Vitamin A premix[c]	0.37	0.37	0.37
Total	100.00	100.00	100.00

[a] Aureomycin-50 contained 50 grams chlortetracycline per pound.
[b] Contained 500 IU vitamin E per gram.
[c] Contained 30,000 IU vitamin A per gram.

Each feed was mixed as a 75-lb. batch, divided equally into two portions, and placed in a 50-lb. commercial paper feed bag. The bags were folded at the top and sealed with masking tape. One bag of each feed mixture was placed in a conventional warehouse storage building of steel construction used to house other feed ingredients. The bags were placed upon the top of other stacked bags of feed material and off the floor. No moisture from rain penetrated the building. However, the structure allowed in the natural moisture from the atmosphere. One bag of each feed mixture was placed in a walk-in freezer operating at -4 C.

Samples from each feed mixture and storage condition were collected weekly for 12 weeks and monthly thereafter for 3 months for a total storage period of 24 weeks. Portions of feed were hand collected at different locations in the bagged feed to give a quantity of about 400 grams at each sampling period. This was ground through a Wiley mill equipped with a 1 mm screen. The mineral mixtures were not ground. The ground and unground feeds were thoroughly mixed and placed in tightly closed storage containers for chemical analysis.

A 20-gram sample (air-dry basis) was weighed into a 250 ml actinic boiling flask immediately following sampling and grinding. Dry matter determinations were made in duplicate on each feed as the samples were processed for chemical analysis. The assay for vitamin A was conducted in triplicate according to procedures of the Association of Official Analytical Chemists (1975) with certain modifications. Methyl alcohol was used in the alkaline digestion (hydrolysis) and petroleum ether was used in the extraction procedure. Chromatography was not used in the determinations. Concentrations of vitamin A were determined by use of the Carr-Price assay procedures and reported as micrograms of vitamin A alcohol per gram of moisture-free sample.

The statistical treatment of the data was by analysis of variance and polynomial regression procedures. Stability of vitamin A for each feed stored under each storage condition is expressed by fitting a curve to the data set that best described the rate of destruction of the vitamin.

Results

The stability of vitamin A acetate in mixed feeds stored under warehouse conditions is shown in table 2 and cold storage conditions in table 3. The feed mixtures used were formulated on an air-dry basis and a quantity of vitamin A premix added to provide 50,800 IU of vitamin A per pound of mixed material. This unitage translates to about 34 micrograms of vitamin A per gram as the alcohol form, assuming 1 IU is equivalent to 0.300 micrograms of vitamin A alcohol.

Table 2. Vitamin A Stability in Feed Mixtures
Warehouse Storage

Week of storage	Vitamin A in feed mixtures mcg vitamin A alcohol/gram[a,b]		
	Ground corn	Minerals	Cattle supplement
0	50.93	39.91	48.47
1	49.68	37.65	46.92
2	47.81	36.29	47.78
3	46.18	33.95	43.75
4	45.03	33.57	39.12
5	45.31	28.29	35.78
6	44.65	28.13	37.52
7	44.35	22.57	37.78
8	45.64	22.22	36.74
9	45.34	18.97	36.26
10	45.39	19.20	36.46
11	45.28	17.48	33.66
12	44.51	14.27	32.87
16	44.60	13.20	31.88
20	42.32	12.43	27.16
24	42.00	9.32	26.73

[a] Moisture-free basis.
[b] Average of triplicate analyses.

Table 3. Vitamin A Stability in Feed Mixtures
Cold Storage

Week of storage	Vitamin A in feed mixtures mcg vitamin A alcohol/gram[a,b]		
	Ground corn	Minerals	Cattle supplement
0	50.93	39.91	48.47
1	49.86	38.42	48.08
2	49.93	38.30	48.32
3	48.44	30.97	48.96
4	46.90	30.74	48.92
5	48.31	33.56	48.86
6	48.52	34.69	48.42
7	48.06	35.25	48.05
8	47.66	35.24	47.61
9	46.76	35.18	48.21
10	47.06	35.29	48.89
11	47.20	35.38	46.20
12	46.62	32.28	45.05
16	46.80	24.21	45.21
20	46.23	15.41	45.21
24	45.97	12.40	45.72

[a] Moisture-free basis.
[b] Average of triplicate analyses.

Differences in the initial dry matter content of the feeds were observed. The ground corn mixture was 87.5% dry matter, while the mineral mixture was 98.9% and the cattle supplement 89.1%. When adjusted to a moisture-free basis, the three feeds theoretically were to contain 38.36, 33.95 and 37.67 micrograms of vitamin A alcohol per gram, respectively, for each feed mixture. Chemical anslyses showed the concentration to be 50.9, 39.9 and 48.5 micrograms of vitamin A alcohol for the ground corn mixture, the minerals and the cattle supplement, respectively, on a moisture-free basis.

The assay values were used throughout the statistical analyses in evaluating the stability of vitamin A. The discrepancy between the theoretical and assayed values could have been the result of sampling, mixing and weighing errors. Assay procedures require small quantities of sample and errors of this type may have a major influence on the resulting values.

The rate of destruction of vitamin A in the ground corn feed in warehouse storage is shown in figure 1 and when it was kept in cold storage in figure 2. Stability of vitamin A was generally good with each method of storage. The vitamin A activity in ground corn feed under warehouse storage dropped sharply during the first 4 weeks with little change to the end of the 24-week period. The corn stored under cold conditions showed a small but linear destruction of vitamin A. The decrease was from 49 micrograms initially to 45 micrograms at the end of the storage period. This amount would be considered rather insignificant.

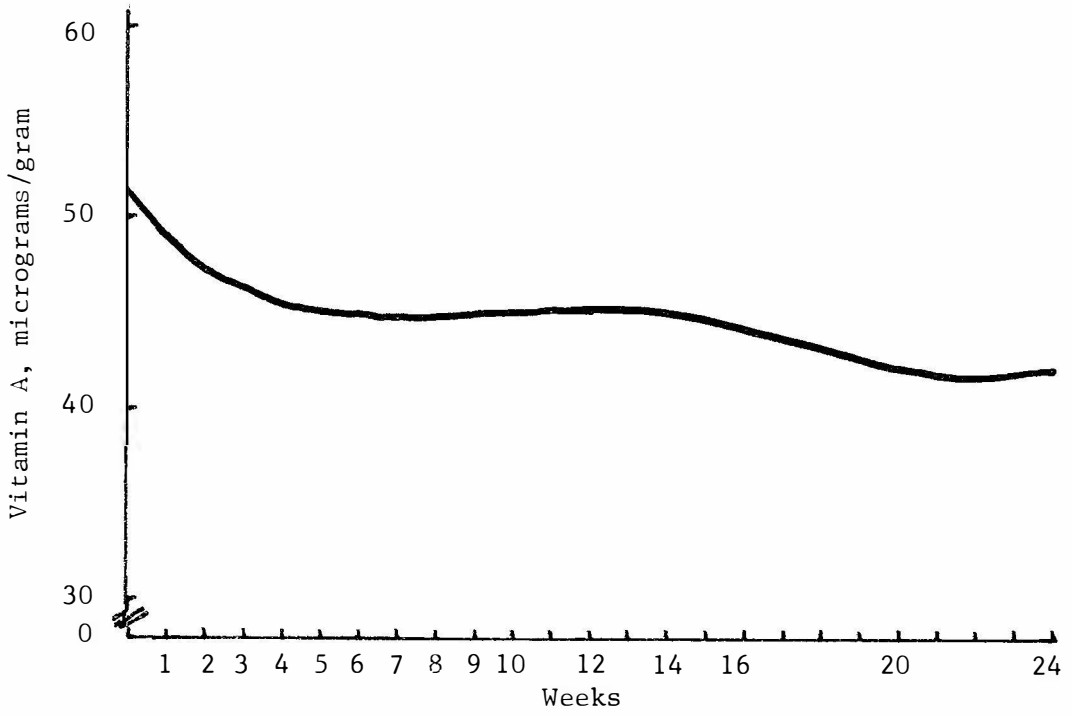

Figure 1. Corn - Conventional Storage.

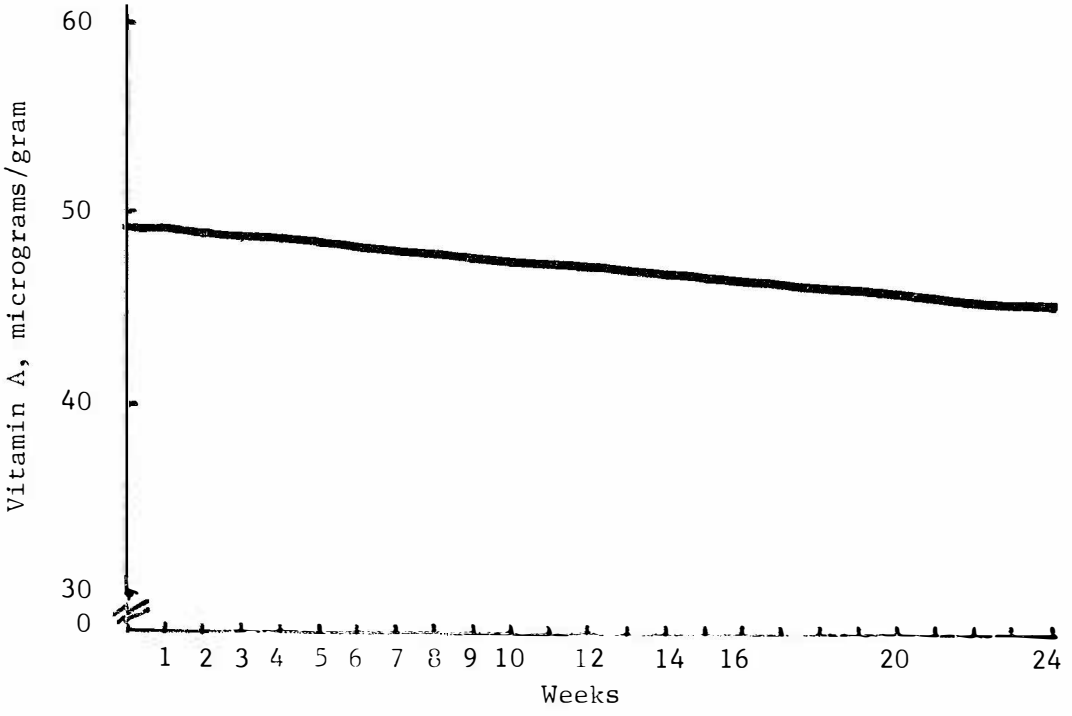

Figure 2. Corn - Cold Storage.

Figures 3 and 4 illustrate the rate of vitamin A destruction in a mineral mixture under the two methods of storage. The vitamin A activity in the warehouse or conventional storage structure declined rather rapidly to 16 weeks of storage and then was relatively stable to 24 weeks. The decrease was from 41 micrograms to 12 micrograms over this period of time, which amounts to about 80% of the initial vitamin A activity being destroyed. This appeared to be due to the oxidizing properties of the mineral elements contained in the mixtures. The stability of vitamin A in mineral mixtures under cold storage generally followed the same trend as with the warehouse storage. There was, however, a slight increase in vitamin A activity beginning at the fifth week and remaining rather constant to the eleventh week before dropping off sharply at the end of the storage period. The reason for this response cannot be readily explained.

Vitamin A destruction in the cattle supplement under the two storage conditions is illustrated in figures 5 and 6. Vitamin A activity gradually decreased over the 24 weeks. The decrease was from 48 micrograms initially to 27 micrograms per gram at the end of 24 weeks. This represents about a 44% destruction in vitamin A activity. Losses of vitamin A were small and took a linear trend with the cattle supplement held under cold storage conditions.

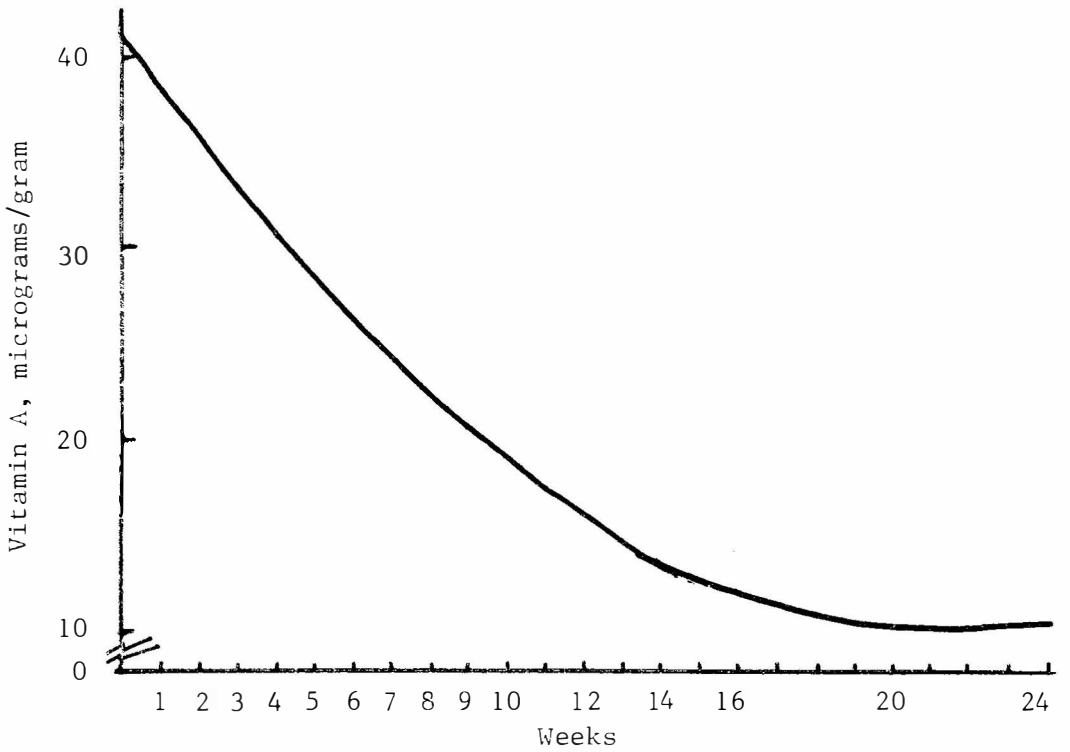

Figure 3. Mineral - Conventional Storage.

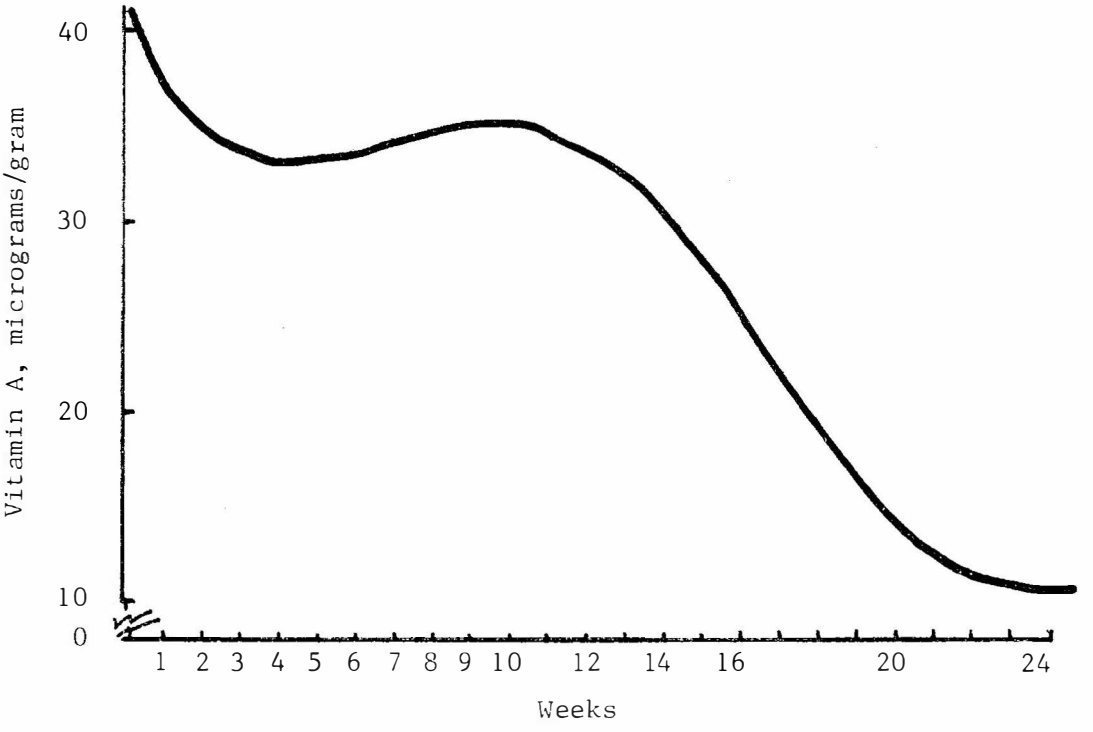

Figure 4. Mineral - Cold Storage.

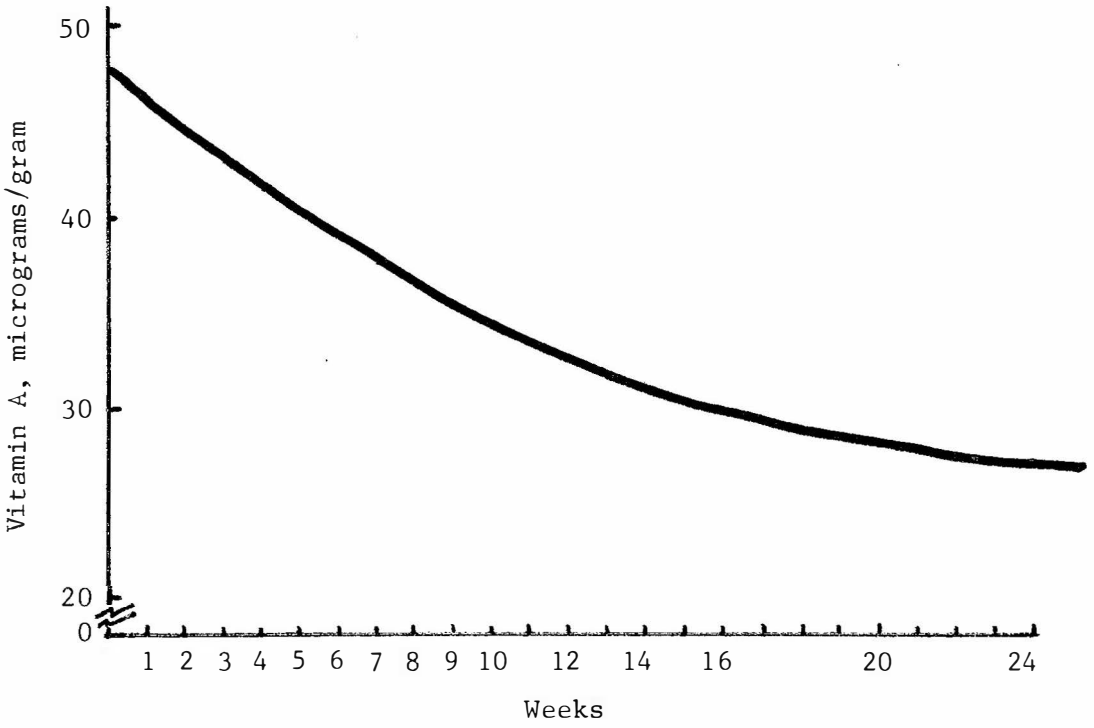

Figure 5. Supplement - Conventional Storage.

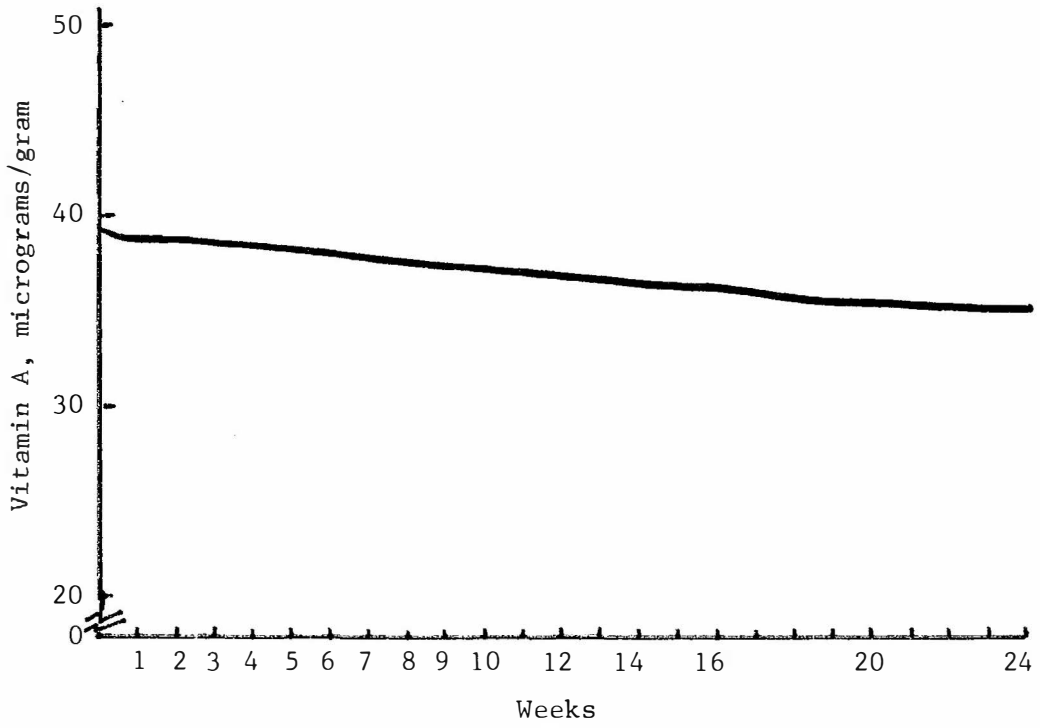

Figure 6. Supplement - Cold Storage.