THE VITAMIN CONTENT OF SWINE COLOSTRUM AND MILK

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By

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Introduction

Swine colostrum and milk have not been studied as extensively as the milk of the other domestic animals. The primary reason for this lack of information is the past difficulty with which sufficient milk for analysis could be obtained. Until recently it has been almost impossible to collect relatively large samples of milk from swine because of the nervous control of milk release exercised by the sow. In 1941 Ely and Petersen (12) devised a method of inducing the "let down" of the milk in the cow by the intravenous injection of pitocin, the oxytocic principle of the pituitary. This method has been adapted in obtaining milk samples from the sow and has the advantage of permitting the collection of relatively large samples of milk, more nearly representative of the entire secretion.

The vitamin content of colostrum and milk is of the utmost importance for the newborn animal, because it represents the sole source of nutrients for the first few days and weeks of life. Information about the diet of pigs before weaning is important, because it is logical that the diet the pigs receive after weaning should be as nearly comparable as practicable to the pre-weaning diet. Thus, knowledge of the composition of swine milk is necessary for the development of both purified and practical rations for very young pigs.

Some limited information has recently appeared concerning the approximate composition and vitamin A content of swine milk. Extensive examination for the vitamin content has not been reported. The magnitude of the differences in the reported vitamin content of swine colostrum and milk is too great to be accounted for on the basis of diet or breed differences. Therefore, the present study was undertaken to provide information of the thiamin, riboflavin, nicotinic acid, pantothenic acid, vitamin A, and ascorbic acid content of swine colostrum and milk.

Studies of the gross composition of swine milk have been reported by various workers over a period of years. However, the data published on the vitamin content of swine colostrum and milk are very limited and of considerable variance.

Benham (3) found that the vitamin A content of sow's colostrum ranged from 131 to 245 I.U. per 100 ml. (291 to 564 micrograms per 100 ml.). The study of Schofield <u>et al</u>. (21) showed that giving sows large doses of vitamin A late in pregnancy increased the concentration of this vitamin in the colostrum. Luecke (17) has reported the vitamin A content of swine colostrum to vary from 13 to 122 micrograms per 100 ml. These pigs received no supplements of vitamin A, but they were fed a suppossedly adequate ration which contained 10 per cent alfalfa hay. Braude <u>et al</u>. (7) in England reported on 18 samples of sow's colostrum in which they obtained a mean value of 347 I.U. per 100 ml. for vitamin A. The same group of workers, Braude <u>et al</u>. (8), reported on the composition of colostrum and milk from nine Large White sows. Their value for colostrum was 71.1 ± 9.1 I.U. of vitamin A per gram of fat and for normal milk 11.0 ± 0.4 I.U. vitamin A per gram of fat. Recently Bowland, Grummer, and Phillips (4) determined the vitamin A content of the colostrum and milk from 20 sows. The mean values for vitamin A were: first and third day colostrum from sows on pasture, 143.6 mcg./ 100 ml., from sows in dry-lot 132.9 mcg./ 100 ml.; normal milk from sows on pasture 52.7 mcg./ 100 ml., from sows in dry-lot 34.8 mcg./ 100 ml.

The vitamin A levels of sow's colostrum and milk reported by Bowland (4) agree quite well with those reported by Braude <u>et al</u>. (8) in England and Schofield <u>et al</u>. (21) in Canada but are generally lower than the values for colostrum given by Benham (3).

Norfeld (18) first reported the ascorbic acid content of swine milk. He found that milk from a normal sow contained 6.1 mg. ascorbic acid per 100 ml. and milk from a sow receiving a vitamin A deficient ration contained 4.1 mg. ascorbic acid per 100 ml. Braude et al. (7) reported on 18 samples of sows' colostrum in which they obtained a mean value of 23.8 mg./100 ml. for ascorbic acid. The same authors (8) in 1947 found the ascorbic acid content of sows' milk was lower than that of colostrum, 13.0 as compared with 30.6 mg./100 ml.

Barnhart et al. (1), feeding a basal ration composed of yellow corn, soybean oil meal, alfalfa meal, 2.5 per cent mineral mix, and vitamin A and D pre-mix, obtained increases in the riboflavin, nicotinic acid, and pantothenic acid content of milk by adding 10 per cent alfalfa and tankage to the basal ration. Luecke, Duncan, and Ely (17) reported the B-vitamin content of swine colostrum and obtained values of 0.52 to 1.01 mcg./ml. for thiamin, 1.65 to 6.25 mcg./ml. for riboflavin, 0.60 to 1.70 mcg./ml. for pantothenic acid and 1.14 to 1.85 mcg./ml. for nicotinic acid. Braude et al. (8) have studied further the B-vitamin content of swine colostrum and milk. They found the mean values for twelve samples of colostrum to be: total thiamin 96.8 ± 7.8 mcg./100 ml.; free thiamin 70.8 ± 7.8 mcg./100 ml.; and riboflavin 44.9 ± 5.7 mcg./100 ml. The mean values for the milk, obtained from the analysis of seventy to seventy-six samples from the 10th to 56th day of lactation, were: total thiamin 67.7 ± 1.8 mcg./100 ml.; free thiamin 14.4 ± 1.2 mcg./100 ml.; and riboflavin 45.7 ± 1.7 mcg./100 ml.

Experimental

Source of Samples

Sows of the Hampshire, Duroc, and Chester White breeds were used in this study. The 16 sows on the spring farrowing were all of Hampshire breeding, while the 19 sows on the fall farrowing were 5 Hampshire, 9 Duroc, and 5 Chester White. All sows whose milk was sampled were in either their first or second lactation period.

The sows were carried through successive gestation and lactation periods on the two rations given in Table 1. The basal ration was supplemented with the various materials indicated in Table 2.

The farrowing dates for the sows in the spring farrowing (Experiment I) ranged between January 14 and April 20, 1948, and the sows in the fall farrowing (Experiment II) between September 27 and November 8, 1948.

Collection and Treatment of Samples

Colostrum was obtained during parturition by normal expression of the udder. Milk samples were obtained on the 5th, 15th, and 55th days of lactation by intravenous injection of 1 to 2 ml. of the oxytocic principle of the pituitary (Pitocin--Parke, Davis and Co.). Ely and Peterson (12) devised this method for inducing the " let down" of milk in the cow and a similar method was employed by Braude (8) for induction of milk ejection in the sow.

Vitamin A and ascorbic acid determinations were made as soon as possible after sampling. The remaining portion of the sample was quick frozen in sealed containers and assayed later for thiamin, riboflavin, nicotinic acid, and pantothenic acid.

Table 1

Rations Fed in Drylot During Gestation and Lactation

Experiment I (Spring 1948 Farrowing)

Basal Ration No. 1

Constituent	Per cent
Ground yellow corn	82.85
Expeller soybean oil meal	11.00
Alfalfa leaf meal	5.00
Ground limestone	0.65
NaCl	0.50

Experiment II (Fall 1948)

Basal Ration No. 2

Constituent	Per cent
Ground yellow corn	82.85
Expeller soybean oil meal	11.00
Alfalfa leaf meal	5.00
Ground limestone	0.65
Iodized NaCl	0.50

Crude carotene concentrate at level of 6,000 I.U. per pound of feed

Table 2

Details of Swine Whose Colostrum and Milk Were Examined

Exp. No.	Lot No.	Ration Fed	No. Sows	Breed	Lactation
I	1	Basal Number 1	3	Hampshire	First
	2	Basal + alfalfa silage <u>ad lib</u>	3	Hampshire	First
	3	Basal + 1/2 gal. buttermilk per gilt per day	3	Hampshire	First
	4	Basal + 3% liver and lung meal	3	Hampshire	First
	5	Basal + Antipernicious anemia liver extract	2	Hampshire	First
	6	Basal + green rye forage <u>ad lib</u> 14 days before farrowing and during lactation	1	Hampshire	First
II	1	Basal Number 2	2	Duroc	First
			1	Chester	First
			3	Hampshire	Second
	2	Basal + 3% fish solubles	3	Duroc	First
			1	Chester	First
			2	Hampshire	Second
	3	Basal + 10% alfalfa leaf meal	1	Duroc	First
			1	Chester	First
	4	Basal + Antipernicious anemia liver extract, 2 ml./week/gilt	1	Duroc	First
			1	Chester	First
	5	Basal in dirt lot	1	Duroc	First
			1	Chester	First
	6	Basal + vitamin B_{12} (equivalent to 2% fish solubles)	1	Duroc	First

Analysis of Samples

General Procedure for Microbiological Assays

The test organisms, *Lactobacillus casei* and *Lactobacillus arabinosus*, were maintained as stab cultures by monthly transfer in a yeast dextrose agar of the following composition:

Yeast dextrose agar (Difco)	2.7 G.
Dextrose	1.0 G.
Sodium acetate	1.6 G.
*Salt solution A	1.0 Ml.
**Salt solution B	1.0 Ml.
Distilled water to make	100 Ml.

*Potassium phosphate	25.0 G.
Potassium dihydrogen phosphate	25.0G.
Distilled water to make	250 Ml.

**Magnesium sulfate	10.0 G.
Ferric sulfate	0.5 G.
Sodium chloride	0.5 G.
Manganese sulfate	0.5 G.
Distilled water to make	250 Ml.

These stock cultures were incubated at 37° C. for 24 to 48 hours, or until good growth along the line of the stab was visible and then stored in the refrigerator for the remainder of the interval between transfers. The inoculum was prepared by transferring the organisms from the agar stab cultures into 10 ml. of the liquid basal medium which had been supplemented with the deficient vitamin at the level of 1 mcg./10 ml. After incubation for 24 hours at 37° C., the cultures were centrifuged; the supernatant medium was poured off and replaced asceptically with an equal volume of sterile 0.9 per cent sodium chloride solution. The cells were washed twice in this manner and one drop of the suspension was used as the inoculum for each assay tube.

The assays were conveniently carried out in 16 x 180 mm. bacteriologic culture tubes, held in metal racks which were easily autoclaved. To one series of tubes, increments of a standard solution of the vitamin were added. To other similar series, increasing amounts of diluted milk samples were added at five levels (1 to 5 ml.) considered by approximation to furnish amounts of the vitamin within the ranges of the standard curve. All tubes were diluted with distilled water to 5 ml., then 5 ml. of the double strength, vitamin-deficient medium were added. The tubes were covered with metal caps lined with gauze and sterilized by autoclaving at 15 pounds pressure for 15 minutes. After cooling to room temperature, each tube was inoculated with one drop of the turbid inoculum culture and incubated at 37° C. The acid produced in each tube was titrated with tenth-normal sodium hydroxide, using bromothymol blue as an indicator, after an incubation period of 72 hours.

To obtain the assay results, a standard curve was plotted relating the response of the test organism (in cubic centimeters of alkali used in titration) to the concentration of the vitamin in the standard tubes. The vitamin content of the various aliquots of sample used was obtained by interpolating the response obtained in tubes containing these aliquots on the standard curve. Results falling outside the assay range of the vitamin were discarded. The vitamin content of the sample was then calculated from that of each aliquot.

Nicotinic Acid

The procedure of Snell and Wright (23) with modifications introduced in this laboratory was used for the determination of nicotinic acid. *Lactobacillus arabinosus* 17-5 (ATCC No. 8014), obtained from American Type Culture Collection, Georgetown University Medical School, Washington, D. C., was used as the assay organism.

The stock standard solution of nicotinic acid contained 100 mcg./ml. of distilled water. This solution was kept under toluene in a refrigerator. From this stock solution, a standard containing 1 microgram of nicotinic acid per ml. was prepared each time an assay was made. At least three similar series of tubes were prepared with the standard containing 0.0, 0.05, 0.10, 0.15, 0.20, 0.30, and 0.50 micrograms of nicotinic acid.

All solutions used in the medium were prepared at concentrations given in a University of Texas publication (27). The basal medium contained per thousand milliliters:

Acid-hydrolyzed casein	10 g.
l-cystine	400 mg.
l-tryptophane	200 mg.
Glucose	40 g.
Sodium acetate	40 g.
Biotin	0.4 mcg.
p-aminobenzoic acid	200 mcg.
Thiamin	200 mcg.
Calcium d-pantothenate	200 mcg.
Pyridoxine	200 mcg.
Riboflavin	400 mcg.
Adenine, guanine, uracil	20 mg.
Salt solution A	10 ml.
Salt solution B	10 ml.

The medium was made to volume and adjusted to a pH of 6.6 to 6.8 with sodium hydroxide. The glucose and sodium acetate were added in the dry state.

Colostrum samples of 2 ml. were diluted to 100 ml. and milk samples of 1 ml. were diluted to a total volume of 100 ml. in volumetric flasks. These dilutions resulted in concentrations suitable for assay. Quantities of 1, 2, 3, 4, and 5 ml. of the dilutions were added to five assay tubes respectively, and each tube was made to a total volume of 5 ml. with distilled water. Five ml. of the nicotinic acid free basal medium were added to each of the assay tubes. The tubes were autoclaved, inoculated, incubated, and the growths measured as described.

The colostrum and milk samples were not treated with enzymes, acids, or alkali, because Cheldelin (9), (10), and Williams (28) found that such treatment did not significantly affect the values obtained. This indicated that in milk nicotinic acid is not essentially in a bound state or in the form of a precursor not readily available to <u>Lactobacillus arabinosus</u>.

Riboflavin

With few exceptions, the basic microbiological procedure described for the assay of nicotinic acid was employed for the determination of riboflavin. The procedure of Snell and Strong (22) with modifications of the basal medium was used for the microbiological assay of riboflavin. *Lactobacillus casei* 17-5 was used as the assay organism.

The basal medium contained per thousand milliliters:

Sodium hydroxide treated peptone	10 g.
l-cystine	200 mg.
l-tryptophane	200 mg.
Yeast supplement	2 g.
Glucose	40 g.
Adenine, guanine, uracil	20 mg.
p-aminobenzoic acid	800 mcg.
Pyridoxine	200 mcg.
Nicotinic Acid	200 mcg.
Calcium d-pantothenate	200 mcg.
Salt solution A	10 ml.
Salt solution B	10 ml.

Pantothenic Acid

Pantothenic acid was determined microbiologically by use of the procedure of Barton-Wright (2). *Lactobacillus casei* (ATCC No. 7469) was used as the assay organism.

Pure synthetic d-calcium pantothenate was used to prepare the stock standard solution of 100 mcg./ml. of distilled water. This solution was stored under toluene in the refrigerator. One ml. of the standard solution of pantothenic acid was diluted to 100 ml., and one ml. of this dilution was further diluted to 100 ml. From these two dilutions, a triplicate set of standard tubes was prepared containing 0.0, 0.01, 0.02, 0.05, 0.10, and 0.20 micrograms of pantothenic acid respectively.

The pH of the basal medium was adjusted to 6.6 to 6.8 with sodium hydroxide. The peptone and the yeast were prepared as described by Strong and associates (26) except that Darco G 60 was used instead of Norit A to treat the yeast supplement. The other ingredients were prepared as in the assay for nicotinic acid. The basal medium contained per thousand milliliters:

Sodium hydroxide-treated peptone	10	g.
l-cystine	200	mg.
Glucose	40	g.
Sodium acetate	28	g.
Acid hydrolyzed casein	4	g.
Adenine, guanine, uracil	20	mg.
Nicotinic acid	400	mcg.
Biotin	0.8	mcg.
Riboflavin	400	mcg.
Pyridoxine	200	mcg.
p-aminobenzoic acid	200	mcg.
Salt solution A	10	ml.
Salt solution B	10	ml.

The samples were diluted to a concentration suitable for assay (colostrum diluted 1 ml. to 100 ml. and milk diluted 1 ml. to 200 ml.). As in the assay of nicotinic acid, 1 to 5 ml. of each dilution was pipetted into five assay tubes. The assay tubes (sample and standard tubes) were made to a total volume of 5 ml. and then 5 ml. of the basal medium were added to each tube. The tubes were covered, and autoclaved fifteen minutes at fifteen pounds pressure. After cooling and inoculation, the tubes were incubated 72 hours at 37° C. and the growths measured as described.

In most foods and animal tissues a part of the pantothenic acid is bound to the protein and must be freed by autolysis or enzymatic hydrolysis before the microbiological assay is carried out. Pantothenic acid in milk is in a free state or in a state in which it is readily utilized by lactobacilli. Strong (25) and Williams (28) report that treatment of milk with enzymes did not significantly affect the pantothenic acid values. Thus, the samples were not hydrolyzed in preparation for analysis.

Thiamin

Thiamin was determined by the fluorometric method described by Hodson (15). The method was a simplification of the procedure reported by Hennessey and

Cerecedo (14).

Duplicate 10 ml. samples of the milk were pipetted into 50 ml. volumetric flasks, 50 mg. of taka-diastase were added, the pH adjusted to 4.0 to 4.5 with 2.5 normal sodium acetate, and incubated for three hours at 50° C. The flasks were shaken occasionally to break up the curd that formed. After three hours the flasks were cooled and diluted to the mark with two per cent trichloroacetic acid, thoroughly mixed, allowed to come to equilibrium by standing for a few minutes, and filtered through Whatman No. 1 filter paper. If the filtrate was very cloudy it was further clarified by passing it through the filter again.

A 5 ml. aliquot of the filtrate was pipetted into each of three centrifuge reaction vessels marked 1, 2, and 3. To reaction vessel No. 2 was added one ml. of a solution containing exactly one microgram of thiamin chloride. To vessels No. 1 and No. 2 were added 0.1 ml. of the ferricyanide solution followed immediately by three ml. of the sodium hydroxide solution. Thirteen ml. of isobutyl alcohol were added to the mixtures in the three vessels, and finally three ml. of sodium hydroxide solution were added to the mixture in Vessel 3. The glass stoppers were then placed in the vessels and vigorously shaken for 1.5 minutes. This was followed by centrifuging for about one minute to separate the aqueous and isobutyl alcohol layers. The aqueous layer was drained off and discarded, and the isobutyl layer was dried with a small amount of anhydrous sodium sulfate. The isobutyl alcohol was then transferred to photofluorometer tubes.

The Coleman photofluorometer was allowed to warm up 10 or 15 minutes before use. The dilute quinine sulfate solution, having a fluorescence approximately equal to that given by the thiochrome from one microgram of thiamin in 13 ml. of isobutyl alcohol, was placed in one of the cuvettes and the diaphragm of the photofluorometer adjusted so that this gave a half-scale deflection when placed in the instrument. The exact point chosed was not critical, but the same reference point was used for the three readings on any one sample. A reading (B) was taken on the thiochrome solution from Vessel 3 (the blank), a reading (X) was taken on the thiochrome solution from Vessel 1, and a reading (X+1) was taken on the solution from Vessel 2. The calculation was: $\frac{X - B}{(X+1) - X}$ (1.0) = micrograms of thiamin per ml. of milk or milligrams per liter of milk.

Vitamin A

The procedure used for the determination of vitamin A and carotene was a modification of the method of Boyer, et al. (6). Two volumes of milk mixed with three volumes of alcoholic potassium hydroxide solution were allowed to stand for three hours at room temperature. The mixture was extracted twice with ether and the vitamin A and carotene were determined by means of the Carr-Price reaction and with the aid of an Evelyn photoelectric colorimeter.

Ascorbic Acid

For the determination of ascorbic acid, 5 ml. of a freshly taken sample of milk were pipetted into 15 ml. of a modified Wilberg's reagent containing 40 g./l. trichloroacetic acid, 65 g./l. metaphosphoric acid, 6 g./l. oxalic acid, and 48 g./l. NaCl. The precipitate was removed by centrifugation or filtration and a 10 ml. aliquot of the filtrate titrated with 2,6-dichloro-phenolindophenol solution to a faint pink end-point stable for 30 seconds. The dye had been previously standardized against pure ascorbic acid.

Results

Detailed results for the vitamin determinations of colostrum and milk are given in Tables 3 and 4. Table 3 shows the vitamin content of the colostrum and milk of gilts in the spring 1948 farrowing (Experiment I). Table 4 presents similar data for the gilts and sows in the fall 1948 farrowing (Experiment II). The mean values for colostrum and milk on the first, fifth, fifteenth, and fifty-fifth day of lactation of 16 animals in the spring farrowing and 19 animals in the fall farrowing are given in Tables 5 and 6. The average values for the vitamin content of colostrum and milk from spring gilts, fall gilts, and fall sows are shown in Table 7.

A comparison of the vitamin content of colostrum and milk for the three breeds of swine used in the fall experiment is given in Table 8.

In Table 9, the average vitamin content of swine colostrum and milk and cow colostrum and milk as determined in these laboratories is compared with selected values given in the literature.

Table 3

VITAMIN CONTENT OF SWINE MILK

Fall-1948 Farrowing

Lot No.	Sow Number	Ration	Vitamin	Vitamin Content			
				Colostrum	5th day	15th day	55th day
	Jim Farrowed 4-9-48		Riboflavin mcg/ml		1.9	1.1	3.0
			Thiamin mcg/ml			0.12	0.32
			Nicotinic Acid mcg/ml		12.3	13.2	10.0
			Pantothenic Acid mcg/ml			4.9	9.8
			Carotene mcg/100ml		2.4	2.4	2.4
			Vitamin A mcg/100ml		44.0	32.4	7.8
			Ascorbic Acid mg/100ml		11.6	13.8	9.1
1	76 Farrowed 4-15-48	Basal	Riboflavin	6.0	2.1	1.8	3.4
			Thiamin		0.21	0.31	0.26
			Nicotinic Acid	1.0	1.3	2.6	5.1
			Pantothenic Acid	1.7	1.1	1.5	2.5
			Carotene	1.4	3.7	1.4	1.8
			Vitamin A	94.8	15.8	15.4	19.0
			Ascorbic Acid	35.1	16.4	14.1	7.7
1	82 Farrowed 2-14-48	Basal	Riboflavin	2.5	All Dead		
			Thiamin	0.75			
			Nicotinic Acid	1.5			
			Pantothenic Acid	2.1			
			Carotene	3.0			
			Vitamin A	92.6			
			Ascorbic Acid	17.8			
1	90 Farrowed 4-2-48	Basal	Riboflavin	5.2	2.6	All Dead	
			Thiamin	0.95			
			Nicotinic Acid	1.2	1.6		
			Pantothenic Acid	0.9	0.9		
			Carotene	2.2	0.0		
			Vitamin A	242.0	90.6		
			Ascorbic Acid	16.7	11.0		
2	77 Farrowed 4-15-48	Basal + Alfalfa Silage	Riboflavin	3.8	2.3	2.4	3.3
			Thiamin				
			Nicotinic Acid	0.9	1.8	5.3	3.6
			Pantothenic Acid	0.6	1.8	1.4	3.2
			Carotene	0.8	7.5	1.2	2.3
			Vitamin A	154.0	21.9	20.9	20.7
			Ascorbic Acid	27.7	11.4	9.7	6.2
2	83 Farrowed 4-15-48	Basal + Alfalfa Silage	Riboflavin	10.7	1.8	2.6	3.0
			Thiamin				
			Nicotinic Acid	1.0	1.4	2.0	5.5
			Pantothenic Acid	0.7	1.5	1.6	2.8
			Carotene	1.4	1.8	1.1	6.0
			Vitamin A	168.0	20.3	19.4	22.3
			Ascorbic Acid	21.8	15.2	10.3	8.0

Lot No.	Sow Number	Ration	Vitamin	Vitamin Content			
				Colostrum	5th day	15th day	55th day
2	93 Farrowed 4-2-48	Basal + Alfalfa Silage	Riboflavin		3.2	3.7	2.6
			Thiamin		0.16		0.18
			Nicotinic Acid		2.0	1.8	3.6
			Pantothenic Acid		2.8	2.4	5.3
			Carotene	3.3	5.1	4.0	1.3
			Vitamin A	82.9	42.7	18.0	6.1
			Ascorbic Acid	10.0	16.5	11.7	8.8
3	81 Farrowed 3-26-48	Basal + 1/2 gal. Buttermilk per Day	Riboflavin	12.8	2.5	2.8	4.6
			Thiamin	0.75	0.69		1.05
			Nicotinic Acid	1.6	2.5	3.0	4.0
			Pantothenic Acid	0.7	0.9	3.2	5.0
			Carotene	3.6	0.0	0.0	1.7
			Vitamin A	64.0	17.7	30.9	17.6
			Ascorbic Acid	13.2	5.5	8.5	15.4
3	88 Farrowed 3-26-48	Basal + 1/2 Gal. Buttermilk per Day	Riboflavin	5.4	3.6	1.0	All Dead
			Thiamin		0.37	0.58	
			Nicotinic Acid	1.4	1.7	1.3	
			Pantothenic Acid	0.5	1.4	2.3	
			Carotene	7.0	2.5	0.0	
			Vitamin A	66.9	53.2	37.8	
			Ascorbic Acid	20.0	9.4	7.6	
3	91 Farrowed 4-14-48	Basal + 1/2 Gal. Buttermilk per Day	Riboflavin	6.6	2.6		3.9
			Thiamin	0.60	0.45		0.42
			Nicotinic Acid	1.8	2.9		3.4
			Pantothenic Acid	0.8	1.4		4.7
			Carotene	8.9	0.0		1.7
			Vitamin A	75.9	38.9		14.0
			Ascorbic Acid	16.9	13.2		11.5
4	85 Farrowed 4-4-48	Basal + Liver-Lung Meal	Riboflavin	5.4	3.3	2.1	All Dead
			Thiamin	0.63	0.34		
			Nicotinic Acid	3.2	4.3	6.8	
			Pantothenic Acid	0.4	2.1	3.0	
			Carotene	0.0	0.0	2.0	
			Vitamin A	259.0	51.5	24.8	
			Ascorbic Acid	20.0	8.7	10.2	
4	86 Farrowed 4-14-48	Basal + Liver-Lung Meal	Riboflavin		3.4	All Dead	
			Thiamin		0.62		
			Nicotinic Acid		1.8		
			Pantothenic Acid		1.2		
			Carotene	0.0	2.0		
			Vitamin A	68.2	75.9		
			Ascorbic Acid	19.8	16.9		
4	87 Farrowed 4-4-48	Basal + Liver-Lung Meal	Riboflavin	8.9		All Dead	
			Thiamin		0.56		
			Nicotinic Acid		1.0		
			Pantothenic Acid	1.6	1.6		
			Carotene		0.0		
			Vitamin A		57.4		
			Ascorbic Acid	6.8	8.1		

Lot No.	Sow Number	Ration	Vitamin	Colostrum	5th day	15th day	55th day
5	92	Basal +	Riboflavin		2.0	1.3	All
	Farrowed	Liver APA	Thiamin		0.45		Dead
	4-17-48	Extract	Nicotinic Acid		2.4	3.5	
		Injection	Pantothenic Acid		2.1	3.0	
			Carotene		2.4	1.1	
			Vitamin A		15.2	13.5	
			Ascorbic Acid		12.3	11.0	
5	95	Basal +	Riboflavin	4.0	1.1	2.6	2.7
	Farrowed	Liver APA	Thiamin	0.34	0.39	0.51	0.41
	4-1-48	Extract	Nicotinic Acid	2.3	1.1	1.1	2.0
		Injection	Carotene	3.9	0.6	2.0	1.4
			Vitamin A	110.0	21.7	19.7	5.1
			Ascorbic Acid	25.6	6.6	11.7	7.8
6	96	Basal +	Riboflavin		2.8	2.4	All
	Farrowed	Green Rye	Thiamin	0.62		0.25	Dead
	4-20-48	Forage	Nicotinic Acid	1.7	2.1	4.7	
			Pantothenic Acid		3.2	4.3	
			Carotene	0.0	5.6	1.1	
			Vitamin A	53.6	21.1	23.1	
			Ascorbic Acid	22.6	20.0	7.1	

Table 4

VITAMIN CONTENT OF SWINE MILK

Fall-1948 Farrowing

Lot No.	Sow Number	Ration	Vitamin	Vitamin Content: Colostrum	5th day	15th day	55th day
1	Chester 1	Basal	Riboflavin	2.43	2.35	2.34	2.17
	Farrowed		Nicotinic Acid	1.23	3.12	4.19	5.05
	9-27-48		Pantothenic Acid	0.94	2.80	9.90	2.11
			Thiamin	0.34	0.78	1.20	0.82
			Ascorbic Acid	167.0	71	85	59
			Vitamin A	44	36	18	24
					7th day		
1	Duroc 24	Basal	Riboflavin	1.89	2.0		3.15
	Farrowed		Nicotinic Acid	1.87	7.85		15.25
	9-30-48		Pantothenic Acid	0.44	4.88		2.85
			Thiamin	0.16	0.42		0.84
			Ascorbic Acid	213	188		93
			Vitamin A	154	18		24
1	Duroc 14	Basal	Riboflavin	2.13	1.16	1.00	No Sample
	Farrowed		Nicotinic Acid	2.50	6.66	12.60	
	10-10-48		Pantothenic Acid	0.43	0.75	1.16	
			Thiamin	0.44	1.26	0.55	
			Ascorbic Acid	79	140	95	
			Vitamin A	161	12	14	
2	Chester 22	Basal +	Riboflavin	5.68	1.65	4.39	3.63
	Farrowed	3% Fish	Nicotinic Acid	1.60	5.03	12.88	11.63
	10-2-48	Solubles	Pantothenic Acid	0.22	2.01	3.25	7.11
			Thiamin	0.86	0.62	0.74	0.77
			Ascorbic Acid	176	107	98	84
			Vitamin A	124	16	26	28
2	Duroc 70	Basal +	Riboflavin	No Sample	1.94	0.83	2.13
	Farrowed	3% Fish	Nicotinic Acid		5.87	7.77	8.76
	10-4-48	Solubles	Pantothenic Acid		2.34	2.05	5.75
			Thiamin		0.62	0.71	0.86
			Ascorbic Acid		188	133	101
			Vitamin A		26	18	19
2	Duroc 21	Basal +	Riboflavin		1.12	1.82	4.38
	Farrowed	3% Fish	Nicotinic Acid	1.40	7.26	11.54	9.54
	10-14-48	Solubles	Pantothenic Acid		2.26	2.30	8.71
			Thiamin	1.31	1.10	1.00	1.05
			Ascorbic Acid	247	184	128	123
			Vitamin A	202	24	31	22

Lot No.	Sow Number	Ration	Vitamin	Vitamin Content Colostrum	5th day	15th day	55th day
2	Duroc 11	Basal +	Riboflavin	No	2.01	1.72	2.80
	Farrowed	3% Fish	Nicotinic Acid	Sample	4.54	8.41	10.35
	11-8-48	Solubles	Pantothenic Acid		2.35	2.08	6.85
			Thiamin		0.45	0.55	0.65
			Ascorbic Acid		189	78	118
			Vitamin A		22	23	17
3	Chester 20	Basal +	Riboflavin	No	1.50	3.12	3.98
	Farrowed	10% Alfal-	Nicotinic Acid	Sample	6.72	11.70	16.02
	10-3-48	fa Meal	Pantothenic Acid		1.81	4.14	7.99
			Thiamin		0.70	0.90	1.02
			Ascorbic Acid		106	130	108
			Vitamin A		27	16	16
3	Duroc 10	Basal +	Riboflavin	2.80	1.47	2.13	2.38
	Farrowed	10% Alfal-	Nicotinic Acid	2.60	7.98	10.09	7.85
	10-3048	fa Meal	Pantothenic Acid	0.19	1.48	0.52	1.41
			Thiamin	0.21	0.89	0.82	
			Ascorbic Acid	284	147	98	114
			Vitamin A	25	22	24	17
4	Chester 21	Basal +	Riboflavin	4.98	1.54	3.70	3.00
	Farrowed	Liver	Nicotinic Acid	1.54	6.05	9.82	1.67
	10-9-48	Injection	Pantothenic Acid	0.46	1.88	3.21	0.37
			Thiamin	0.59	0.79	0.69	0.41
			Ascorbic Acid	148	169	135	180
			Vitamin A	85	62	26	24
4	Duroc 23	Basal +	Riboflavin	No	1.26	1.96	2.44
	Farrowed	Liver	Nicotinic Acid	Sample	6.80	12.41	12.48
	10-31-48	Injection	Pantothenic Acid		2.01	4.86	4.48
			Thiamin		0.44	0.75	1.10
			Ascorbic Acid		151	111	120
			Vitamin A		26	14	16
5	Chester 55	Basal, in	Riboflavin	2.17	1.19	3.68	No
	Farrowed	Dirt Lots	Nicotinic Acid	1.57	4.60	5.11	Sample
	10-9-48		Pantothenic Acid	0.25	1.32	3.71	
			Thiamin	0.29	0.56	0.57	
			Ascorbic Acid	137	90	84	
			Vitamin A		30	19	
5	Duroc 2	Basal, in	Riboflavin	3.53	1.00	1.04	3.05
	Farrowed	Dirt Lots	Nicotinic Acid	1.44	3.88	11.33	8.77
	10-29-48		Pantothenic Acid	0.25	1.82	1.50	7.61
			Thiamin	0.21	0.53	0.54	1.25
			Ascorbic Acid	207	140	125	120
			Vitamin A	127	20	19	23

Lot No.	Sow Number	Ration	Vitamin	Vitamin Content			
				Colostrum	5th day	15th day	55th day
6	Duroc 32	Basal +	Riboflavin	5.00	1.30	1.26	3.31
	Farrowed	Vitamin	Nicotinic Acid	1.90	4.83	6.94	7.14
	10-12-48	B_{12}	Pantothenic Acid	0.13	2.01	2.21	5.53
			Thiamin	0.60	1.00	1.10	1.20
			Ascorbic Acid	148	111	116	110
			Vitamin A	245	11	22	26
1	Hampshire 76	Basal	Riboflavin	6.13	1.87	1.37	2.53
	Farrowed		Nicotinic Acid	1.20	3.39	3.41	4.71
	10-23-48		Pantothenic Acid	0.52	1.30	1.10	3.28
			Thiamin	0.32	0.52	0.43	0.47
			Ascorbic Acid	308	190	120	108
			Vitamin A	189	54	29	23
1	Hampshire 73	Basal	Riboflavin	6.75	1.86	1.34	2.68
	Farrowed		Nicotinic Acid	1.38	3.01	5.73	4.37
	10-25-48		Pantothenic Acid	0.41	1.00	0.90	3.70
			Thiamin		0.59	0.49	1.15
			Ascorbic Acid	131	168	117	109
			Vitamin A	285	47	19	19
1	Hampshire 86	Basal	Riboflavin	3.71	1.24	2.66	3.10
	Farrowed		Nicotinic Acid	1.71	5.46	9.01	15.00
	10-29-48		Pantothanic Acid	0.35	1.73	2.83	11.97
			Thiamin		0.53	0.36	0.73
			Ascorbic Acid	89	111	98	114
			Vitamin A	76	20	14	25
2	Hampshire 75	Basal +	Riboflavin	3.81	1.41	2.98	3.78
	Farrowed	3% Fish	Nicotinic Acid	1.74	8.04	5.81	11.48
	9-30-48	Solubles	Pantothenic Acid	0.38	1.30	3.75	3.88
			Thiamin	0.44	1.33	0.56	0.67
			Ascorbic Acid	259	131	91	88
			Vitamin A	153	25	20	17
2	Hampshire 68	Basal +	Riboflavin	3.09	1.58	2.72	3.75
	Farrowed	3% Fish	Nicotinic Acid	2.37	4.82	8.15	13.07
	10-25-48	Solubles	Pantothenic Acid	0.62	2.30	3.03	11.53
			Thiamin		0.37	0.40	0.61
			Ascorbic Acid	247	145	107	123
			Vitamin A	167	29	17	21

Table 5

MEAN VALUES FOR COLOSTRUM AND MILK OF SPRING LACTATION

Vitamin	Day of Lactation			
	Colostrum	5th Day	15th Day	55th Day
Riboflavin (mcg./ml.)	6.48	2.72	2.16	3.31
Thiamin (mcg./ml.)	0.66	0.42	0.30	0.41
Nicotinic Acid (mcg./ml.)	1.60	2.73	4.12	4.65
Pantothenic Acid (mcg./ml.)	1.02	1.74	2.89	5.10
Carotene (mcg./100 ml.)	2.73	2.24	1.48	2.32
Vitamin A (mcg./100 ml.)	117.8	38.2	23.3	14.1
Ascorbic Acid (mg./100 ml.)	19.6	12.19	10.5	9.31

Table 6

MEAN VALUES FOR COLOSTRUM AND MILK OF FALL LACTATION

Vitamin	Day of Lactation											
	Colostrum			5th Day			15th Day			55th Day		
	Gilts	Sows	Weighted Average	Gilts	Sows	Weighted Average	Gilts	Sows	Weighted Average	Gilts	Sows	Weighted Average
Riboflavin mcg./ml.	3.40	4.70	3.86	1.54	1.59	1.54	2.23	2.21	2.23	3.04	3.17	3.07
Nicotinic Acid Mcg./ml.	1.76	1.68	1.74	5.80	4.94	5.57	9.60	6.42	8.72	9.54	9.73	9.60
Pantothenic Acid mcg./ml.	0.37	0.46	0.40	2.16	1.53	1.99	3.14	2.32	2.92	5.06	6.87	5.60
Thiamin mcg./ml.	0.50	0.38	0.48	0.72	0.67	0.71	0.78	0.45	0.69	0.83	0.73	0.82
Ascorbic Acid mg./100 ml.	18.06	20.68	18.93	14.15	14.90	14.35	10.89	10.66	10.83	11.08	10.84	11.01
Vitamin A mcg./100 ml.	129.27	174.00	145.5	25.14	35.00	27.74	20.77	19.80	20.50	21.33	21.00	21.24

Table 7

AVERAGED VALUES OF SPRING AND FALL LACTATIONS

Vitamin	Day of Lactation			
	Colostrum	5th Day	15th Day	55th Day
Riboflavin (mcg./ml.)	4.73	1.97	2.17	3.17
Thiamin (mcg./ml.)	0.56	0.60	0.51	0.66
Nicotinic Acid (mcg./ml.)	1.67	4.26	6.46	7.76
Pantothenic Acid (mcg./ml.)	0.68	1.81	2.78	5.68
Carotene (mcg./100 ml.)	2.70	2.12	1.22	2.32
Vitamin A (mcg./100 ml.)	139.8	33.03	21.29	19.65
Ascorbic Acid (mg./100 ml.)	19.3	14.1	10.68	11.41

Table 8

VITAMIN CONTENT OF COLOSTRUM AND MILK BY BREED

Day of Lactation	Breed	Vitamin: Nicotinic Acid	Riboflavin	Pantothenic Acid	Thiamin	Ascorbic Acid	Vitamin A
Colos-trum	Chester	1.48	3.82	0.47	0.52	15.70	84.33
	Duroc	1.95	3.07	0.27	0.49	19.63	153.33
	Hampshire	1.68	4.70	0.46	0.38	20.68	124.00
5th Day	Chester	5.10	1.65	2.06	0.69	10.86	34.20
	Duroc	6.18	1.47	2.21	0.74	15.68	20.11
	Hampshire	4.94	1.59	1.53	0.67	14.90	35.00
15th Day	Chester	8.74	3.45	4.84	0.82	10.64	21.00
	Duroc	10.14	1.45	2.08	0.75	11.05	20.62
	Hampshire	6.42	2.21	2.32	0.45	10.66	19.80
55th Day	Chester	8.59	3.20	4.40	0.76	10.78	23.00
	Duroc	10.02	2.96	5.40	0.99	11.24	20.50
	Hampshire	9.73	3.17	6.87	0.73	10.84	21.00

Table 9

THE VITAMIN CONTENT OF BOVINE AND SWINE COLOSTRUM AND MILK

Vitamin	Colostrum				Milk			
	Bovine		Swine		Bovine		Swine	
	Literature	Experimental	Literature	Experimental	Literature	Experimental	Literature	Experimental
Riboflavin mcg./ml.	5.74 (17)	5.4	4.0 (17)	4.7	1.77 (19)	1.8	0.46 (8)	3.2
Thiamin mcg./ml.	0.91 (17)	0.55	0.86(17)	0.56		0.49	0.66 (8)	0.49
Nicotinic Acid mcg./ml.	0.87 (17)	1.0	1.4 (17)	1.7	1.08 (24)	0.9		7.8
Pantothenic Acid mcg./ml.	2.08 (17)	2.0	1.05(17)	0.7	2.7 to 4.5 (24)	3.4		5.7
Ascorbic Acid mg./100 ml.	30.6 (8)	21.0	18.8 (4)	19.3	2.0 to 2.5 (16)	0.8	13.0 (8)	11.4
Vitamin A mcg./100 ml.	122 (17)	101.0	143.6 (4)	140.0		24.5	34.8 (4)	20.0

Discussion

On the basis of the levels of the vitamin content of the colostrum and milk, breed differences were not detected in either the spring or fall lactations where Chester White, Duroc, and Hampshire breeds were on experiment. The results of the vitamin determinations in the colostrum and milk of the three breeds of swine on the fall experiment are presented in Table 8. Examination of these data does not show any consistent trends in the components studied. It must be emphasized, however, that the small number of animals and the variation in ration precludes drawing any final conclusions in this regard.

The influence of the ration fed during gestation and lactation on the vitamin content of milk taken on the 55th day of lactation from the swine on the fall experiment is given in Table 10. The basal ration was presumed to be adequate in all known nutrients. Hence, it is not unexpected that no obvious differences in these vitamins determined was found. The differences observed between the values found at this station and those reported elsewhere may, however, probably be explained by ration differences.

Table 10

INFLUENCE OF RATION FED DURING GESTATION AND LACTATION ON THE VITAMIN CONTENT OF MILK TAKEN ON THE 55TH DAY OF LACTATION
FALL FARROWING

Ration	Vitamin					
	Riboflavin	Nicotinic Acid	Pantothenic Acid	Thiamin	Ascorbic Acid	Vitamin A
	mcg./ml.	mcg./ml.	mcg./ml.	mcg./ml.	mg./100ml.	mcg./100ml.
Basal No. 2	2.75	8.94	4.78	0.80	97	23.0
Basal + 3% Fish Solubles	3.38	9.14	7.30	0.77	106	20.7
Basal + 10% Alfalfa Silage	3.18	11.98	4.70	1.02	111	16.5
Basal + APA Liver Injections	2.72	7.08	2.42	1.51	150	15.0
Basal in Dirt Lots	3.05	8.77	7.61	1.25	120	23.0
Basal + Vitamin B_{12}	3.31	7.14	5.53	1.20	110	26.0

Riboflavin

The values for riboflavin in colostrum and milk obtained from the gilts on the spring experiment, the gilts on the fall experiment, and the sows on the fall experiment are plotted in Figure 1. The data for which were obtained by straight-line interpolation from values of colostrum and milk from the 5th, 15th, and 55th day post partum. The graph shows a rapid decrease in the riboflavin content of swine milk during the first five days of lactation and a slight rise from the 5th to the 55th day of lactation.

The spring value for colostrum, 6.48 mcg./ml., was higher than the fall value of 3.86 mcg./ml. The average riboflavin content of the milk from the spring lactation: 5th day, 2.72; 15th day, 2.16; and 55th day, 3.31 mcg./ml. is not believed to be significantly different from the values obtained in the fall: 5th day, 1.54; 15th day, 2.23; and 55th day, 3.07 mcg./ml.

The average riboflavin content for colostrum from both lactations was 4.73 mcg./ml. and the values for milk were: 5th day, 1.97; 15th day, 2.17; and 55th day, 3.17 mcg./ml. The value for colostrum is in agreement with that found by Luecke (17) who reported a range of 1.65 to 6.25 mcg./ml. with a mean value of 4.00 mcg./ml. However, the colostrum value obtained in this study is twice as high as that reported by Barnhart (1) and about ten times higher than the 44.9 ± 5.7 mcg./100 ml. reported by Braude _et al_.(8). The average value of 3.17 mcg./ml. for milk from both experiments on the 55th day of lactation is also in disagreement with the value for milk reported by Braude _et al_. (8) as 46 mcg./100 ml.

In an effort to resolve the differences in the riboflavin values for colostrum and milk reported by Braude _et al_. (8) and those obtained in this study, eight samples of milk from the fall experiment were analyzed chemically after five months in storage to verify the results obtained by

THE AVERAGE RIBOFLAVIN CONTENT OF SOWS' MILK THROUGHOUT LACTATION

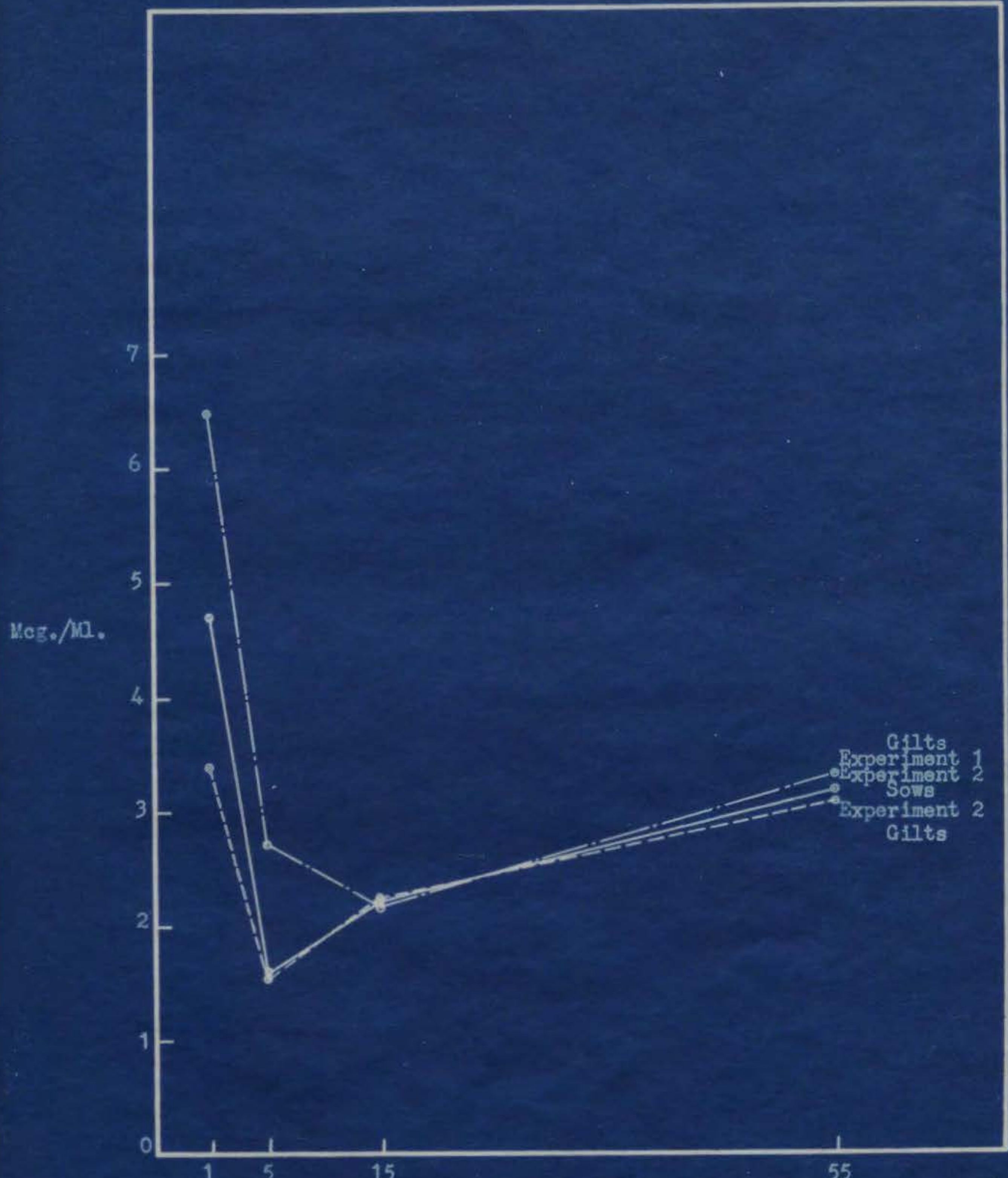

Figure 1

the microbiological method. A modified Conner and Straub (11) procedure for the chemical determination of riboflavin was used. An average of 2.19 mcg./ml. was obtained for the eight samples from the 5th, 15th, and 55th day post partum. This value compares with the average for all milk samples of the 5th, 15th, and 55th day of lactation of 2.64 mcg./ml. obtained by the microbiological procedure used in this study.

Further verification of the validity of the results obtained by the microbiological procedure was shown by the agreement of the riboflavin levels in cows' colostrum of 5.4 micrograms per ml. with that reported by Luecke (17) of 5.7 micrograms per ml. and the value of 6.1 micrograms per ml. found by Pearson and Darnell (19). The value for cow milk of 1.8 micrograms per ml. obtained by the microbiological procedure also agrees with the level reported by Pearson and Darnell (19) of 1.77 micrograms per ml.

Braude _et al_. (8) reported that the ascorbic acid of sow's colostrum was little affected by exposure to light and attributed this phenomena to a very low ratio in sow's colostrum of riboflavin to ascorbic acid. He found that colostrum to which riboflavin was added at the rate of 200 mcg./100 ml. lost its ascorbic acid in the characteristic way on exposure to light.

An experiment was made in an attempt to duplicate these findings of Braude. The results of this experiment are given in Table 11. Examination of this data reveals that the ascorbic acid was photo laible whether or not ascorbic acid, riboflavin, or both ascorbic acid and riboflavin were added to the milk. No increased déstruction of ascorbic acid was obtained when riboflavin was added to the milk at the level of 100 mcg./100 ml.

The fact that swine colostrum is much richer than the milk in riboflavin is in accord with the observations on the cow and ewe given by Pearson and Darnell (19). Cows' colostrum contains more than three times as much riboflavin as does the milk, while in the case of the ewe the difference is still greater.

Table 11

THE EFFECT OF RIBOFLAVIN ON THE PHOTO-DESTRUCTION OF ASCORBIC ACID

Experiment	Treatment	Adjuncts per 100 ml. Ascorbic Acid	Adjuncts per 100 ml. Riboflavin	Ascorbic Acid After Treatment Mg %
1	Light	None	None	1.52
	Dark	None	None	14.9
	Light	100 mg.	None	89.4
	Dark	100 mg.	None	114.6
	Light	None	100 mcg.	2.17
	Dark	None	100 mcg.	15.8
	Light	100 mg.	100 mcg.	59.9
	Dark	100 mg.	100 mcg.	110.3
2	Light	None	None	1.56
	Dark	None	None	13.7
	Light	50 mg.	None	48.2
	Dark	50 mg.	None	67.0
	Light	None	100 mcg.	0.98
	Dark	None	100 mcg.	13.2
	Light	50 mg.	100 mcg.	26.4
	Dark	50 mg.	100 mcg.	65.8

Thiamin

The thiamin content of milk obtained from swine on the spring experiment was lower than that of colostrum. The average values obtained for thiamin during the spring lactation were: colostrum, 0.66; 5th day, 0.42; 15th day, 0.30; and 55th day, 0.41 mcg./ml. The variation in thiamin content of the milk from the gilts on the spring experiment follows the pattern reported by Braude *et al.* (8) but the levels are lower than his values for colostrum of total thiamin 96.8 ± 7.8 mcg./100 ml.; free thiamin 70.8 ± 7.8 mcg./100 ml.: and for milk of total thiamin 67.7 ± 1.8 mcg./100 ml.; free thiamin 14.4 ± 1.2 mcg./100 ml.

The weighted averages for the gilts and sows on the fall experiment, as shown in Figure 2, followed a reverse pattern from those of the spring experiment. In this case, the mean value for colostrum, 0.48 mcg./ml., was lower than the value for milk. The thiamin content of the milk rose from the 5th day, 0.71; 15th day, 0.69, to a high of 0.85 mcg./ ml. for the 55th day of lactation. No adequate explanation for these anomalous results is at present forthcoming.

Luecke (17) found there was little difference in the thiamin content of either swine colostrum, having a range of 0.52 to 1.01 mcg./ml. with a mean value of 0.86, or beef colostrum with a range of 0.64 to 1.00 mcg./ml. and a mean value of 0.85 mcg./ml. However, the colostrum of dairy cows contains a range of 0.90 to 2.70 mcg./ml with a mean value of 1.22 mcg./ml. This is about 30 per cent more thiamin than his reported value for swine colostrum.

THE AVERAGE THIAMIN CONTENT OF SOWS' MILK THROUGHOUT LACTATION

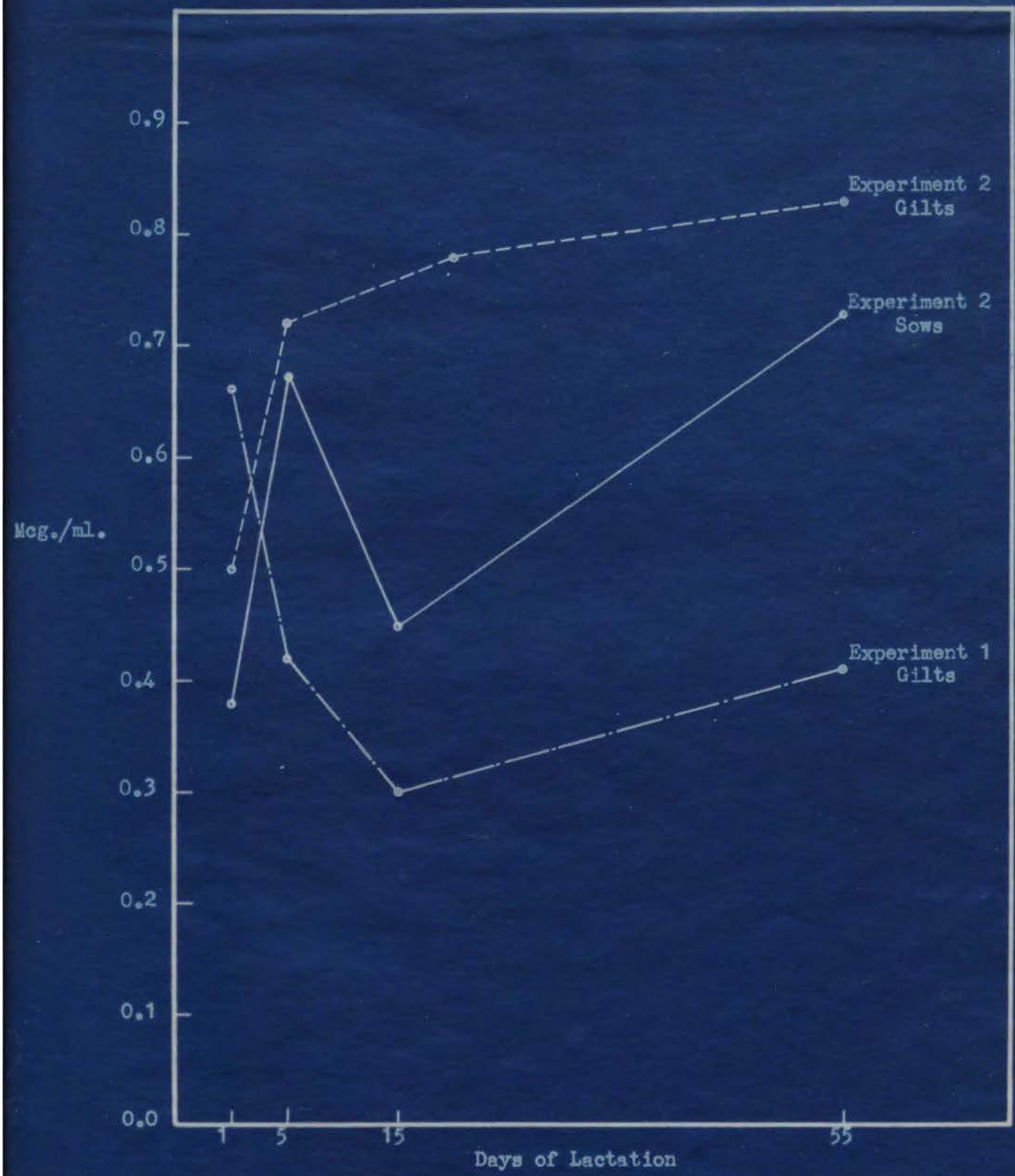

Figure 2

Nicotinic Acid

As in the case of thiamin, the nicotinic acid values for the milk obtained during the spring lactation were lower than those obtained from the swine on the fall lactation. The mean values for the 19 Hampshire gilts on the spring lactation were: colostrum, 1.60; 5th day, 2.73; 15th day, 4.12; and 55th day, 4.65 mcg./ml. The weighted averages for the fall lactation were: colostrum, 1.74; 5th day, 5.57; 15th day, 8.72; and 55th day, 9.60 mcg./ml. These results are presented graphically in Figure 3.

The rations received by the swine on the two experiments were so nearly identical that this does not appear to be an adequate explanation for this striking variation.

The wide variance between the results for the spring and fall lactations pointed to a possible error in analysis. Samples from both lactations had been preserved in a frozen state. Representative samples from both experiments were analyzed again and the results agreed with those originally obtained.

As a further check of the accuracy of the microbiological procedure employed for the nicotinic acid determinations, Jersey cow colostrum and milk were analyzed. The value of 1.0 mcg./ml. obtained for Jersey cow colostrum is in close agreement with the value reported by Luecke (17) 0.61 to 1.70 mcg./ml. with a mean value of 0.87 mcg./ml.

The work of Luecke (17) is the only publication on the nicotinic acid content of swine colostrum, and no data are available on the level of this vitamin in the milk. He reported on the nicotinic acid content of the colostrum of six swine and obtained a range of 1.14 to 1.85 mcg./ml. with a mean value of 1.43 mcg./ml. This value agrees favorably with the results of this study. The average values for both the spring and fall lactations for nicotinic acid were: colostrum, 1.67; 5th day, 4.26; 15th day, 6.46;

THE AVERAGE NICOTINIC ACID CONTENT OF SOWS' MILK THROUGHOUT LACTATION

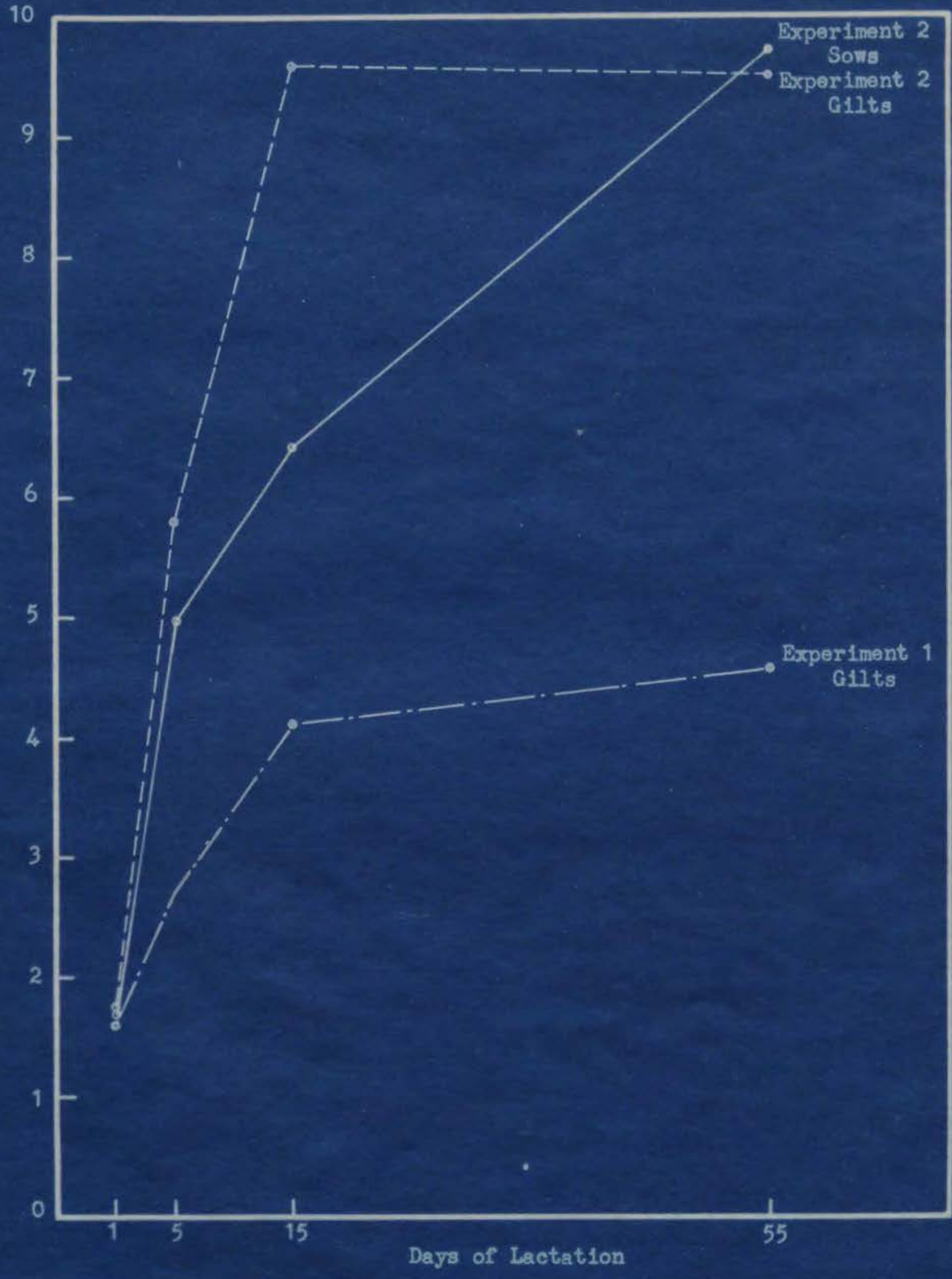

Figure 3

and 55th day, 7.76 mcg./ml.

Swine colostrum is markedly higher in nicotinic acid than either the dairy or beef cow colostrum. Luecke (17) reported that the nicotinic acid content of swine colostrum is 150 to 68 per cent higher, respectively, than that found in the colostrum of the beef cow or the dairy cow.

Pantothenic Acid

The variation in the pantothenic acid content of swine milk obtained on the 1st, 5th, 15th, and 55th day of lactation from the animals on the spring and fall experiments are given in Figure 4. As with the other B-vitamins except riboflavin, pantothenic acid was at a relatively low level on the first day, the pantothenic acid averaging 0.68 mcg./ml. Unlike thiamin and riboflavin the average pantothenic acid content rose abruptly during lactation in a manner similar to nicotinic acid. The mean values for all samples were: 5th day, 1.81; 15th day, 2.78; and 55th day, 5.68 mcg./ml.

The average values for pantothenic acid in swine milk throughout lactation for the animals on the spring experiment were: colostrum, 1.02; 5th day, 1.74; 15th day, 2.89; and 55th day, 5.10 mcg./ml. The weighted averages of the pantothenic acid content of the milk of the gilts and sows on the fall experiment were: colostrum, 0.46; 5th day, 1.99; 15th day, 2.92; and 55th day, 5.60 mcg./ml.

Information about the pantothenic acid content of sows' colostrum and milk is very scanty. The only publication referring to the pantothenic acid content of swine milk is that of Luecke (17) in which he reported on the vitamins in the colostrum of the dairy cow, beef cow, and swine. As a result of the analysis of colostrum obtained from six swine, he reported a range in the pantothenic acid content of 0.60 to 1.70 mcg./ml. with a mean value of 1.05 mcg./ml. This is in agreement with the results for

THE AVERAGE PANTOTHENIC ACID CONTENT OF SOWS' MILK THROUGHOUT LACTATION

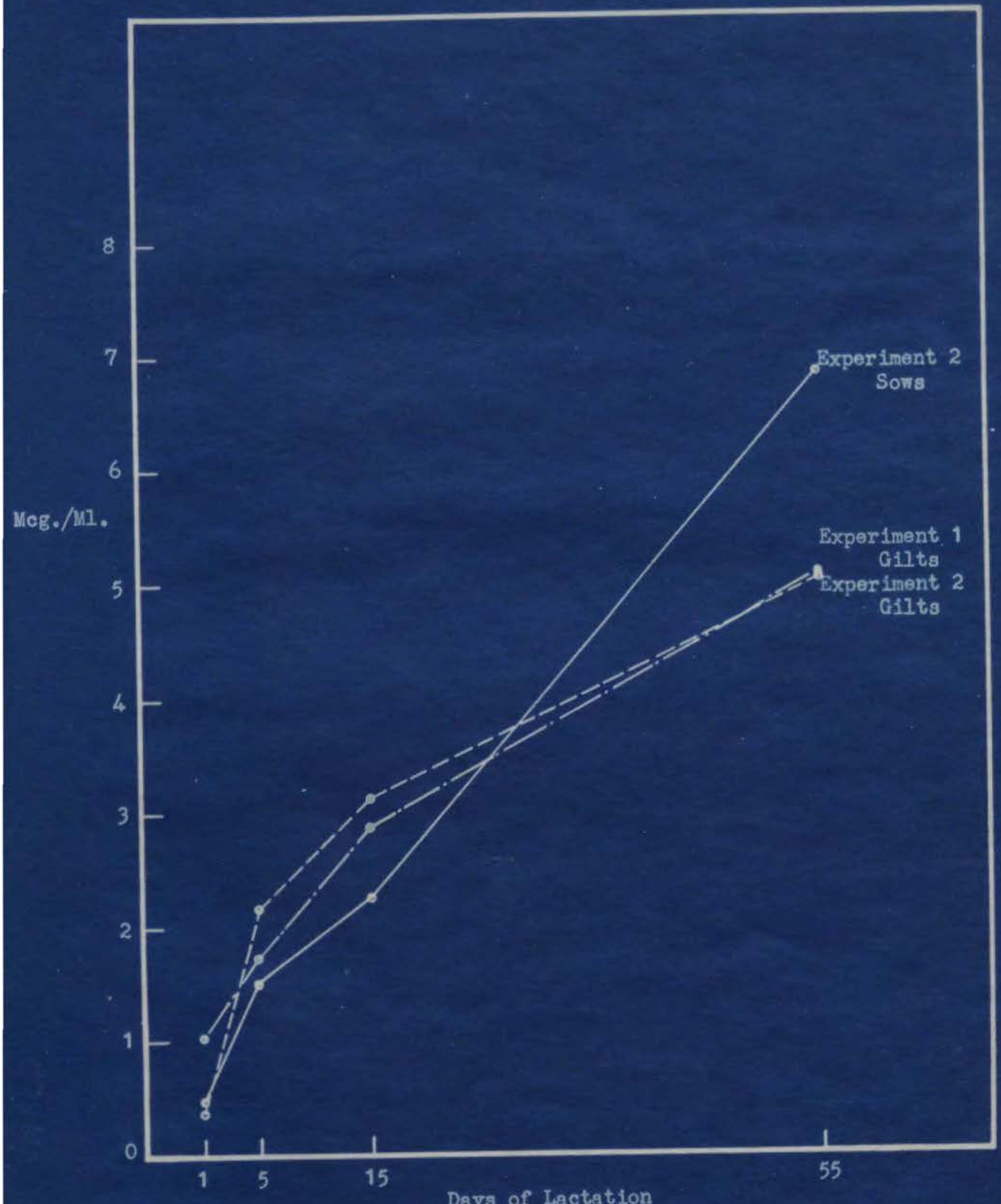

Figure 4

colostrum obtained in this study. The same author (17) found both beef and dairy cow colostrums contain more pantothenic acid than swine colostrum, approximately 63 and 95 per cent respectively. On the basis of the analysis of colostrum from 14 Jersey cows, he reported a mean value of 2.08 mcg./ml. Results obtained in this study, when samples of Jersey cow colostrum and milk were analyzed as a check on the accuracy of the methods employed, were in close agreement with those obtained by Luecke. The pantothenic acid content of Jersey cow colostrum was found to be 2.0 mcg./ml.

Vitamin A

The vitamin A level of sows' milk in changing from colostrum to milk followed the same general trend as in other species, namely, decreasing fairly rapidly. The mean vitamin A content of the colostrum was 139.8 mcg./100 ml. while the values for milk were: 5th day, 33.03; 15th day, 21.29; and 55th day, 19.65 mcg./100 ml.

The value for colostrum of the fall farrowing, 145.5 mcg./100 ml., was higher than the value of the spring farrowing, 117.8 mcg./100 ml. This is of interest, because the swine in the fall experiment received crude carotene concentrate at the level of 6,000 I.U. per pound of feed. However, for milk the differences found between the spring values of: 5th day, 38.20; 15th day, 23.3; and 55th day, 14.1 mcg./100 ml. and the fall values of: 5th day, 27.74; 15th day, 20.50; and 55th day, 21.24 mcg./100 ml. are not believed to be significant.

The results of the vitamin A determinations of the colostrum and milk of the 35 experimental swine are given in Figure 5. The average vitamin A content of the milk throughout lactation of the 16 gilts on the spring experiment, the 14 gilts on the fall experiment, and the 5 sows in their second lactation period on the fall experiment all closely follow the same pattern.

THE AVERAGE VITAMIN A CONTENT OF SOWS' MILK THROUGHOUT LACTATION

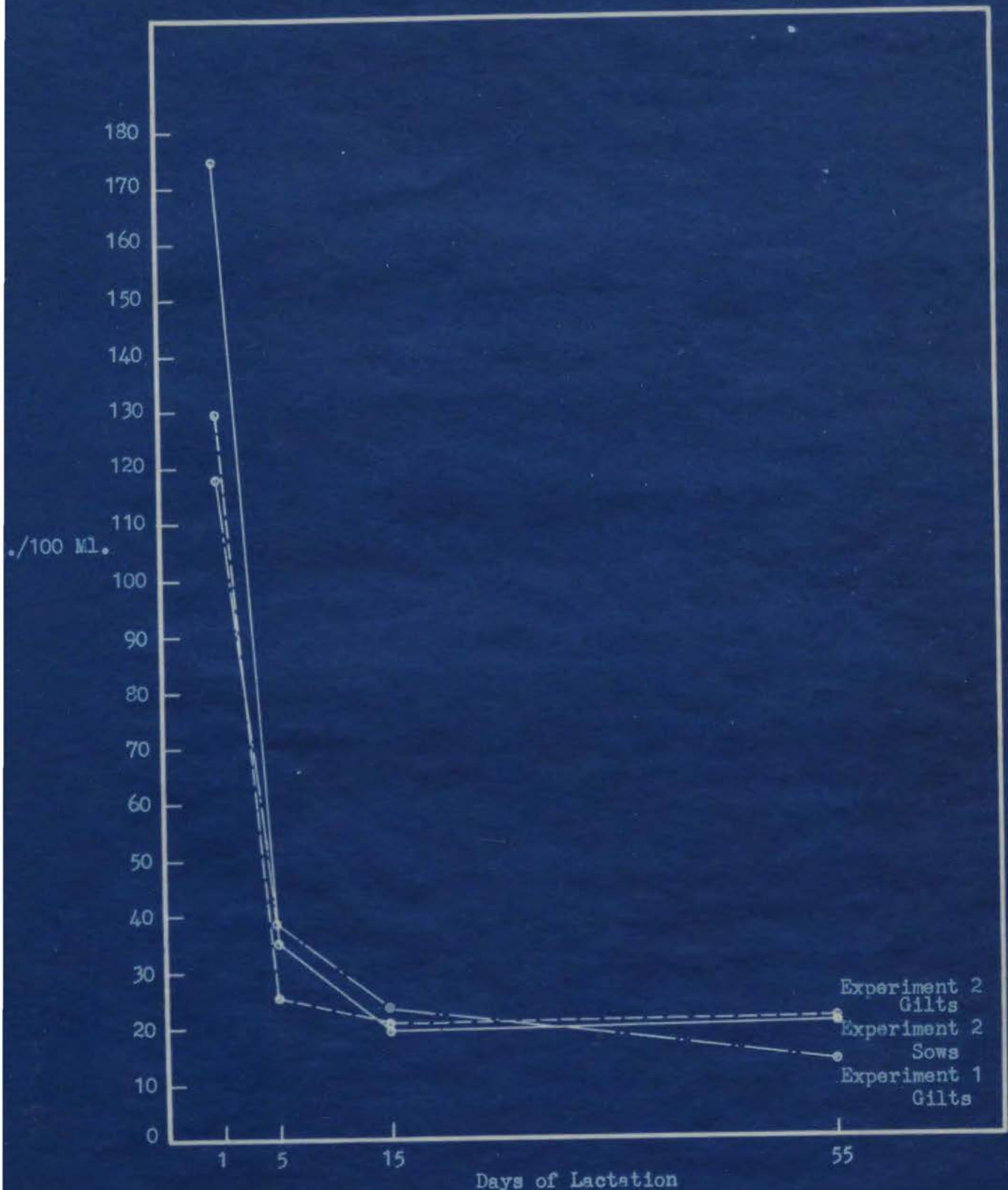

Figure 5

The level of vitamin A in swine colostrum was only 4 to 5 times as high as in normal milk. This observation agrees with the reports of Braude et al. (8) and Bowland (4) (5). Swine colostrum is much different from the colostrum of cattle, where the concentration of vitamin A is 20 times that of normal milk, as reported by Stewart and McCallum (25) and Hansen et al. (13).

Ascorbic Acid

The average ascorbic acid content of swine colostrum, 19.3 mg./100 ml., is higher than that of milk: 5th day, 14.19; 15th day, 10.68; and 55th day, 11.41 mg./100 ml. As in the case of vitamin A, the ascorbic acid values for the milk obtained from the spring and fall lactations followed the same pattern. The ascorbic acid level in changing from colostrum to milk decreased rapidly from the 1st to the 15th day and then remained fairly constant from the 15th to the 55th day post partum.

The average values for ascorbic acid in swine milk throughout the spring lactation were: colostrum, 19.6; 5th day, 12.19; 15th day, 10.5; and 55th day, 9.31 mg./100 ml. The weighted averages for the ascorbic acid content of the milk obtained from the gilts and sows during the fall lactation were: colostrum, 18.93; 5th day, 14.35; 15th day, 10.66; and 55th day, 11.01 mg./100 ml. The values for ascorbic acid obtained from the spring and fall lactations are plotted in Figure 6.

Swine milk contains a relatively high concentration of ascorbic acid. It is of interest that the ascorbic acid contents of the colostrum and milk of the swine are much higher than the values for the cow and ewe. Sows' milk contains an average of 11.41 mg./100 ml. as compared with 2 to 2.5 mg./100 ml. for cows' milk (16) and 0.8 mg./100 ml. for ewes' milk (20).

THE AVERAGE ASCORBIC ACID CONTENT OF SOWS' MILK THROUGHOUT LACTATION

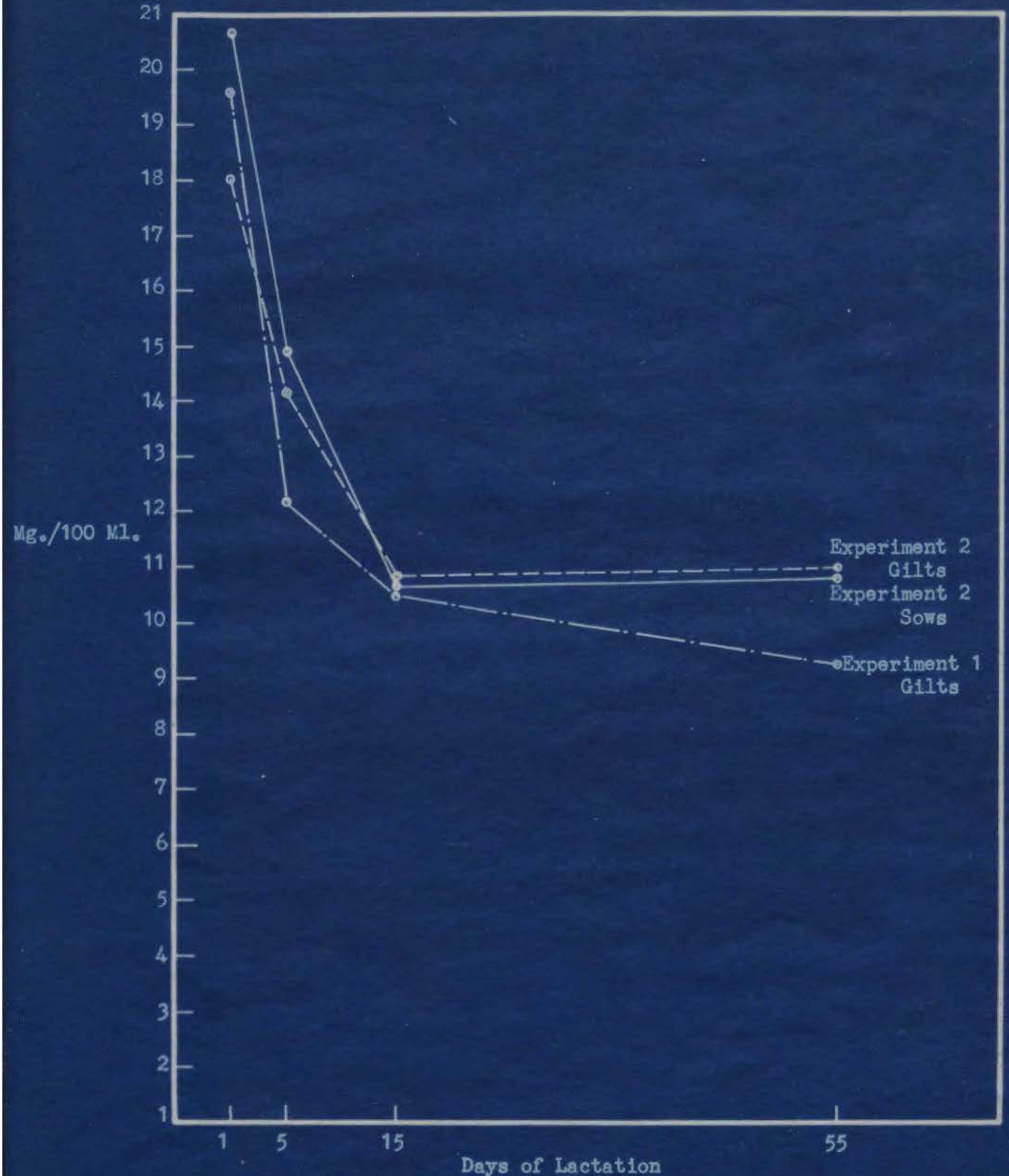

Figure 6

Summary

Studies were made of the riboflavin, thiamin, nicotinic acid, pantothenic acid, vitamin A, and ascorbic acid content of the colostrum and milk of 19 Hampshire gilts, 5 Hampshire sows, 9 Duroc gilts, and 5 Chester White gilts. Colostrum was obtained by manual expression during parturition and the milk on the 5th, 15th, and 55th days post partum after intravenous injection of pitocin.

The average values for all samples of colostrum were: riboflavin 4.73 mcg./ml.; thiamin 0.56 mcg./ml.; nicotinic acid 1.67 mcg./ml.; pantothenic acid 0.68 mcg./ml.; vitamin A 139.8 mcg./100 ml.; and ascorbic acid 19.3 mg./100 ml.

The average values for all samples of milk on the 55th day of lactation were: riboflavin 3.17 mcg./ml.; thiamin 0.66 mcg./ml.; nicotinic acid 7.76 mcg./ml.; pantothenic acid 5.68 mcg./ml.; vitamin A 19.65 mcg./100 ml.; and ascorbic acid 11.41 mg./100 ml.

Swine colostrum and milk had a much greater ascorbic acid content than that of the cow and ewe. Swine colostrum was also higher in nicotinic acid and vitamin A than bovine colostrum. Swine milk had a greater concentration of riboflavin, thiamin, nicotinic acid, and ascorbic acid than bovine milk.

No marked breed differences were found in the vitamin content of colostrum and milk. Differences in vitamin content related to rations fed were not observed.

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