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The composition and quantity of milk produced by cows on pasture and dry feed

Alvin F. Cannon

To the Graduate Council:

I am submitting herewith a thesis written by Alvin F. Cannon entitled "The composition and quantity of milk produced by cows on pasture and dry feed." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

C. E. Wylie, Major Professor

We have read this thesis and recommend its acceptance:

Eric Winters, R. H. Lush

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

August 6, 1948

To the Committee on Graduate Study:

I am submitting to you a thesis written by Alvin F. Cannon entitled "The Composition and Quantity of Milk Produced by Cows on Pasture and Dry Feed". I recommend that it be accepted for nine quarter hours credit in partial fulfillment of the requirements for the degree of Master of Science, with a Major in Dairying.

C. E. Wylie

Major Professor

We have read this thesis and recommend its acceptance:

E. Winters

R. H. Tush

Accepted for the Committee

E. G. Waters

Dean of the Graduate School

THE COMPOSITION AND QUANTITY OF MILK PRODUCED

BY

COWS ON PASTURE AND DRY FEED

A THESIS

Submitted to
The Committee on Graduate Study
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

By

Alvin F. Cannon

August, 1948

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CHAPTER I

INTRODUCTION

There is not much comparative data available on the value of winter grazing. The object of this study was to determine the quantity and composition of milk produced by cows on pasture and dry feed.

The effect of green feed on the composition of milk may be of great importance in improving the human diet, especially during the winter months when the diet is most likely to be deficient in other vitamin A rich foods. Moreover, at this time, vitamin A is most needed to maintain resistance to respiratory infections of children and calves, whose main source of vitamin A is in the milk consumed.

CHAPTER II

REVIEW OF RELATED SUBJECTS

The proteins, carbohydrates, and minerals such as calcium and phosphorous are present in rather constant amounts and do not vary greatly with the breed or type of feed consumed (16), while the fat content varies with the breed (3). Feiger (16) states the total vitamin A content of milk is affected by the diet of the animal and to a less extent by the breed.

Milk fat contains both forms of vitamin A and the biological effect of the two are termed vitamin A activity. This vitamin A activity is expressed as vitamin A equivalent.

Kennedy and Dutcher (33) were among the first to report that the vitamin A activity of milk is influenced by the vitamin A activity of the feed. Moore (45) has shown that the cow converts carotene into vitamin A. The vitamin A activity of roughage in general has been shown to be related to its carotene content. Guilbert (22) has used the carotene analysis as a measure of the vitamin A activity.

Daniel (9) states that vitamin A activity was early associated with highly pigmented foods, particularly those having a deep green or yellow color. This association became extremely puzzling when it was discovered that vitamin A itself is an almost colorless substance. It was some time before scientists recognized that certain yellow-orange pigments which are contained in many plants are changed over into vitamin A in the body. These substances, belonging to a class of pigments known as carotinoids, are precursers of the vitamin and are often referred to as provitamin A. (9)

Moore (44) explains the process by which the animal body changes the carotenes into vitamin A as follows:

> When the animal consumes these carotenes, they are carried by the blood stream to the liver where they are changed to true Vitamin A.

A technical committee (55) who made a survey and study of butter as a source of vitamin A in the diet of the people of the United States recognized that it was desirable to express the total vitamin A value of the butter either in International Units or U. S. Pharacopoeia Units. These are the forms in which human and animal requirements are usually expressed. This committee assumed that for the purpose of their report that all the pigment obtained in the "carotene" fraction by the chemical method was beta carotene and it agreed that 0.6 microgram of the carotene and 0.25 microgram of the vitamin A shall each be taken as equal to one International Unit of vitamin A.

The minimum requirements of vitamin A and carotene needed to cure night blindness in various species of animals have been determined by Hart (24) as shown in the following table:

TABLE I

DAILY INTAKE PER KILOGRAM (2.2 POUNDS) OF BODY WEIGHT

	Vitamin A in I. U.	Carotene in I.U.
Cattle	21-27	43-55
Sheep	17-26	47-58
Swine	18-24	42-65
Horses	17-22	33-50

However, Hart (25) recommends that at least five to ten times the minimum level of carotene and vitamin A should be furnished under practical conditions since little or no storage occurs at the minimum level needed to prevent night blindness. Ward (58) showed that the minimum carotene requirements of growing calves is eleven micrograms per day per pound of body weight. This was sufficient to maintain growth and to prevent the usual vitamin A deficiency symptoms. He explains, however, that the adequacy of this amount of carotene depends upon the source of supply of carotene. In his studies, increased above the level did not result in marked improvement in the growth rate.

Moore (44) stated that one quart of milk is sufficient to meet the daily human requirements of vitamin A. However, his requirement is lower than that recommended by the Committee on Foods and Nutrition of the National Research Council which recommends that 5,000 International Units (1500 micrograms) of vitamin A be allowed daily to meet the adult requirements. Koehn (35) points out that milk of an Alabama herd, produced under excellent conditions for that state, contained enough vitamin A to meet half the human daily requirements for only four months of the year. In mid-winter, the milk contained only one-seventh the amount of vitamin A needed to meet this requirement. His results show that it is possible to increase this period when one quart of milk will furnish one-half the daily human requirements to eight months (instead of four) by means of supplemental pasture. A technical committee (55) states that it is not essential that the day to day consumption of vitamin A be the same as the recommended daily allowance. When more vitamin A is consumed that is required for immediate use, the excess is stored in the body and used later if the intake is deficient.

Feiger and Lewis (16) list the human requirements for vitamin A suggested by the Food and Nutrition Board of the National Research Council.

TABLE II

VITAMIN A REQUIREMENTS OF HUMAN BEINGS

Children under 1 year	1,500 I. U.
Children 1-3 years	2,000 I. U.
Children 4-6 years	2,500 I. U.
Children 7-9 years	3,500 I. U.
Children 10-12 years	4,500 I. U.
Adults	5,000 I. U.

Feiger and Lewis (16) state that one quart of Louisiana milk daily will supply enough of vitamin A to meet the daily needs of children under one year of age during the three winter months when milk of the lowest vitamin A potency is produced. They also state that one quart of winter creamery milk will supply one-fifth of the daily adults need, while one quart of spring milk will supply two-fifths to one-half of the daily need.

Human beings and animals require vitamin A and/or carotene in their diets in order to have normal growth, development, and health (16). They also have a remarkable capacity for storing vitamin A in their livers and this storage is utilized when the food intake does not provide sufficient amounts of this material. When body stores have become practically exhausted, signs of vitamin A deficiency soon become apparent. These symptoms include night blindness, muscular weakness, a hardening of the lining of the mouth, lungs, and digestive system, in fact the linings of all the cavities within the body. These changes may lead to invasion by disease germs thereby causing infections. For this reason vitamin A has been called the anti-infective vitamin. Defective tooth structure and deformities of the teeth may occur during periods of tooth formation where there is a deficiency of vitamin A (16).

Moore (24) lists the symptoms of vitamin A deficiency as night blindness, loss of weight, infections involving the eyes, salivary glands and lungs. This deficiency is also associated with diarrhea, development of kidney stones and degeneration of nerve tissue. Feiger and Lewis (16) state that cows may show deficiency by premature calving, weak or dead calves, or abnormality in reproduction. Herzer (27) states that when the carotene intake fell below this point during the last ninety days before calving, there was some indication of a shortened gestation period.

Kunerth (38) shows that butter produced from cows on restricted ration in dry lot contained only eleven International Units, or less than one-fourth the figure for butter computed by Sherman (54). He states that this low figure can be attributed to the absence of green feed or pasture in the ration of these cows and the lower carotene of the hay consumed.

Knott, et al (34) show the relationship between the amount of carotene in the roughage and the amount secreted in the milk in the following table

TABLE III

RELATIONSHIP BETWEEN THE AMOUNT OF CAROTENE IN THE ROUGHAGE AND THE AMOUNT SECRETED IN THE MILK

Kind of roughage	Average carotene content of roughage	Carotene content of butterfat
Hay ration	14.8 micrograms	3.6 Units/gm.
Hay and silage ration	57.0 micrograms	6.5 Units/gm.
Grass silage ration	197.3 micrograms	6.8 Units/gm.
Pasture ration	259.0 micrograms	7.9 Units/gm.

As shown by the above table, the carotene content of the butterfat was not in the same proportions as the increase in the carotene content of the feeds.

The average percentage of the carotene ingested that was secreted as carotene in the butterfat was as follows: (34)

0.72 percent for cows receiving hay.

0.23 percent for cows receiving hay and silage.

0.14 percent for the cows receiving silage.

The carotene in the butterfat accounted for only a small percentage of the total vitamin A activity.

Fraps (18) states that cows in general secure their vitamin A activity from the carotene in grasses and fodders and from the cryptoxanthine and carotene in yellow corn. Koehn (35) states that for the production of milk rich in vitamin A the carotene requirement of dairy cattle is greater than minimum requirements. This can be readily seen by the very low percentage transfer of carotene from diets to the milk (from 0.14 to 2.67 percent).

The percentage transfer of carotene from the diet to the milk reported by the various investigators is as follows:

Fraps (18) 2.38-2.67

Hodgson, et al (30) 0.14-0.72

Russell (53) 2.5-3.4

Petersen, et al (50) 2.0

Fraps (19) states that in his experiments one unit of vitamin A in butter requires approximately eleven units in the feed over maintenance requirements.

Feiger (16) in 1944 concluded that with very large quantities of carotene in the diet Vitamin A in the butterfat appeared to reach a rather definite ceiling value. However, Koehn (35) in 1943 concludes just the opposite as shown by his statement:

> "No time of the year did the vitamin A reach a constant level in the milk. It appears that although large amounts of carotene were ingested during the summer, the limit of the cows ability to secrete vitamin A into milk was never reached."

Koehn (35) states that because of the tremendous losses of carotene during the curing and storage of hays and in the making of silage, winter rations for dairy cattle are low in carotene -- the precursor of vitamin A.

Kunerth (38) demonstrated the ineffectiveness of alfalfa hay and sorghum silage for maintaining a high level of vitamin A in butter. They found that a Holstein herd receiving alfalfa hay and sorghum silage with little or no pasture produced butter with only one-half the vitamin A content as cows on pasture (36)

A technical committee (55), previously referred to, states that in all but two states there was a distinct difference between the vitamin A activity of butter produced under winter feeding conditions and that produced under summer feeding conditions. In comparing the two, they claim about sixty-five percent of all butter produced in the United States is "summer" butter -- that is, produced by cows on pasture, and has an average vitamin A activity of 17,000 or 18,000 International Units per pound. Whereas, the thirty-five percent of all butter produced in the United States is "winter" butter (produced by cows not on pasture) has a vitamin A activity of 10,500 or 11,200 I. U. per pound. According to the results of this study, milk produced under winter feeding conditions has an average vitamin A activity of approximately 1,120 I. U. per quart (four percent fat basis) and that produced under summer feeding conditions has an activity of about 1,820. The difference in vitamin A activity shown at Beltsville under various summer and winter feeding conditions was as follows: at the end of the season, the Holstein milk reached a low vitamin A activity of about 900 I. U. per quart; and the Jersey milk a low of 1,240 I. U. per quart; however, during the summer, the Holstein milk varied from 1,370 to 2,580 I. U. per quart, whereas the Jersey milk varied from about 1,850 to 3,070 I. U. per quart.

Dornbush, Petersen, and Olson (13) give the average vitamin A activity of "market" milk as 1,088 U.S.P. Units per quart in winter and 1,906 U.S.P. Units per quart in summer.

Feiger (16) states that the values obtained for April represent about the maximum or ceiling value of vitamin A in cow's milk.

A consideration of the four winter months, November through February, indicate low values both on the basis of units per quart and per gram of butterfat, and suggest that it may be worth while to consider the adequacy of the average dairyman's feed and pasture program during the winter months (16).

Herzer, et al (27) state that the Mississippi butter examined showed a much greater seasonal variation in carotene than in vitamin A content. The butter analyzed in this study contained approximately 18,000 I. U. of vitamin A per pound from April to October inclusive, but from November through March, it contained an average of approximately 12,000 I. U. per pound.

Moore (44) concludes that his results show that under ordinary farm conditions, summer milk has a much higher vitamin A activity than winter milk. Archibald (1) adds that not only was the vitamin A content of milk from cows receiving green succulent feed considerably higher than milk from cows receiving dried hay, but the flavor of the milk was also superior.

Since it is necessary that the cow's diet be high in carotene in order to maintain good nutrition and secrete milk rich in vitamin A, one can understand the importance of green pasture (16). The lushness of the pasture tends to increase the efficiency of the utilization of carotene by the cow (55).

The question of the length of time required to increase the vitamin A activity of the butterfat has been studied by many investigators. The Minnesota results show how rapidly this change may occur in the butter when the cows are put on pasture in the Spring (55):

February 26--March 25....................9,826 I. U.

March 26--April 22.......................10,602 I. U.

April 23--May 6..........................12,160 I. U.

At Beltsville, the vitamin A activity of Holstein milk increased more than one hundred percent during the first two weeks (April 21--May 8) the cows were on pasture (55).

Fraps, et al (18) state that in their experiments in Texas, when cows were placed on pasture, the carotene in the butterfat reached the maximum of 13.96 parts per million from one cow in twenty-eight days and a maximum of 19.06 ppm. with the other cow in fourteen days, followed by a decrease with both cows.

Feiger and Lewis (16) state that milk from herds grazing oat or rye pasture showed a marked increase (780 I. U.) in vitamin A per quart over cows receiving no such pasture. Their work also shows that two hours of grazing on dark green oat pasture is slightly better for supplying vitamin A and carotene in the milk than three to ten hours on light green natural pasture.

Koehn (35) of the Alabama Station found that milk from cows placed on a temporary pasture of abruzzi Italian rye, crimson and white Dutch clover in February increased in two weeks time to a vitamin A content equal to that of good summer milk and remained at that level until the permanent pastures were ready for spring grazing.

Moore (24) found that when the Michigan college herds were placed on pasture in May, that the vitamin A activity tripled and held up well until October. He also states that green pasture may contain 200 to 300 parts per million of carotene on the dry basis, while alfalfa hay fed during the winter may contain only fifteen to twenty parts per million.

The carotene content of forages in Alabama is shown in Table IV.

TABLE IV

CAROTENE CONTENT OF FORAGES, DRY WEIGHT BASIS

	Forage	Date analyzed	Carotene content mg/100 gm.
Pasture	Crimson clover	2/28	37.7
	Crimson clover	4/1	41.2
	White Dutch clover	3/24	42.9
	White Dutch clover	4/7	47.22
	Abruzzi rye	2/28	56.4
	Abruzzi rye	4/7	64.6
	Italian rye	2/24	38.7
	Italian rye	4/1	60.6
	Oats	2/24	36.2
	Oats	4/1	48.5
	Bermuda grass	8/20	30.1
	Bermuda grass	11/20	4.2
	Carpet grass	8/20	28.4
	Carpet grass	11/20	10.0
	Lespedeza (common)	9/20	21.9
	Lespedeza (common)	10/20	17.0
Other Feeds	Alfalfa hay	2/5	1.08
	Alfalfa hay	7/29	3.06
	Alfalfa hay	12/14	0.86
	Sweet potatoes	10/14	13.70

Several factors affect the nutritive value of home grown roughage. Hodgson (30) lists the following: proper choice of crops, pasture management, soil deficiencies, and losses of nutrients during storage. Douglass (14) and Hilton (29) studied the effect of stage of maturity on the carotene content. Hodgson (31) lists other factors affecting the nutritive value as method of drying and variety of plants.

In experiments, Hodgson (30) showed that cows maintained on all roughage ration which included good pasture in summer and home grown hay and silage in winter, maintained themselves, produced healthy offspring and produced a liberal amount of milk during the three year experimental period. He concludes that greater production and more efficient utilization of pasture and other home grown roughage feeds are the most practical methods of reducing the price of dairy products.

At Beltsville, the investigators found that the feeding of an aliquot of the same crop of alfalfa as silage instead of hay may double the vitamin A of winter butter. The alfalfa silage apparently supplies from four to twenty times as much carotene per unit of dry matter as the hay (55).

The Bureau of Dairy Industry at Beltsville Station, Maryland, found that the fluctuations in the vitamin A activity were not so great in the butter from the Jerseys as in that from the Holsteins (55).

Feiger (16) states that some species of animals convert carotene into vitamin A more completely than others. This fact is also true for the different breeds of cattle. Moore (44) found that with the same feeding conditions, the fat of the Holsteins and Ayrshires has more of its vitamin A activity present as true vitamin A and less as carotene. In the case of the Guernsey or Jersey breeds, the opposite is true. However, the total vitamin A activity of the different breeds per unit weight of fat is approximately the same.

The individuality of the cow has a lot to do with the amount of vitamin A secreted in the milk. One unusual cow at Beltsville (55) on the alfalfa-silage ration produced butter in January, February, and March with an average vitamin A of 20,000 International Units, per pound, and while she was on pasture she produced butter with about 30,000 I. U. per pound. This suggests that possibly breeding as well as feeding may affect the vitamin A activity of the butter produced. Fraps (18) agrees with this conclusion. When two cows per placed on pasture, one reached a maximum of 13.96 parts per million in twenty-eight days, while the other cow reached the maximum of 19.06 ppm. in fourteen days.

As previously stated, increasing the carotene content of the diet of the cow does not increase her milk yield. Therefore, any improvement in farm practice which is recommended as a means of increasing beyond certain limits the vitamin A activity of milk for commercial purposes, must, at the same time, have other advantages as a method of producing feed, or else be compensated for by "trade" considerations (55).

Several workers have made a study of the effect of pasture on milk production and recommend it not only because it gives an increase in vitamin A and carotene and therefore an increase in the nutritive value of milk, but also because increased economical yields have been noted from the use of pasture. The value of green winter pasture as represented by rye, oats, or barley in increasing milk production has been stressed by the Louisiana Agricultural Experiment Station since 1929 (16). Lush (40) reported that rye grass and clover in January contained more than twenty-six percent protein. In his 1935-36 report, Lush further showed that winter grazing on oat pasture averaged 2.2 pounds more milk per cow daily than permanent pasture or no pasture. In 1937-38, the increase was 2.26 pounds daily and in 1941-42, 4.8 pounds per cow daily or 22.5 percent in production increase in one week's time on oat pasture in February (40).

Feiger (16) reports an experiment in which ten cooperators out of eleven reported an average increase of approximately twenty percent in milk yields due to oat pasture.

Herzer (27) reports that fifty-two cows and eighteen heavy springers were turned on a twelve acre field of oats and vetch for fifteen days. The milk yield increased 16.3 percent the first week and 24.6 percent the second week.

Hodgson (31) states that by turning cows on pasture that had previously been on an all roughage ration of low protein caused an immediate and marked increase of as much as 160 percent in production within four weeks of the time of the change from dry feeding to pasture. This stimulus to increased production was about the same for cows freshening at all periods of the year.

Wylie (60) concludes that a good all year pasture for dairy cows may reduce the concentrates requirements as much as one-half ton per cow per year or approximately fifty percent below the requirements of average summer pasture practice.

The effects of pasture on quantity and composition of milk as reviewed in this paper may be summarized as follows:

Milk from cows on rye pasture contained approximately five times as much vitamin A activity as milk from cows on low carotene roughage of cottonseed hulls; it was possible to increase the period when one quart of milk will furnish one-half the daily human requirements to eight months (instead of four) by means of supplemental pasture; the technical committee claim that butter produced under "summer" conditions (on pasture) contained 17,000 I. U. per pound whereas that produced under "winter" conditions (not on pasture) contained only about 10,500 I. U. per pound.

Several investigators reported markedly increased milk yields as a result of placing cows on pasture, especially supplemental winter pasture. Many report production increases up to 22.5 percent. Eleven out of twelve Louisiana cooperators reported an average increase of approximately 20 percent in milk yields due to oat pasture.

CHAPTER III

EXPERIMENTAL PROCEDURE

This study included groups of cows located at Columbia, Knoxville, and Jackson. The method of treatment and procedure is noted under each location.

Work at Columbia. A study to determine the effect of pasture on the quantity and composition of milk produced was conducted at the Middle Tennessee Experiment Station at Columbia, and was started in December, 1947. Eight Jersey cows were divided into two groups. The cows in each group were paried on the basis of the stage of lactation, previous production, body weight, and freedom from disease. Both groups received grain at the rate of one pound of grain per four pounds of milk, and alfalfa and orchard grass hay ad. lib. Group I had access to balbo rye and crimson clover pasture when pasture and weather conditions permitted grazing. Group II was barn fed.

Milk samples for the purpose of determining the composition were collected by Professor R. H. Lush from each group. Night and morning milkings from each group were well mixed and a quart sample taken. In order to obtain fresh samples, they were securing personally by Professor Lush when visiting the Experiment Station. No preservation was used. On arrival at Knoxville, the samples were frozen in ice cream containers in the hardening room of the U. T. Creamery until the analysis could be made. All analyses were made in June and July.

Milk samples were also taken from cows on early-cut and late-cut lespedeza hay. These cows were fed a ration of equal parts corn and cob shuck meal, barley oats, and cottonseed meal at the rate of one pound of grain mixture to four pounds of milk. They were fed hay ad. lib. They did not have access to silage or pasture while on the experiment.

Work at Knoxville. In the University herd, Knoxville, a group of three Jersey cows and a group of three Holstein cows were selected on the basis of stage of lactation and freedom from mastitis. These cows were fed a ration consisting of equal parts of corn, cottonseed meal, oats, wheat bran, one percent salt and one percent bonemeal, with alfalfa hay ad. lib. The Holstein cows were fed at the rate of one pound of grain to four pounds of milk; the Jersey cows were fed at the rate of one pound of grain to three pounds of milk. Eight milk samples were collected from these herds to determine the vitamin A activity of the milk. Milk samples were collected from the cows before they had access to pasture, after one day on pasture, after one week on pasture, after two weeks on pasture, after three weeks on pasture, after one month on pasture, and monthly thereafter. The night's milking from each herd was poured in a can and well mixed. A quart sample was taken for analysis. These samples were stored in an ice cream container and stored in the hardening room until the analyses were run.

Work at Jackson. Samples were collected by Mr. B. P. Hazelwood at the West Tennessee Experiment Station, Jackson, from Jersey cows on pasture and cows on dry feed. The milk from cows on pasture was from the station herd, whereas the milk from cows on dry feed was from a farmer herd and therefore not comparable because of uncontrolled conditions. These samples were brought to Knoxville by Mr. L. O. Coleband and thereafter treated in the same manner as Groups I and II.

At all locations, the butterfat test, total solids, vitamin A and carotene content were determined on all milk samples. The fat test was run in duplicate by the Babcock method. Total solids were run in duplicate on the Majonnier tester.

The vitamin A and carotene content was determined in triplicate by a modification of the rapid extraction procedure of Boyer, et al (6). This procedure was modified as follows: the alcohol content of the wash solution was increased from ten percent to twenty percent and the sample was exposed to the alkali for four hours instead of three. Both of these modifications help prevent emulsification and were suggested by Dr. P. D. Boyer in personal correspondence. Replicate determinations for vitamin A agreed within five scale readings which represent .05 to .08 micrograms of vitamin A permilliliter of milk. Replicate determinations for carotene agreed within one scale reading which represents .02 to .03 micrograms of carotene per milliliter of milk.

CHAPTER IV

RESULTS

Work at Columbia. The milk and butterfat records for the cows in Group I in the Columbia experiment are shown by periods in Table V. Table VI shows the production of cows on dry feed. Group I produced 12.4 percent more milk and 13.5 percent more butterfat or 13.3 percent more four percent fat corrected milk than Group II. The four percent fat corrected milk was obtained by the method of Gaines and Davidson (20). However, a statistical analysis of variance showed no significant difference in total pounds of milk produced because of the difference between individuals within the group.

The feed consumption is shown by periods in Table VII for Groups I and II, respectively. Group I, on pasture, consumed 68.8 percent as much hay as Group II; however, Group II consumed only 82.7 percent as much grain as Group I because of the lower milk production of Group II. Both groups were fed grain in proportion to milk production.

The live weight records for Groups I and II are shown in Table VIII. Group I gained two pounds for the 115 day period; whereas, Group II lost 36 pounds for the same period. This difference is probably not significant.

The composition of three milk samples from Groups I and II, Columbia is shown in Table IX. The milk from Group I showed an average of 53.4 percent more vitamin A activity than milk from Group II.

TABLE V

MILK AND BUTTERFAT RECORDS - GROUP I

Cow No.	Dec. 8-15 Milk	Dec. 8-15 B. F. Test	Dec. 8-15 B. F.	Dec. 16-31 Milk	Dec. 16-31 B. F. Test	Dec. 16-31 B. F.	Jan. 1-15 Milk	Jan. 1-15 B. F. Test	Jan. 1-15 B. F.	Notes
	Lbs.	%	Lbs.	Lbs.	%	Lbs.	Lbs.	%	Lbs.	
210	102.7	7.4	7.60	278.3	6.7	18.65	225.0	5.1	11.48	
215	171.9	5.8	9.97	373.9	6.3	23.56	341.2	5.9	20.13	
359	51.8	6.4	3.32	113.5	6.3	7.15	89.6	6.5	5.82	359 (dry)
295	229.5	5.4	12.39	508.1	5.8	29.47	471.0	5.2	24.49	replaced by 373 1/16/48
Total	555.9		33.28	1273.8		78.83	1126.8		61.92	

Cow No.	Jan. 16-31 Milk	Jan. 16-31 B. F. Test	Jan. 16-31 B. F.	Feb. 1-15 Milk	Feb. 1-15 B. F. Test	Feb. 1-15 B. F.	Feb. 16-29 Milk	Feb. 16-29 B. F. Test	Feb. 16-29 B. F.	Notes
	Lbs.	%	Lbs.	Lbs.	%	Lbs.	Lbs.	%	Lbs.	
210	187.1	7.2	13.47	179.6	6.9	12.39	201.5	6.9	13.90	
215	311.5	5.4	16.82	296.6	5.2	15.42	324.7	5.3	17.21	
373	417.5	4.8	20.04	382.2	4.7	17.96	369.3	4.7	17.36	
295	380.0	5.8	22.04	332.6	5.3	17.63	356.1	5.3	18.87	
Total	1296.1		72.37	1191.0		63.40	1251.6		67.34	

Cow No.	Mar. 1-15 Milk	Mar. 1-15 B. F. Test	Mar. 1-15 B. F.	Mar. 16-31 Milk	Mar. 16-31 B. F. Test	Mar. 16-31 B. F.	Milk	B. F. Test	B. F.	Notes
	Lbs.	%	Lbs.	Lbs.	%	Lbs.	Lbs.	%	Lbs.	
210	205.3	7.5	15.40	210.9	7.5	15.82				
215	353.6	5.8	20.51	401.3	5.8	23.28	Project concluded 3/31/48			
373	379.2	6.0	22.74	378.1	6.0	22.68	Total milk		9,436.90	
295	386.9	5.7	22.05	426.4	5.7	24.30	Total Fat		543.93	
Total	1325.0		80.71	1416.7		86.08	Total 4% corrected milk		11,933.71	

TABLE VI.

MILK AND BUTTERFAT RECORDS - GROUP II

Cow	Dec. 8-15			Dec. 16-31			Jan. 1-15			
No.	Milk	B. F. Test	B. F.	Milk	B. F. Test	B. F.	Milk	B. F. Test	B.F.	Notes
	Lbs.	%	Lbs.	Lbs.	%	Lbs.	Lbs.	%	Lbs.	
211	113.0	5.5	6.22	213.1	5.5	11.72	200.5	5.4	10.83	329 (dry)
218	165.3	6.8	11.24	353.2	5.8	20.49	304.4	6.2	18.87	replaced by
263	486.4	5.2	4.49	597.3	5.2	31.06	500.1	5.1	25.51	323 1/16/48
329	51.1	7.8	3.99	114.7	6.9	7.91	97.5	7.5	7.31	
Total	415.8		25.94	1278.3		71.18	1102.5		62.52	

Cow	Jan. 16-31			Feb. 1-15			Feb. 16-29			
No.	Milk	B. F. Test	B. F.	Milk	B. F. Test	B. F.	Milk	B. F. Test	B. F.	Notes
	Lbs.	%	Lbs.	Lbs.	%	Lbs.	Lbs.	%	Lbs.	
211	189.0	4.7	8.88	163.1	5.3	8.64	160.4	5.3	8.50	
218	303.8	6.3	19.14	291.7	6.5	18.96	285.0	6.2	17.67	
263	470.7	5.6	26.36	392.5	5.8	22.77	361.9	5.5	19.90	
323	365.8	4.9	17.92	315.3	4.7	14.82	269.1	4.9	13.19	
Total	1329.3		72.30	1162.6		65.19	1076.4		59.26	

Cow	Mar. 1-15			Mar. 16-31						
No.	Milk	B. F. Test	B. F.	Milk	B. F. Test	B. F.	Milk	B. F. Test	B. F.	Notes
	Lbs.	%	Lbs.	Lbs.	%	Lbs.	Lbs.	%	Lbs.	
211	141.2	6.1	8.61	113.3	6.1	6.91				
218	263.8	6.7	17.67	275.7	6.7	18.47	Project concluded 3/31/48			
263	337.1	5.2	17.53	357.4	5.2	18.58	Total milk 8,396.20			
323	266.6	6.3	16.80	276.2	6.3	17.40	Total fat 478.36			
Total	1008.7		60.61	1022.6		61.36	Total 4% corrected milk 10,533.88			

TABLE VII

FEED CONSUMPTION OF COWS IN POUNDS-GROUP I
(Balboa Rye and Crimson Clover Pasture,
Alfalfa and Orchard Grass Hay,
Grain - 1 to 4)

Cow	Dec. 8-15		Dec. 16-31		Jan. 1-15		Jan. 16-31		Feb. 1-15		
No.	Hay	Grain	Hay	Grain	Hay	Grain	Hay	Grain	Hay	Grain	Notes
210		40.0		64.0		75.0		64.0		60.0	In barn Jan. 17,18,19,20
215		48.0		96.0		90.0		112.0		105.0	359 (dry) replaced by 373
359		48.0		64.0		60.0		112.0		105.0	Jan. 16, 1948. Jan.1-16 early
295		40.0		128.0		120.0		128.0		120.0	cut lesp. hay fed. Cows on pasture 24 days in December.
Total	603.0	176.0	633.0	352.0	748.0	345.0	1404.0	416.0	1360.0	390.0	

Cow	Feb. 16-29		Mar. 1-15		Mar. 16-31		
No.	Hay	Grain	Hay	Grain	Hay	Grain	Notes
210		64.0		60.0		64.0	Cows on pasture 18 days in Jan., 10 days
215		84.0		90.0		80.0	in Feb. and 31 days in March.
373		98.0		90.0		96.0	Total hay 7159.0
295		98.0		105.0		112.0	Total grain 2720.0
Total	940.0	344.0	794.0	345.0	677.0	352.0	

TABLE VII (Cont'd)

FEED CONSUMPTION OF COWS IN POUNDS-GROUP II
(Alfalfa and Orchard Grass Hay,
Grain - 1 to 4)

Cow	Dec. 8-15		Dec. 16-31		Jan. 1-15		Jan. 16-31		Feb. 1-15		
No.	Hay	Grain	Hay	Grain	Hay	Grain	Hay	Grain	Hay	Grain	Notes
211		40.0		64.0		60.0		64.0		60.0	Early cut lesp. fed
218		40.0		80.0		80.0		80.0		75.0	Jan. 1-16
263		27.0		144.0		135.0		144.0		135.0	329 replaced by 323 1/16/48
329		32.0		64.0		60.0		112.0		105.0	
Total	822.0	139.0	1056.3	352.0	1263.4	335.0	1631.0	400.0	1410.6	375.0	

Cow	Feb. 16-29		Mar. 1-15		Mar. 16-31		
No.	Hay	Grain	Hay	Grain	Hay	Grain	Notes
211		42.0		45.0		48.0	Hay fed: U. S. Sample Grade Lesp. chopped
218		84.0		90.0		64.0	U. S. No. 2 alfalfa
263		98.0		90.0		112.0	U. S. No. 3 alfalfa
323		84.0		75.0		80.0	Total hay 10,555.60
Total	1166.2	308.0	1444.0	300.0	1762.0	304.0	Total concentrates 2,513.00

TABLE VIII

LIVE WEIGHTS OF COWS IN POUNDS

Group I

Cow No.	12/1	1/1	Gain	2/1/48	Gain	3/1/48	Gain	3/29/48	3/30/48	3/31/48	3 day avg.	Gain	Total gain 115 days
210	955	940	-15	1045	105	985	-60	1015	1010	1025	1017	32	
215	825	795	-30	845	50	795	-50	805	825	815	815	20	
359	815	865	50	855	-10								
295	Dry	770		725	-45	670	-55	680	705	700	695	25	
373	Dry			695		655	-40	660	690	690	680	25	
Total			5		100		-205					102	2

Group II

Cow No.	12/1	1/1	Gain	2/1/48	Gain	3/1/48	Gain	3/29/48	3/30/48	3/31/48	3 day avg.	Gain	Total gain 115 days
211	585	610	25	670	60	715	45	690	705	696	697	-18	
218	875	880	5	830	-50	835	5	845	870	880	865	30	
263	Dry	835		810	-25	800	-10	790	785	810	795	- 5	
329	755	800	45	715	-85								
323	Dry			750		730	-20	695	695	685	692	-38	
Total			75		-100		20					-31	-36

TABLE IX

COMPOSITION OF MILK FROM COWS ON WINTER PASTURE AND DRY FEED

Date	T. S.	B-Fat	Micrograms vit. A (2)	Per ml of milk carotene (1)	Vit. A equiv.* per quart (2)
	%	%		Pasture	
			Group I		
1/19/48	15.05	6.6	.36	1.17	900
3/2/48	15.22	5.8	.49	.90	890
3/25/48	14.75	4.9	.33	.90	740
			Group II	Dry Feed	
1/19/48	15.52	5.8	.47	.51	680
3/2/48	15.17	5.5	.26	.22	350
3/25/48	14.08	4.9	.34	.62	610

* The vitamin A activity is the sum of the vitamin A and caroten values expressed as micrograms vitamin A equivalents assuming that two micrograms of carotene are equivalent to one microgram of vitamin A.

The composition of two samples taken from cows on early-cut lespedeza and late-cut lespedeza is shown in Table X. The early-cut lespedeza showed 21.0 percent more vitamin A equivalents over late-cut lespedeza.

Work at Jackson. The composition of the milk secured from Jackson is shown in Table XI. All the cows of the station herd were on pasture, but Mr. B. P. Hazelwood, Superintendent, West Tennessee Experiment Station, secured a sample from a barn fed herd. The milk sample from the Station herd on pasture showed 52.3 percent more vitamin A equivalents than the barn-fed herd sample.

Work at Knoxville. Table XII gives the days pasture and the composition of the samples of the Holstein cows. This group's milk showed a progressive increase in vitamin A equivalents from 330 per quart in February to 730 per quart in April and then started to decline. This is a 108 percent increase in vitamin A equivalents.

Table XIII gives the same information for the Jersey cows which showed an increase in vitamin A equivalents from 410 per quart in February to 830 per quart of milk in April. This is a 103 percent increase in vitamin A equivalents.

TABLE X

COMPOSITION OF MILK FROM JERSEY COWS ON
EARLY-CUT AND LATE-CUT LESPEDEZA HAY

Date	T. S.	Butter fat	Micrograms per ml. of milk Vit. A	Carotene	Vit. A equiv. per quart
	%	%			
			Early-cut Lespedeza Hay		
1/19/48	15.02	7.6	.37	1.00	820
3/2/48	15.89	6.5	.31	.83	680
			Late-cut Lespedeza Hay		
1/19/48	15.05	6.4	.27	.88	670
3/2/48	14.63	5.5	.22	.78	570

TABLE XI

COMPOSITION OF MILK FROM JERSEY COWS ON
WINTER PASTURE AND DRY FEED - JACKSON

				Micrograms per ml. of milk		Vit. A equiv.
Date	Group	T. S.	Fat	Vit. A	Carotene	per quart
		%	%			
3/12/48	Winter pasture	13.73	4.1	.30	.75	640
3/12/48	Dry feed	14.06	4.2	.22	.45	420

TABLE XII

COMPOSITION OF MILK FROM HOLSTEIN HERD - KNOXVILLE

Date	Days Pasture	T. S.	Fat	Micrograms per ml. milk Vit. A	Carotene	Vit. A equivalents per quart milk
		%	%			
2/2/48	0	11.07	2.8	.15	.41	330
3/2/48	1	11.86	2.6	.16	.37	330
3/10/48	5	12.05	3.4	.28	.45	470
3/19/48	11	12.30	3.3	.36	.51	580
3/23/48	15	12.12	3.4	.30	.86	680
4/17/48	40	12.42	3.6	.43	.68	730
5/17/48	70	12.40	3.3	.34	.61	610
6/11/48	95	12.56	3.5	.20	.49	430

TABLE XIII

COMPOSITION OF MILK FROM JERSEY COWS - KNOXVILLE

Date	Days Pasture	T. S.	Fat	Micrograms per ml. milk Vit. A	Carotene	Vit. A equivalent per quart milk
		%	%			
2/2/48	0	14.75	4.7	.26	.34	410
3/2/48	1	13.64	3.8	.15	.70	470
3/10/48	5	14.61	4.8	.26	.76	610
3/19/48	11	14.72	4.3	.29	.85	680
3/23/48	15	14.75	4.9	.33	.90	740
4/17/48	40	14.92	5.1	.38	1.00	830
5/17/48	71	14.64	4.8	.34	.88	740
6/11/48	95	14.72	4.6	.34	.78	690

CHAPTER V

DISCUSSION

The data of Tables I and II on milk production are shown graphically in Figure I. Group I produced 13.3 percent more milk than Group II. Although in this experiment it was not statistically significant because of the design of the experiment, the difference may be real because in agrees with the data obtained by other investigators (16,40,27) who report a 16.3 ro 22.5 percent increase in milk production due to pasture. The increase in milk production of Group I over Group II is consistent, with one exception, January 16 to 31, but the greatest difference occurs during the last month of the experiment. From February 1 to March 31, Group I made a progressive increase in milk production; whereas, Group II made a progressive decrease in milk production. This suggests that pasture may be a factor in preventing a decrease in production as the lactation advances.

The data of Tables I and II on butterfat production are shown graphically in Figure 2.

Since only 68.8 percent as much hay was consumed, the total roughage needed for cows on pasture would be considerably less. Figure 3 shows the hay consumption. However, according to this data, more grain was required to maintain the high level of production, instead of less as reported by many investigators (16, 60). The grain consumption is shown in Figure 4.

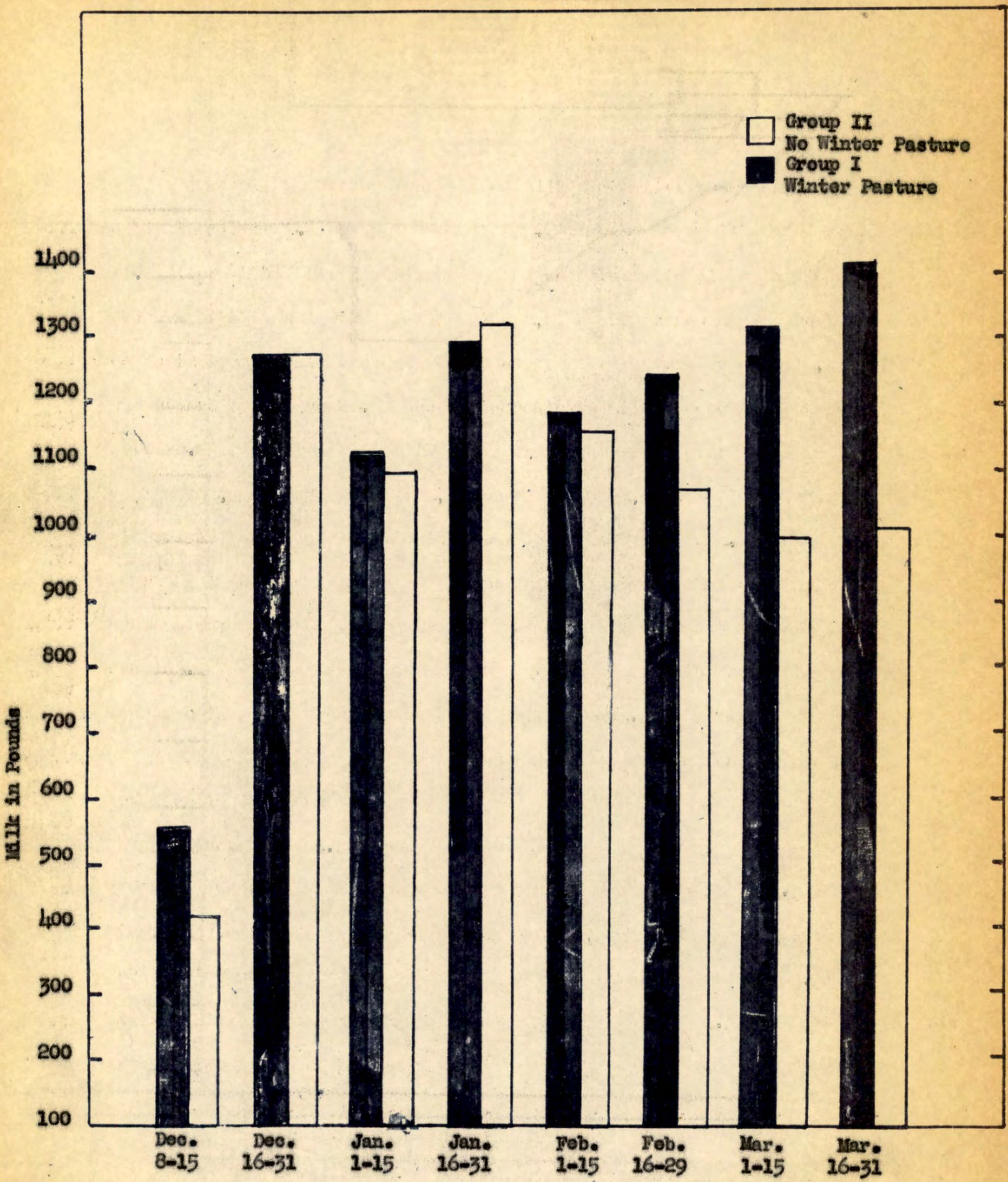

Figure 1. Milk production, Groups I and II

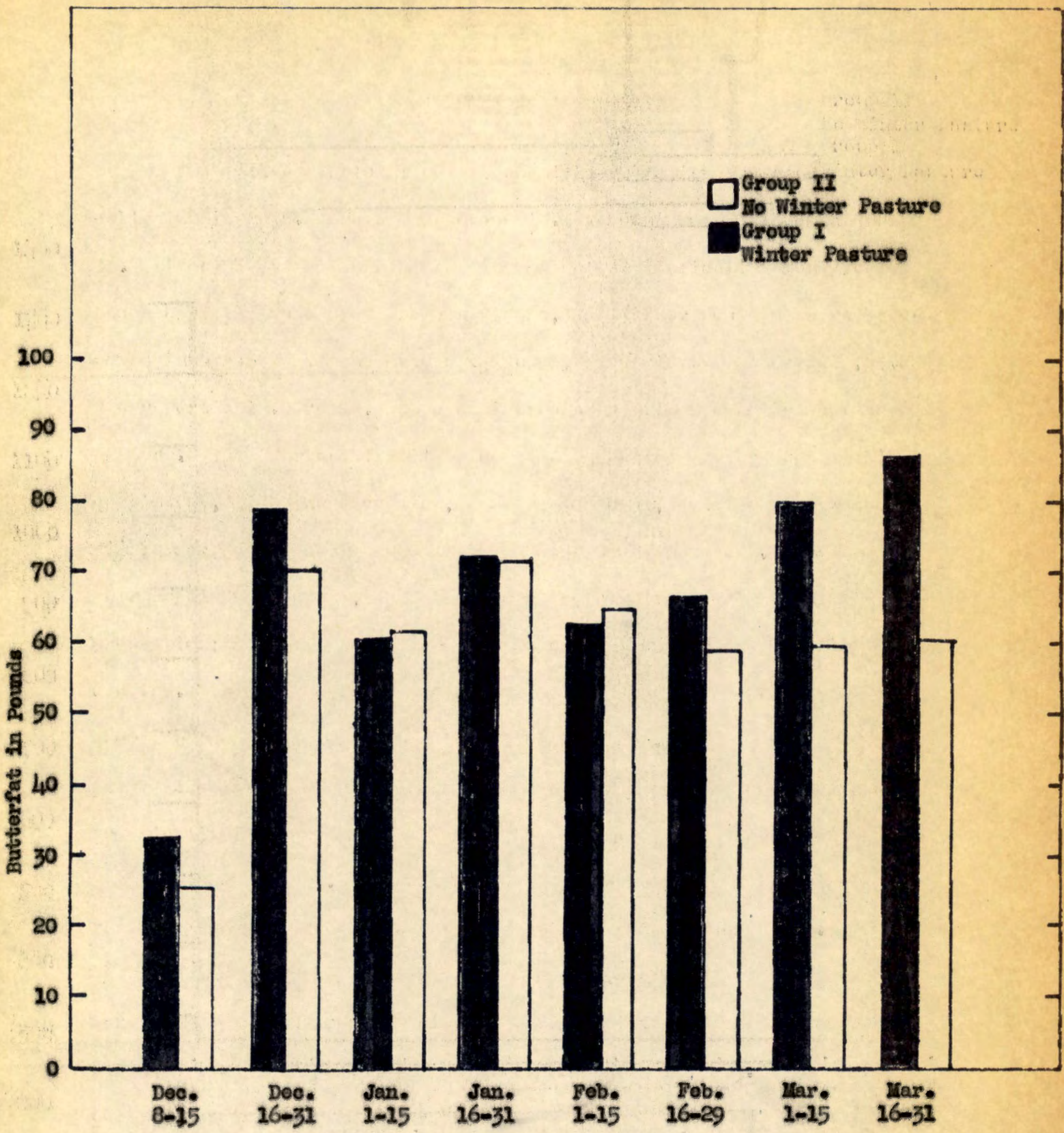

Figure 2. Butterfat production, Groups I and II

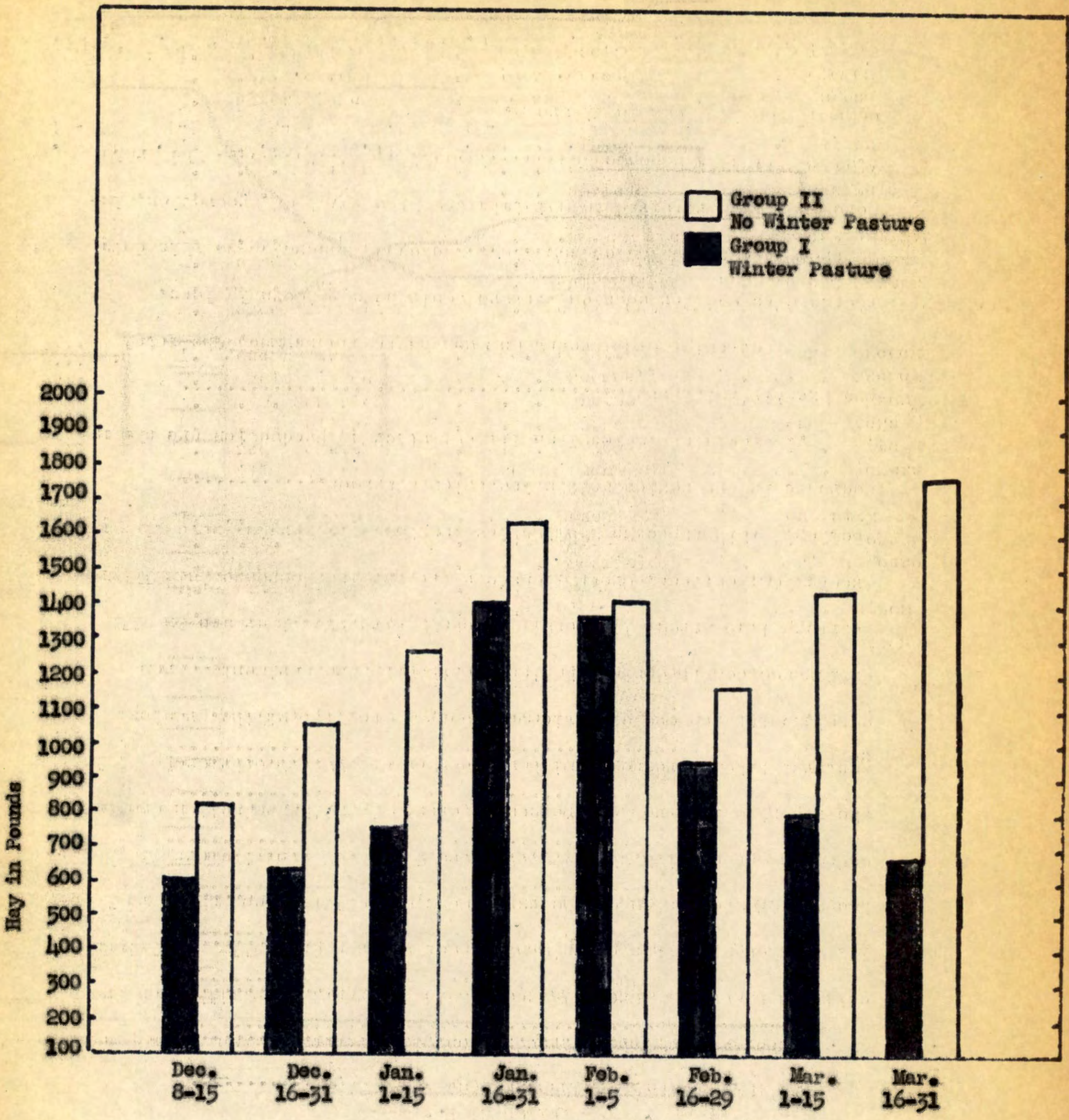

Figure 3. Hay consumption, Groups I and II

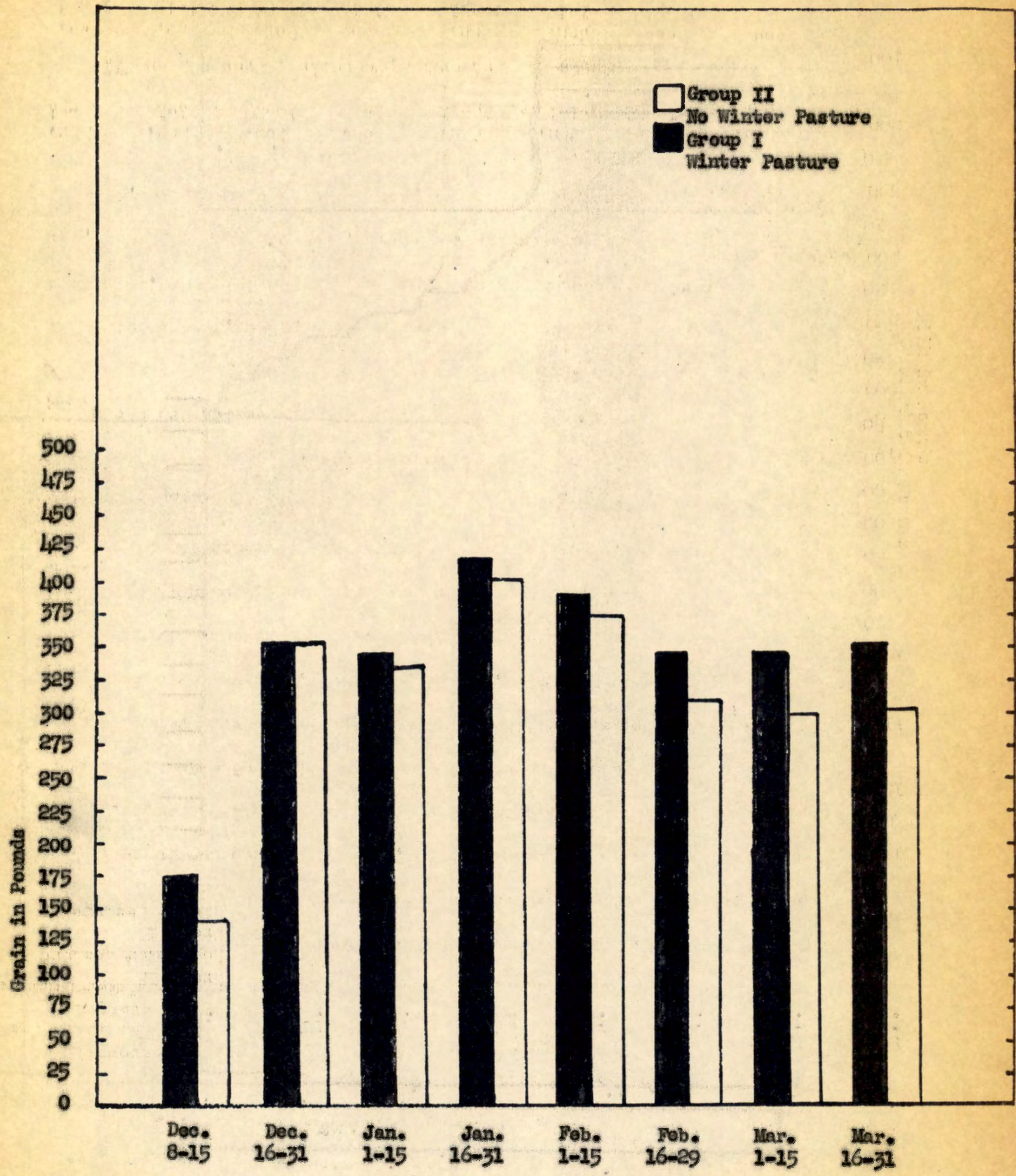

Figure 4. Grain consumption, Groups I and II

The comparison of vitamin A activity is shown in Figure 5. The 53.4 percent greater vitamin A activity for Group I indicates that the vitamin A content of milk is affected by the diet of the animal. This is in accordance with the conclusion of Feiger (16). At no time did the samples from Group II exceed those of Group I in Vitamin A activity.

The milk from cows on early-cut lespedeza showed 21.0 percent greater vitamin A equivalents than late-cut lespedeza, for the four samples analyzed. This relationship is shown in Figure 6. This was probably due to the higher carotene content of the early-cut lespedeza. As shown in Figure 6, the vitamin A equivalents of both the early-cut and late-cut lespedeza hay decreased at the later date. This is in accordance with Koehn (35) who has shown that there are large losses of carotene in forage during storage.

The 52.3 percent increase in vitamin A equivalents of the winter pasture herd over the dry feed herd at Jackson indicate a similar relationship to that shown with Groups I and II, respectively, at Columbia. The comparison in vitamin A activity is shown in Figure 7.

Figures 8 and 9 show graphically the secretion of vitamin A into the milk by the Holstein and Jersey herds respectively. It will be noted that the greatest amount of vitamin A was secreted in April and the least amount was secreted in March for the Holstein herd. The period of greatest vitamin A activity value was the same for the Jersey herd but the minimum value occurred in February.

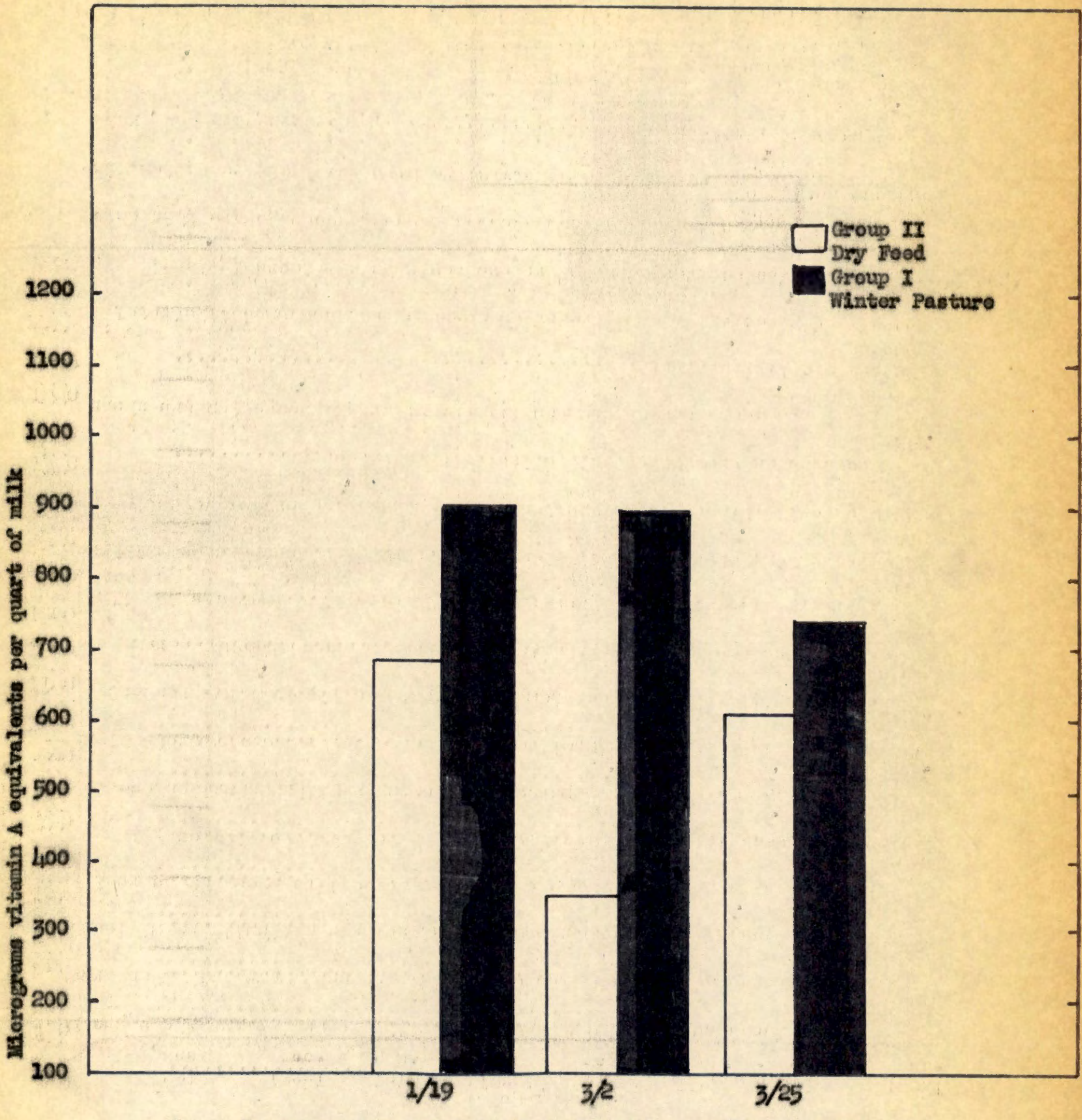

Figure 5. Comparison of vitamin A activity of milk from cows on pasture and cows on dry feed. The vitamin A activity is the sum of the vitamin A and carotene values expressed as microgram vitamin A equivalents assuming that two micrograms of carotene are equivalent to one microgram of vitamin A.

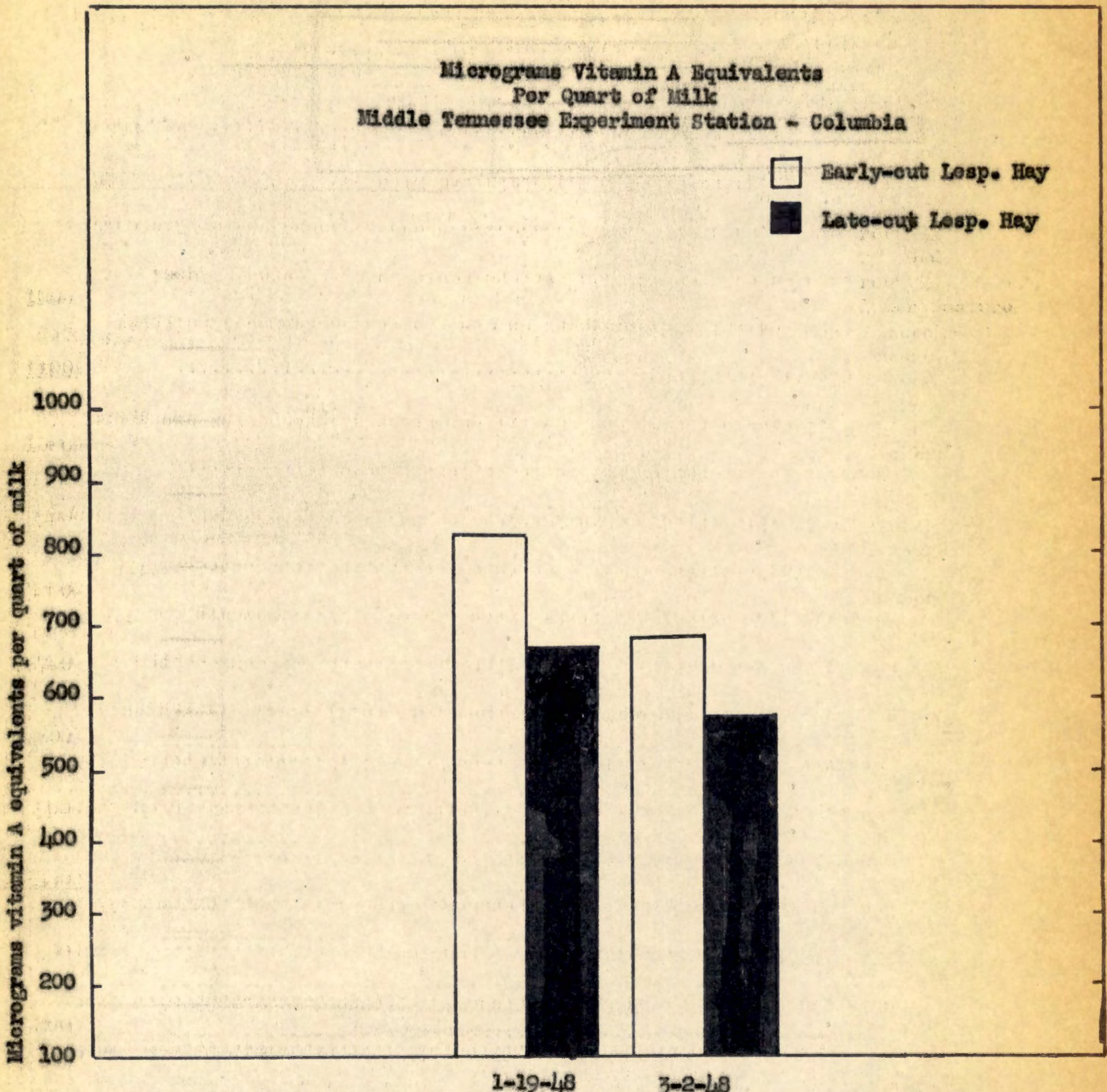

Figure 6. Comparison of vitamin A activity of milk from cows fed early-cut lespedeza and cows fed late-cut lespedeza. The vitamin A activity is the sum of the vitamin A and carotene values expressed as micrograms vitamin A equivalents assuming that two micrograms of carotene are equivalent to one microgram of vitamin A.

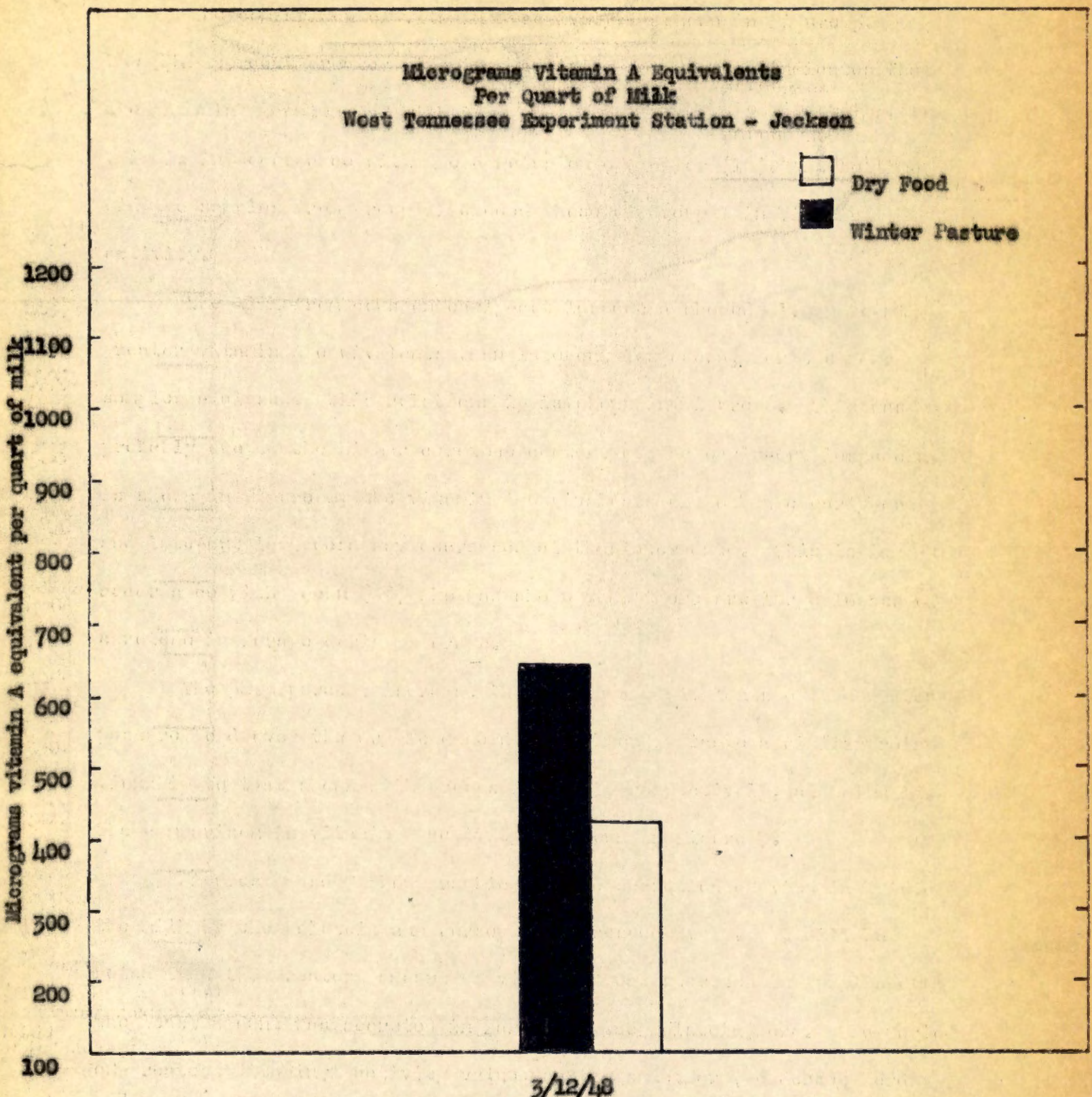

Figure 7. Comparison of vitamin A activity of milk from cows on pasture and cows on dry feed. The vitamin A activity is the sum of the vitamin A and carotene values expressed as microgram vitamin A equivalents assuming that two micrograms of carotene are equivalent to one microgram of vitamin A.

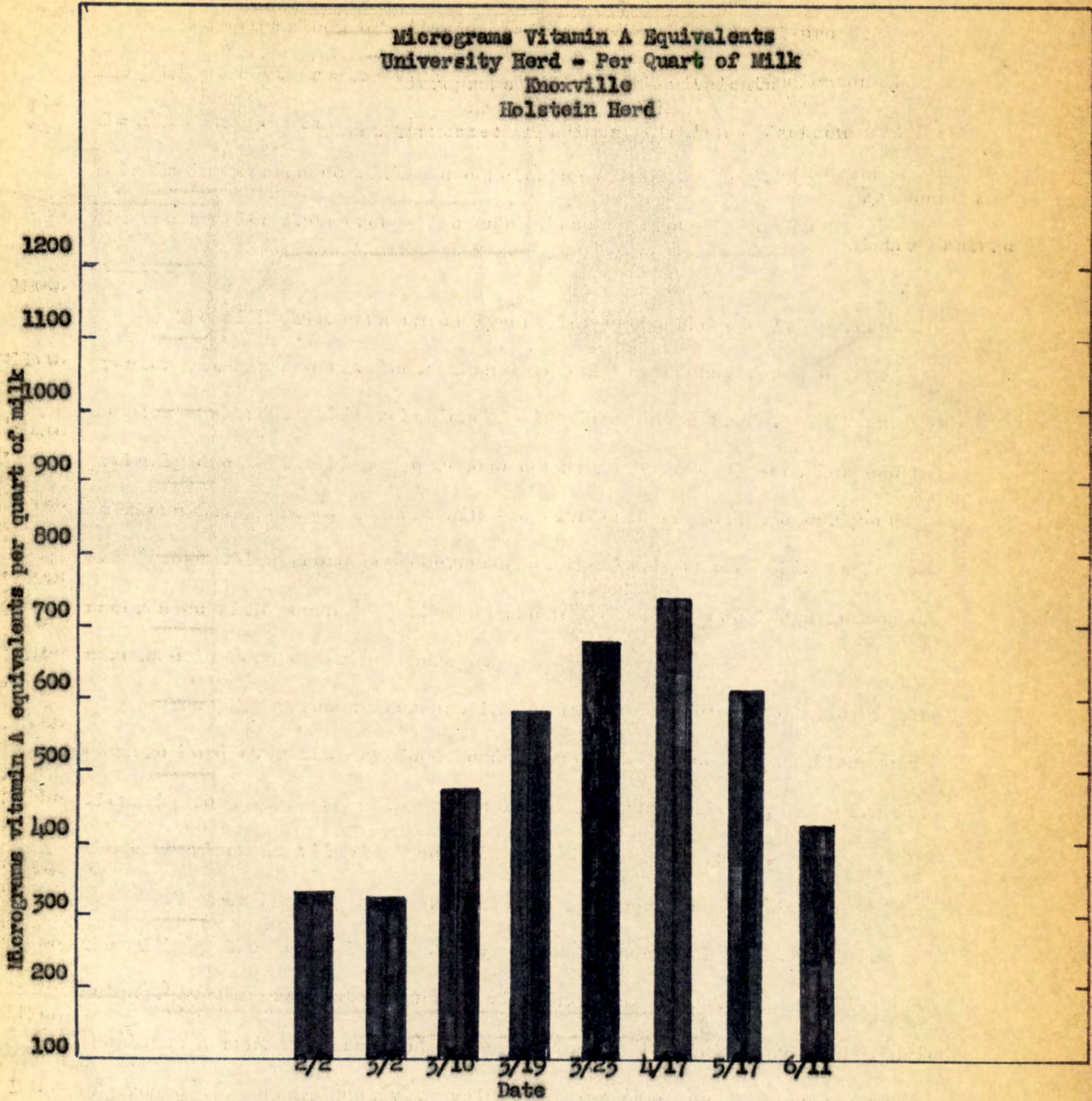

Figure 8. Seasonal variation in the vitamin A activity of milk. The vitamin A activity is the sum of the vitamin A and carotene values expressed as micrograms vitamin equivalents assuming that two micrograms of carotene are equivalent to one microgram of vitamin A.

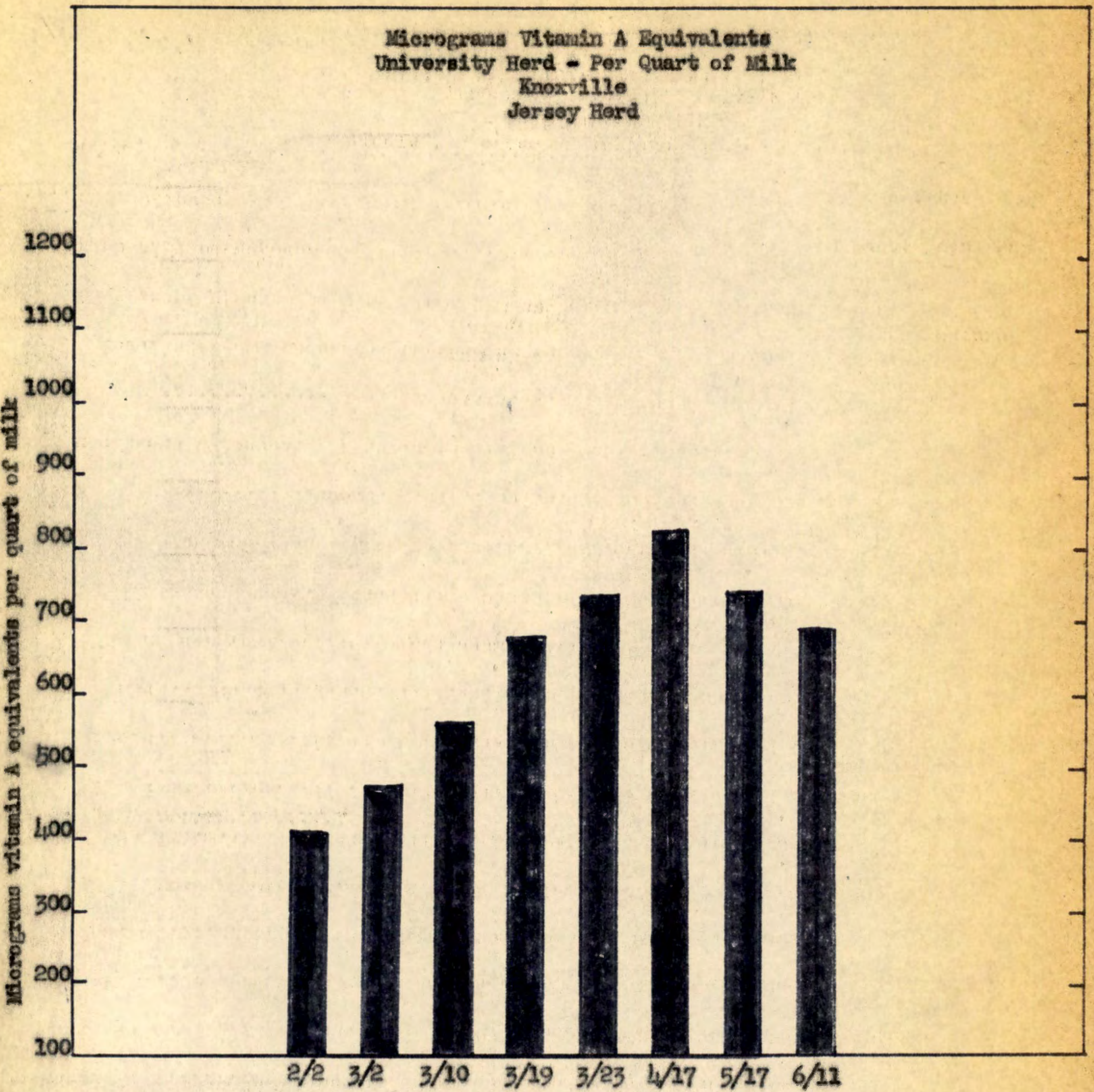

Figure 9. Seasonal variation in the vitamin A activity of milk. The vitamin A activity is the sum of the vitamin A and carotene values expressed as micrograms vitamin A equivalents assuming that two micrograms of carotene are equivalent to one microgram of vitamin A.

Feiger (16) also found the values obtained for April represented the maximum value of vitamin A for cows milk in Alabama. Koehn (35) obtained his maximum value of vitamin A in August on permanent pasture and in May on supplementary pasture. It will be noted from figures 8 and 9 that at no time during the period sampled did the vitamin A activity level off in the milk. This data disagrees with that collected by Feiger (16), who concluded that the vitamin A activity appeared to reach a definite ceiling value. After being on pasture fifteen days, the vitamin A activity of the Holstein herd increased 102.4 percent; whereas, the Jersey herd increased 82.0 percent in vitamin A activity. This agrees with the data obtained at Beltsville reported by the Technical Committee (55) in which the vitamin A potency of the Holstein cows was increased more than one hundred percent during the first two weeks the cows were on pasture.

SUMMARY

Eight Jersey cows at Columbia were paired on the basis of production, stage of lactation, body weight and freedom from disease. They were divided into two groups. Group I was placed on balbo rye and crimson clover pasture when weather and pasture conditions permitted. Group II was barn fed.

Group I produced 13.3 percent more four percent fat corrected milk, consumed 68.8 percent as much hay for the 115 day period as Group II. However, Group II consumed 82.7 percent as much concentrates for the same period. The greater consumption of grain by Group I was due to the higher level of production.

The samples from Group I at Columbia were 53.4 higher in vitamin A activity than samples from Group II. The analysis of milk samples from cows on early-cut and late-cut lespedeza hay showed 21.0 percent more vitamin A activity in milk from those fed early-cut lespedeza than those fed late-cut lespedeza.

Milk from cows on pasture at Jackson showed 52.3 percent more vitamin A activity than milk from cows on dry feed. Since the milk from cows on dry feed was a farmer herd and the milk from cows on pasture was from the West Tennessee Experiment Station, conditions were not controlled and therefore results are not comparable. However, with such a large difference in the vitamin A activity, the difference is probably significant.

Milk samples from the Holstein and Jersey cows at Knoxville were collected from February to May. The maximum values of vitamin A were found in April and the minimum in March for the Holstein cows. The samples from the Jersey cows showed highest vitamin A activity in April and the lowest in February. At no time did the vitamin A activity appear to level off in the milk. The vitamin A activity of the Holstein cows increased 102.4 percent in 15 days, while the vitamin A activity of the Jersey cows increased 82.0 percent in the same period.

The vitamin A activity of the milk is related to the feed consumed by the cow. In all cases, samples from cows on green feed showed a rapid and marked increase in the vitamin A content of the milk produced for a period of one month and then tended to level off.

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