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A TWO-YEAR STUDY OF THE VITAMIN A POTENCY OF LOUISIANA MILK AND BUTTER

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Dairy products have long been considered one of our most important sources of vitamin A, a food nutrient essential for health in people of all ages. The amount of this vitamin in milk and butter varies greatly according to the feed given the cows and season of the year. Back in 1941, in order to answer questions raised by the Food and Nutrition Board of the National Research Council on the importance of butter in the diet, a nationwide survey on the vitamin A potency of butter was inaugurated. Twenty agricultural experiment stations, the Bureau of Dairy Industry, and the Office of Experiment Stations all cooperated in making this survey of butter produced and marketed in different seasons of the year and in different regions.

The Louisiana Agricultural Experiment Station joined this cooperative project even though the amount of creamery butter produced in this state is small. Monthly samples were obtained from two creameries which account for about two-thirds of the creamery butter production in the state. In addition to studying the vitamin A potency of butter, milk was included in the survey. Milk samples representing twenty-eight dairy herds and six creameries were received and assayed for vitamin A each month. Since vitamin A and its precursor, carotene, are found only in the fat portion of milk, it was necessary to know the fat content of each sample. This was determined by the Babcock method. By stating the vitamin A potency in terms of a weight of fat it was possible to consider creamery milk with a standardized and usually lower fat content along with herd milk. Dairy products were analyzed for vitamin A and carotene over a period of two years.

Vitamin A in Nutrition

Vitamin A potency in food is composed of two factors, vitamin A per se and carotene, which is a yellow pigment that gives the color to butter, carrots, sweet potatoes and other foods. Carotene, which is sometimes called provitamin A, is also found in green leaves such as grass, clover, oat and rye grasses, alfalfa, spinach, mustard greens and turnip greens. In the animal body, provitamin A is converted into vitamin A. It follows that vitamin A itself is found only in foods of animal origin—butter, milk, liver, fish liver oils, and some other animal foods.

Either carotene or vitamin A or both may be utilized by the human or animal body. Chickens, rabbits and lambs utilize carotene efficiently. This is not the case with horses, cows and humans. Only a small portion of the carotene ingested is actually used as vitamin A. Since the cows' feed normally does not contain any animal source of vitamin A, it is important that they consume a sufficient quantity of carotene to maintain their own body's requirements and produce milk high in vitamin A.

Since vitamin A is stored in the body, it is not essential that the full requirement be consumed every day. An excess at one time will make up for a shortage at another. A diet low in vitamin A over a prolonged period of time, however, will induce symptoms which become increasingly acute if the diet is not improved. These symptoms of vitamin A deficiency in humans are changes in the membrane covering the eye and lining the eyelid, night blindness, and roughened or very dry skin. These conditions may be overcome by continued feeding of a normal diet.

Daily allowances of vitamin A as recommended by the National Research Council are:

Age Group	*International Units per Day*
Under 1 year	1500
1-3 years	2000
4-6 years	2500
7-9 years	3500
10-12 years	4500
13-15 years	5000
16-20 years, girls	5000
16-20 years, boys	6000
Adults	5000

The International Unit of vitamin A is a measurement used for both vitamin A and carotene.

Studies made at the Texas Agricultural Experiment Station (2) reveal the effect of a low carotene intake on the health of the cow. Usually the first symptom is night blindness. In a dim light the animal when approaching an obstacle will suddenly stop and veer to avoid it. A lack of normal alertness is usually one of the early symptoms of vitamin A deficiency. Convulsions is a symptom which sometimes appears early, after night blindness. Later results of vitamin A deficiency are complete night blindness, affection of the eyes, nasal discharge, extreme sensitivity to solar heat, swellings, especially of the legs, thighs, shoulders and neck, and harsh, dry hair coat.

A deficiency of vitamin A or its precursor, carotene, in the cow's feed has little or no effect upon milk production. The amount of the vitamin consumed does have a very marked influence on the vitamin A content of the milk. Ordinarily, the vitamin A content of winter milk is much lower than that of summer milk. Various breeds of cows differ in the ability to convert carotene into vitamin A. Guernsey and Jersey milk is deeper in color as a result of containing more carotene. In Holstein milk a greater proportion of vitamin A is present. For this reason it is not safe to judge the nutritive quality of milk on color alone. The amount of butterfat in milk influences the total amount of vitamin A, as it is found only in the fat.

Experimental

Thirty-three samples of milk and two of creamery butter were analyzed each month for vitamin A and carotene over a two-year period. One butter sample was from cream produced by cows in the northern part of the state and one from cream produced by cows in the southern part. Six samples represented milk from a creamery in each of the largest cities. Of the herd milk, six samples were from the northern part of the state, three from the central part and 18 from the southern part.

Each milk sample was taken from well-mixed milk, placed in a bottle and mailed to the laboratory. A preservative was used to prevent souring. Previous work in this laboratory showed that this preservative had no effect on vitamin A or carotene. At the same time, the cooperator reported the type of pasture and its condition, nature of roughage and concentrate which were fed, and the number of cows which freshened.

A preliminary report (1) of this study was published in November, 1944. Since that time other workers have found that the factor for converting micrograms of vitamin A into International Units of the vitamin is nearer four, instead of three and one-third as was formerly used. All the results have been recalculated using this factor, which makes the values slightly higher.

Chemical methods suggested by the Technical Committee of the National Cooperative Butter Project were used for determining both carotene and vitamin A. Fat was estimated by the Babcock test in order to calculate the vitamin A content per gram of fat as well as per quart of milk. By stating the vitamin contents in terms of a weight of fat, differences caused by varying amounts of fat in the milk may be overcome. The fat content of butter samples was also measured. As the vitamin A content in terms of a weight of butterfat was known, it was possible to draw a comparison between the milk and butter and between dairy products produced in this state and those in other regions.

Results and Discussion

Table I gives average monthly vitamin A values for herd milk, creamery milk and creamery butter. Milk from creameries contained less vitamin A per quart because the fat content had been standardized to about 3.8% butterfat. Figure I shows the monthly variations of herd milk, creamery milk and creamery butter on the basis of International Units of vitamin A per gram of butterfat.

As might be expected, total vitamin A values for dairy products were high when there was ample green pasture available, and low during the winter and extremely dry summer months. There were great differences between the individual samples of milk, but usually the same herds supplied the milk high in vitamin A each month. In the spring, milk from the southern part of the state showed a rise in vitamin A content earlier

TABLE I. Average Vitamin A Content of Milk and Butter

Month and Year	*Herd Milk*		*Creamery Milk*		*Creamery Butter*	
	No. Samples	*I.U.* per Quart*	*No. Samples*	*I.U.* per Quart*	*No. Samples*	*I.U.* per Pound*
1943:						
October	18	2252	6	1817	2	17,731
November	22	1557	6	1137	2	11,138
December	22	1793	6	1195	2	11,712
1944:						
January	25	1474	6	1207	2	9,258
February	24	1654	6	1493	2	12,789
March	24	2515	6	2267	2	17,110
April	23	3211	6	2803	2	22,505
May	..	....	..	....	2	17,633
July	23	1391	6	1219	2	12,224
August	20	2028	6	1280	2	14,549
September	25	2622	6	2103	2	16,964
October	25	2738	6	2137	2	19,323
November	26	1890	6	1674	2	13,610
December	26	1719	6	1301	2	11,229
1945:						
January	24	1163	6	815	2	6,886
February	25	1097	5	976	2	7,920
March	24	1984	6	1432	2	12,025
April	23	1513	5	1093	2	11,068
May	24	1985	6	1855	2	16,763
June	24	2300	6	1962	2	14,574
July	23	2248	5	1981	2	18,361
August	24	2032	6	1730	2	17,600
September	24	2319	6	2075	2	19,258
Average	..	1977	..	1616	..	14,445

*International Units.

than that from the northern section. Highest average values for the whole state occurred in September, October, March, April and June. Low values were found during the months November through February. Some differences were found between monthly values for the two years. Low average vitamin A content of milk was found in July of one year and in April of the next as a result of climatic conditions affecting pastures. Hot, dry summer weather caused some of the pastures to be as brown as they were during the winter.

The most striking effect of pasture conditions was shown by grazing cows for one or two hours a day on fall planted oats. In Table II, the average vitamin A content of milk from cows grazed on oat pastures and those not grazed on oat pastures is shown. During the months November through April the increase in vitamin A potency brought about by the use of supplemental oat pasture was approximately 33 per cent.

In November, 1943, four of the five herds had been on oats only ten days or a week before the samples were taken. This was too short a time for the improvement in feed to be reflected in the quality of the milk,

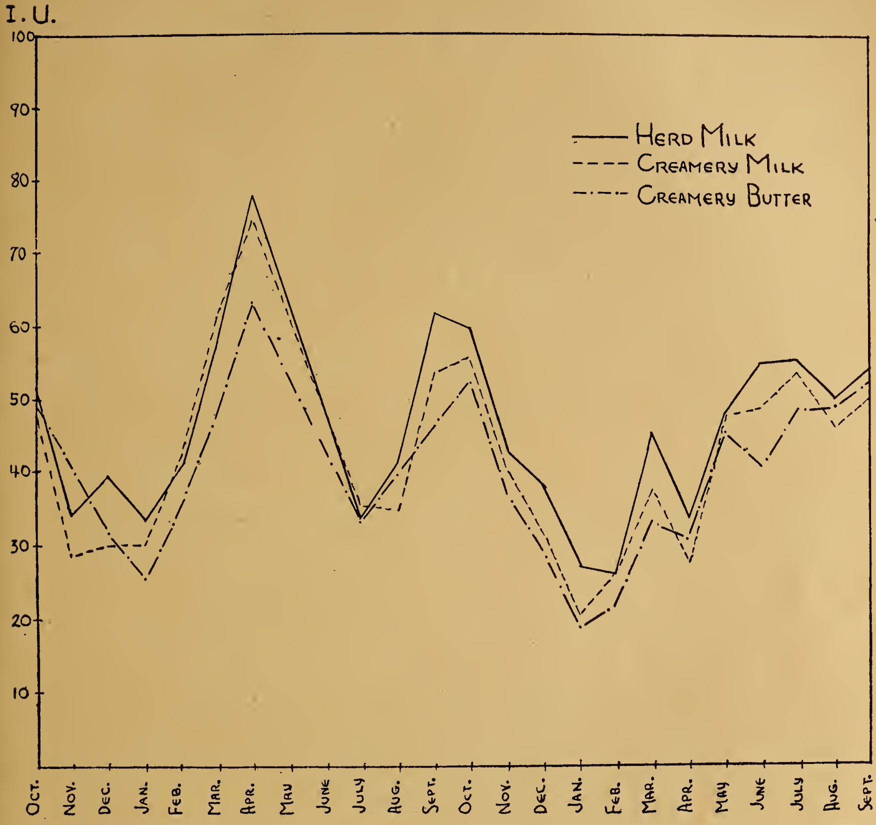

FIGURE 1. Average Vitamin A Content in International Units per Gram of Butterfat.

and the improvement in vitamin content did not show up until the following month, when there was a 62 per cent increase. Some observations made by sampling milk weekly from the University herd showed that two weeks or more elapsed before the milk reflected good feeding practices. It has also been observed that a decrease in carotene intake brings about a gradual rather than a sudden drop in vitamin A potency of milk.

Oat pastures grazed in December, 1943, caused a 40 per cent increase in vitamin content of milk samples analyzed in January, 1944. In March the increase was 33 per cent. Low values for February, 1944, resulted from inability to use pastures during the greater part of January because of cold, rainy weather. During March and April the grazing of clover pastures was reflected in increased vitamin A potency of milk from practically all herds. The combination of clover with supplemental oat pastures resulted in milk more potent in vitamin A than did either forage alone.

TABLE II. Effect of the Use of Supplemental Oat Pastures on the Vitamin A Content of Milk

Month and Year	*Grazed on Oat Pastures*		*Not Grazed on Oat Pastures*		*Per Cent Increase By Use of Oat Pastures*
	No. of Herds	*I.U.* per Quart*	*No. of Herds*	*I.U.* per Quart*	
1943:					
November	5	1437	17	1592	—9.74
December	7	2433	15	1495	62.74
1944:					
January	4	1983	23	1412	40.44
February	5	1671	19	1649	1.33
March	5	3137	19	2351	33.43
April	6	3477	17	3118	11.51
November	7	2317	19	1732	33.78
December	10	2109	16	1476	42.89
1945:					
January	10	1702	14	779	118.49
February	13	1304	12	872	49.54
March	11	2454	13	1586	54.73
April	10	1784	13	1306	36.60
Average	..	2151	..	1614	33.27

*International Units.

In the fall of 1944 and spring of 1945 oat pastures increased the nutritive value of the milk as they did during the preceding season. The increases fluctuated from month to month depending on amount of rainfall, condition of native pastures and amount of oat pastures available.

Other feeds which caused an increase in the vitamin A content of milk were sweet potato roots and vines and clover. Only a few herds were fed sweet potato roots, but a marked increase in vitamin A content of milk followed such a practice. Clover pastures were used generally in the spring. Maximum vitamin A values in milk occurred while clover was at its height. The effect of clover pasture is shown in Table I in the high vitamin A content of milk and butter during the months of March through June. Individual samples from herds which had no clover pasture showed a vitamin A content during the spring as low as winter milk.

Vitamin A in creamery butter, the average of two samples, ranged from 6,886 to 22,505, with an average of 14,445 International Units per pound. The results of this study were included in a publication of the United States Department of Agriculture (3), along with those from other states cooperating in the study of the vitamin A potency of creamery butter. Weighted averages which take into consideration the amount of butter produced each month were calculated. A correction was made for vitamin A loss during the determination, so that the final weighted, corrected average vitamin A potency for Louisiana butter was 16,379 International Units per pound. Table III gives the vitamin A potency of creamery butter produced in 14 states taking part in the cooperative survey.

TABLE III. VITAMIN A POTENCY OF CREAMERY BUTTER PRODUCED DURING THE WINTER AND SUMMER MONTHS IN FOURTEEN STATES*

Region and Participating State	*Average Vitamin A Potency in I.U.† per Pound*		
	Winter Butter	*Summer Butter*	*Annual*
NORTH CENTRAL:			
Minnesota	10,808	17,946	14,855
Wisconsin	10,663	18,884	16,039
Ohio	9,698	15,459	13,650
Iowa	10,946	17,434	15,010
Nebraska	11,287	20,667	17,030
Kansas	11,606	15,030	13,768
Average	10,863	17,810	15,150
SOUTH ATLANTIC AND SOUTH CENTRAL:			
North Carolina	9,674	16,253	14,312
Louisiana	12,283	18,068	16,379
Mississippi	12,014	17,868	16,533
Average	11,301	17,471	15,903
ROCKY MOUNTAIN AND PACIFIC COAST:			
Washington	12,162	19,827	18,467
Oregon	12,899	18,464	16,535
California	15,140	18,968	18,241
Idaho	13,312	18,197	16,384
Montana	18,637	22,018	21,014
Average	13,931	19,170	17,754
GRAND AVERAGE	11,160	17,955	15,529

**Vitamin A in Butter*. 1945. Misc. Pub. No. 571, U.S.D.A.

†International Units.

From the work in this laboratory and studies carried on in other states, it has been proved that the vitamin A potency of milk and butter is a reflection of the amount of carotene in the cows' feed. The use of oat and rye pastures in the winter and clover in the spring is a practice which assures cows of an ample supply of the precursor of vitamin A at a time when green vegetation is scarce. Conditions other than the quantity of carotene in the ration which affect the efficiency of its utilization by the cow have not been investigated thoroughly. It is known that any condition which increases the lushness of pastures or the carotene content of silages and hays will increase the vitamin A potency of milk and butter.

The carotene content of hays varies greatly depending upon the method of curing. Alfalfa or timothy hay which is green in color has retained carotene. Silage properly made and stored contains a large portion of the carotene which was in the crop at the time it was harvested and ensiled. As carotene content decreases with maturity or loss of green color, it is important that harvesting of forages take place soon after optimum yield has been reached.

From results reported by 14 agricultural experiment stations (3), the average vitamin A potency was calculated to be 1,140 International Units per quart for winter milk and 1,800 for summer milk. Approximately 40 per cent of the milk consumed as milk or milk products is winter milk and 60 per cent is summer milk. From this, the average vitamin A potency of the milk consumed annually is 1,530 International Units per quart. In 1941 the average domestic consumption of milk in all forms was 1.052 quarts per capita per day. This amount of milk furnished 1,600 International Units of vitamin A per capita per day, or one-third of the recommended 5,000 International Units allowed for a normal adult. If, by proper feeding practices, the vitamin A potency of all milk were increased to that of summer milk, the dairy industry would contribute about 40 per cent of the national need for vitamin A.

In several instances it was found that the use of oat or rye pastures, in addition to improving the quality of milk from a nutritional standpoint, caused increased milk production. One cooperator reported a 20 per cent increase, and another a 25 per cent increase in the amount of milk produced. In these cases, the use of oat pastures benefited the dairyman not only from the standpoint of health but financially.

It is to the advantage of the farmer to use adequate, green pastures when possible and conserve the carotene in hays and other roughages at least to the extent that the cows and calves are normal and healthy. Although milk of high quality in regards to vitamin A content receives no recognition economically at the present time, the producer of such milk has the satisfaction of making a contribution to the health of his family and that of the nation as a whole.

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