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THE VITAMIN A POTENCY OF CREAMERY BUTTER PRODUCED IN MISSISSIPPI

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The Food and Nutrition Board of the National Research Council, in making wartime food recommendations, recognized that a seasonal variation in the vitamin A potency of milk and butter existed. While previous studies have disclosed many fundamental facts regarding the vitamin A content of butterfat, the actual variation of this substance in the butter offered the consuming public in the various sections of the United States at different seasons of the year was not known. A nation-wide study to learn these facts was recommended by the Bureau of Dairy Industry and the Office of Experiment Stations. To date the Experiment Stations of 19 states have participated in this project. The Mississippi Station began its first studies in March 1943.

An appraisal of the actual contribution which dairy products make to the national requirements was suggested by Palmer and Jenness, who estimated that the total vitamin A potency in the milk and milk products consumed in the United States is adequate to supply the vitamin A needs of 42,000,000 people. If by conserving the carotene in hays and silages and developing winter grazing, the vitamin A potency of winter milk could be increased to that of average summer milk, the vitamin A requirements of 11,000,000 more people could be satisfied. This would mean that 40 percent of the total units now considered essential in the human diet would be contributed by the dairy industry.

Since the vitamin A potency of milk depends upon the carotene content of the feeds consumed by the cow, conditions which are conducive to fresh growing pasture grasses, properly cured hay, and preserved silage, will enhance the vitamin value of the milk and at the same time stimulate production. Unquestionably, a higher vitamin A potency of milk and butter can be secured immediately and economically through better pasture management and the proper care of cured roughages.

Methods

Samples of butter were secured from three creameries located within a radius of 25 miles. These plants make about 60 percent of the butter manufactured in Mississippi. The samples selected by these plants represented butter of three general types, namely: that made from cream separated on the farm and delivered sweet to the creamery, designated as A; that from cream separated on the farm and held in most instances until sour before delivery to the plant, designated as B; and that from sweet cream secured by separating sweet milk at the plant, designated as C.

Much of the cream delivered to creamery A averaged 0.18 to 0.25 percent acidity. This cream was heated to 160° F. by a steam jet and agitated in a coil pasteurizer for 30 minutes at 155° F. before cooling to churning temperature. The bulk of this cream was churned within 1 or 2 hours after pasteurization.

The butter used in this project from creamery B was made from sour cream ranging in acidity from 0.5 to 1 percent, much of which originated with smaller shippers and cream stations scattered throughout the State. This was neutralized with sodium carbonate and sodium bicarbonate to approximately 0.25 percent acidity, forewarmed to 90° F. and flash pasteurized at 210° F. in a high temperature vacuum-type unit. As the hot cream sprayed into the vacuum compartment the temperature dropped to 140° F. This cream was immediately cooled to churning temperature over a surface cooler, held from 1 to 2 hours, and churned.

The cream used by creamery C was secured by separating fresh milk delivered to the plant. This cream had a very low acidity of 0.10 percent to 0.12 percent and was heated to 155° F. in a coil vat, pasteurized and held for 30 minutes before being cooled to churning temperature in the vat.

One pound samples of butter were secured from these creameries the first of each month. Analyses for carotene, vitamin A, and composition, (moisture, salt, curd, and butterfat) were made immediately. The butter was held in a 45° to 50° F. refrigerator to simulate storage conditions in the retail store and home refrigerator. At the end of 15 days and 30 days storage the same analyses were made. Since much of the butter produced in April, May, and June goes into cold storage, additional one-pound samples were stored at 0° F. for 5 months. This butter was then placed in a 45° F. storage, analyzed immediately and after storage for 15 days and after 30 days, to learn what effect, if any, storage and marketing routine might have on the vitamin A content.

Analytical Methods

The antimony trichloride method of determining vitamin A was used, the procedure being that of Koehn and Sherman.[1] Crystalline vitamin A alcohol (Distillation Products, Inc., 755 Ridge Road West, Rochester, New York) was used for vitamin A, Standard.

EXPERIMENTAL

Effect of Season

Approximately twice as much butter was made during the months of May, June, July, and August as in December, January, February, and March. This is shown in table 1 which lists the percentage of years' production of creamery butter manufactured each month during the year period from 1940 to 1944.

A statistical study of the analyses showed that there was no significant change in carotene and vitamin A content of the butter during the 15- and 30-day holding periods. All analyses of the nine samples of butter examined each month were therefore averaged in establishing the seasonal trend. The monthly variation in International Units of vitamin A per pound of butter throughout the year is shown in table 2 and graphically presented in figure 1.

A high level of vitamin A potency continued through July, August, September, and October 1943 and was resumed during April, May, and June of 1944. During these months the samples of butter averaged 18,230 International Units per pound. Since these values are probably representative of the entire State's make, approximately 70 percent of the annual butter production would be expected to contain a relatively high vitamin A potency.

The lack of feed of high carotene content such as properly preserved silage, high grade hay, fall and winter cover crops, is reflected in the lower levels reached during November, December, January, February, and March. During these months the total vitamin A potency averaged slightly over 12,000 International Units, the lowest level of 10,128 Units being reached in February.

With the appearance of pasture grasses and clovers some increase in vitamin A content is shown on March 1st, however, the effect of a plentiful supply of green feed is shown by the increase to 18,860 International Units on April 1st.

The carotene content of the butter reached both higher and lower levels than the vitamin A, ranging from 1.55 in March to 7.86 micrograms per gram of butter in August. The vitamin A content remained between the rather narrow limits of 4.42 on February 1st and 7.5 micrograms per gram of butter on

[1] Koehn, C. J. and Sherman, W. C. The Determination of Vitamin A and Carotene with a Photoelectric Colorimeter. Jour. Biol. Chem., 132: 527-538. 1940.

Table 1. Mississippi butter production, 1940-1944, percentage by month.

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5.13	5.14	6.08	8.38	11.81	11.05	11.43	11.25	9.22	8.09	6.79	5.63

Table 2. Monthly average carotene, vitamin A and total vitamin A potency per pound of butter from three Mississippi creameries.

Production period	Carotene mcg./gm.	Vitamin A mcg./gm.	Vitamin A potency per pound, International Units
July 1943	7.70	6.15	17,812.4
August	7.86	6.35	18,325.0
September	7.35	6.34	17,921.6
October	5.92	6.40	16,955.2
November	5.33	5.24	14,252.1
December	3.49	5.08	12,546.6
January 1944	3.09	5.00	12,088.4
February	2.00	4.42	10,128.8
March	1.55	5.33	11,557.8
April	5.60	7.50	18,860.6
May	7.76	6.90	19,323.3
June	7.40	6.57	18,407.0

Table 3. Effect of one month's storage at 45° F. on the carotene and vitamin A content of butter.

Month	Carotene content after			Vitamin A content after		
	0 days mcg./gm.	15 days mcg./gm.	30 days mcg./gm.	0 days mcg./gm.	15 days mcg./gm.	30 days mcg./gm.
July	7.3	8.1	7.7	6.3	5.8	6.3
August	7.6	7.9	8.1	6.6	6.4	6.0
September	8.2	7.5	6.3	5.9	6.2	6.8
October	6.3	5.1	6.4	6.6	6.1	6.4
November	5.7	5.7	4.7	5.4	5.2	5.2
December	3.8	3.2	3.5	5.2	4.8	5.1
January	3.7	2.7	2.8	5.3	4.8	4.6
February	2.7	1.8	1.8	4.5	3.2	4.5
March	1.6	2.0	1.0	5.2	5.6	5.2
April	5.0	5.8	6.0	7.2	7.5	7.6
May	7.3	8.2	7.8	7.1	7.1	6.4
June	7.5	7.6	7.2	6.6	6.7	6.3
Average	5.56	5.47	5.28	6.0	5.78	5.87

April 1st. The vitamin A recovered from its downward trend March 1st, one month earlier than the carotene. However the carotene increased from 1.55 on March 1st to 5.6 on April 1st, which was the greatest spread between any two months of either material. During the months of low carotene intake, namely November, December, January, February, and March, approximately 20 percent of the total vitamin A potency was furnished by carotene, while during the remainder of the year 30 percent was supplied by carotene.

Effect of Short Storage

The values in table 3 are based on the average carotene and vitamin A content of the butter from the three creameries for the first, fifteenth, and thirtieth of each month. This butter was held in a 45° to 50° F. refrigerator in quarter-pound prints, and storage corresponded to retail store and home refrigerator conditions. The data presented indicate that both carotene and vitamin A were very stable.

Statistically, the variation in carotene and vitamin A due to 15- and 30-day

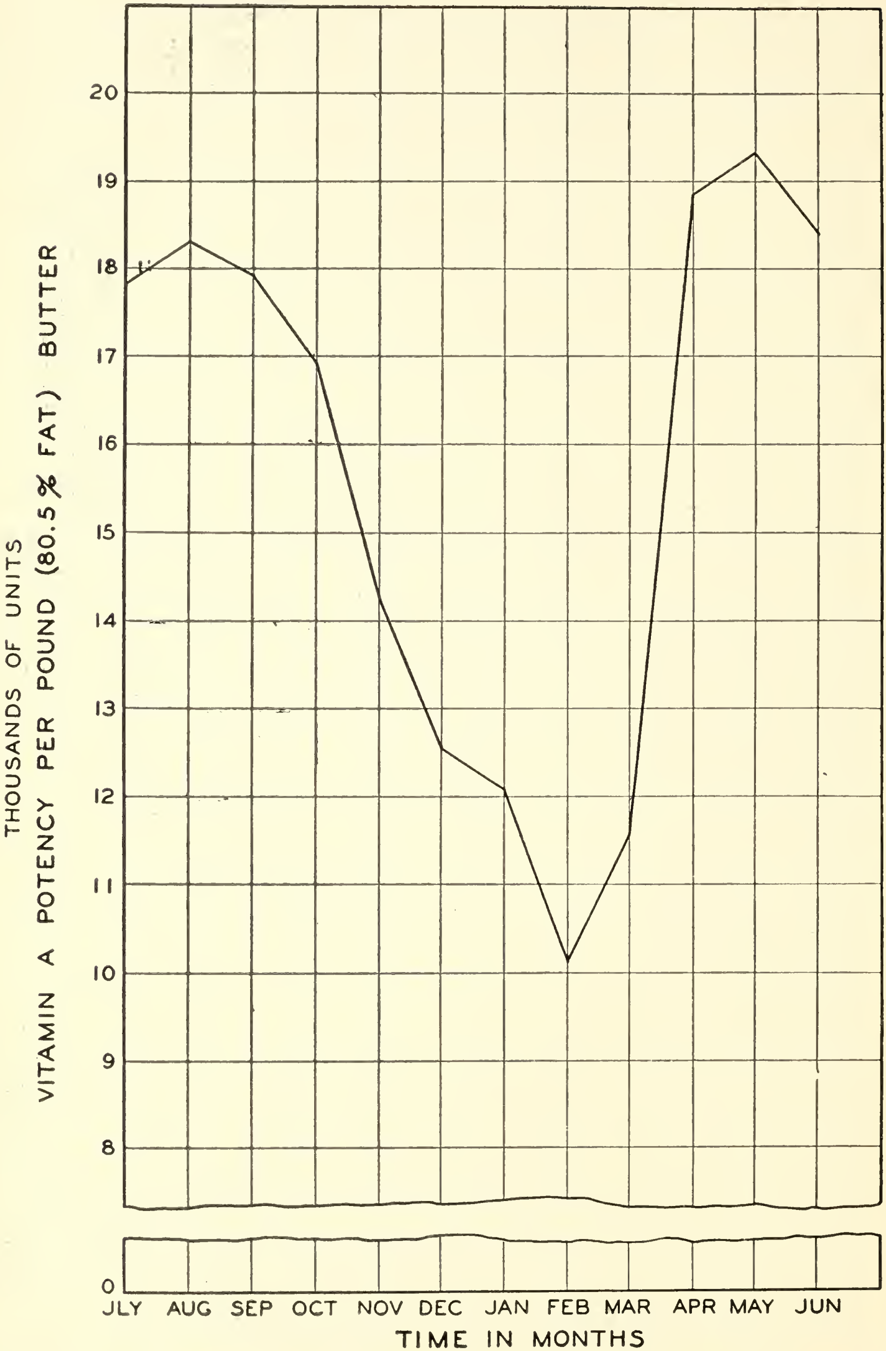

Figure 1. Seasonal variation of total vitamin A potency of the butter from three Mississippi creameries.

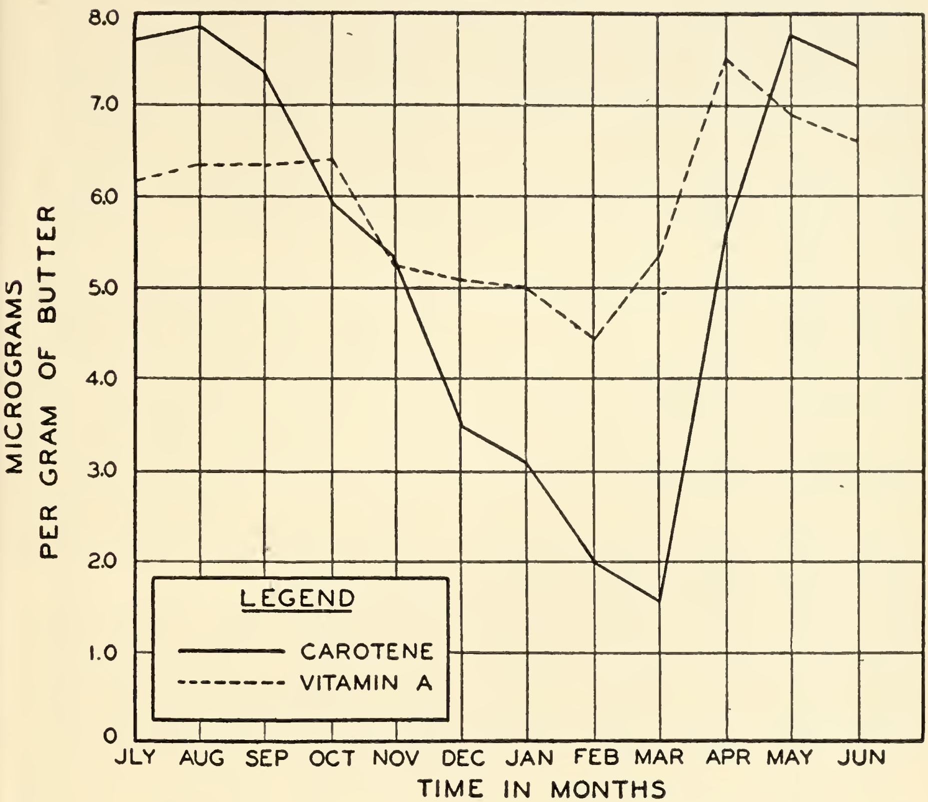

Figure 2. Seasonal variation of carotene and vitamin A in butter from three Mississippi creameries.

storage was not significant. F values for the 15- and 30-day storage periods were 1.00 for vitamin A and 0.51 for carotene. To be statistically significant at odds of 20 to 1, the F value for either carotene or vitamin A would need to exceed 3.11. On numerous sequences the 15- or 30-day storage samples were higher in carotene or vitamin A than fresh butter. These disturbing results have been reported by other Stations and at this time are not explainable.

No trends were established which indicated any deterioration in the vitamin potency due to holding for one month at 45° to 50° F.

Effect of Long Storage

Much butter goes into cold storage during the season of greatest production. This butter is generally held at 0° to -10° F. for 3 to 6 months and is then brought out during seasonal shortage, whereupon it follows the ordinary marketing channels at relatively high temperatures. Additional samples of butter were secured during April, May, and June from the same churnings used in the original tests. These samples were held in a 0° to -10° F. storage room for 5 months, then removed and placed in a 45° F. refrigerator. This butter was analyzed on the 1st, 15th, and 30th day after removal from the low

Table 4. Effect of 5 month's storage at 0° to -10° F. on carotene and vitamin A content.

Month	Carotene after No months ug./gm.	Carotene after 5 months ug./gm.	Vitamin A after No months ug./gm.	Vitamin A after 5 months ug./gm.
April	5.0	5.8	7.26	7.34
May	7.3	8.8	7.15	7.00
June	7.5	7.6	6.62	6.75
Average	6.6	7.4	7.01	7.03

temperature room, and the data are presented in table 4.

From the data obtained, no trend indicating that the carotene or vitamin A decreased due to storage at 0° F. or during the succeeding 30-day holding period at 45° F. was established.

The average values secured for the carotene and vitamin A after 5 months storage were actually higher than the original samples. While there were a few tests which might be questioned, most determinations were within the range of experimental error and indicate that the carotene and vitamin A were not adversely affected by 5 months storage at 0° F.

Effect of Holding Cream

Of interest was the somewhat lower potency of the butter from creamery B, the source of the sour cream butter. Although the three creameries in the study were located in the same immediate territory, a study of the data showed a significantly lower carotene and vitamin A content in the butter from this one plant.

While the higher acidity in the cream used in making the samples of butter secured from creamery B might be expected to minimize any reduction in vitamin A potency, a series of tests was conducted to learn if holding cream at fairly high temperatures with accompanying high acid, yeast and mold development, and partial neutralization, might have some influence.

Five tests were completed wherein fresh cream was collected directly from the separator, divided into five lots, and made into butter after different holding periods. Lot 1 was churned immediately without pasteurizing. Lot 2 was pasteurized at 155° F. for 30 minutes, cooled and churned. The remaining lots were held at room temperatures, neutralized, pasteurized and churned at 3-day intervals.

Some of the samples held at 80° to 90° F. developed a very high acidity (1 percent to 1.9 percent) and a yeasty moldy condition. Although the butter was not held for a prolonged storage period, much of the butter made from sour cream partially neutralized was actually in storage for several weeks before being analyzed. An examination of table 6 shows that while there was the same fluctuation in the carotene and vitamin A content experienced in some of the other tests, no significant reduction in vitamin A potency was recorded in the sour cream butter. Since feed and pasture conditions are quite similar in the territory immediately surrounding these plants, the fact that creamery B received cream from direct shippers and cream stations located in various parts of the State possibly not so favored with satisfactory pasture, offers the most logical explanation. The most noticeable spread between the three butters, occurs in the fall and winter months, when many small dairymen make little effort to supply a high quality roughage for their cows.

Table 5. Comparison of carotene, vitamin A and total vitamin A potency of butter from three creameries.

Production period	Carotene mcg./gm.			Vitamin A mcg./gm.			Total vitamin A potency per pound, International Units		
	Creamery			Creamery			Creamery		
	A	B	C	A	B	C	A	B	C
July 1, 1943	7.3	7.1	7.5	5.9	6.6	6.4	17143	18341	18230
August 1	7.7	7.1	8.0	6.4	6.9	6.6	18303	18878	18873
September 1	7.8	7.7	9.2	5.9	5.8	6.2	17484	17079	18981
October 1	7.0	5.2	6.6	6.6	6.6	6.6	18100	16831	17913
November 1	6.1	5.2	5.7	5.8	5.1	5.4	15922	13952	14845
December 1	3.8	3.5	4.0	5.5	4.9	5.3	13549	12311	13388
January 1, 1944	3.7	2.6	4.9	5.2	5.0	5.7	12970	11676	14780
February 1	3.1	2.0	2.0	4.9	4.0	4.6	11887	9292	10569
March 1	2.4	1.2	1.2	6.8	3.7	5.3	14638	8229	11178
April 1	6.0	4.2	4.8	7.3	7.2	7.2	18820	17259	17753
May 1	7.9	6.5	7.4	7.4	6.9	7.1	20393	18434	19528
June 1	7.3	7.5	7.6	6.5	6.5	6.8	18165	18429	19137

Table 6. Effect of holding cream on carotene and vitamin A content of butter.

Production period	Initial acidity	Acidity after neut.	Condition of cream	Temp. held	Condition of pasture	Age of cream	Carotene mcg./gm.	Vitamin A mcg./gm.
Test 1								
8/8	.11	—	Sweet	80-85°	Green	Fresh	8.85	7.52
8/8	.11	—	Sweet	80-85°	Green	Fresh	10.36	7.78
8/11	.93	.25	Sour, yeasty, moldy	80-85°	Green	3 days	11.39	7.66
8/14	1.40	.21	Sour, yeasty, moldy	80-85°	Green	6 days	7.61	7.62
8/17	1.90	.22	Sour, yeasty, moldy	80-85°	Green	9 days	8.70	7.44
Test 2								
8/25	.10	—	Sweet	80-85°	Green	Fresh	8.90	7.66
8/25	.10	—	Sweet	80-85°	Green	Fresh	9.20	7.72
8/28	.90	.25	Sour, yeasty, moldy	80-85°	Green	3 days	10.35	7.37
8/31	1.20	.30	Sour, yeasty, moldy	80-85°	Green	6 days	9.36	8.37
9/4	1.90	.35	Sour, yeasty, moldy	80-85°	Green	9 days	9.05	7.89
Test 3								
10/13	.10	—	Sweet	60-70°	Dry	Fresh	6.38	5.99
10/13	.10	—	Sweet	60-70°	Dry	Fresh	6.80	6.16
10/16	.70	.30	Sour, yeasty, moldy	60-70°	Dry	3 days	6.52	5.97
10/19	.80	.31	Sour, yeasty, moldy	60-70°	Dry	6 days	6.82	6.22
10/22	.85	.25	Sour, yeasty, moldy	60-70°	Dry	9 days	6.59	6.12
Test 4								
11/14	.10	—	Sweet	55-65°	Dry	Fresh	2.80	3.69
11/14	.10	—	Sweet	55-65°	Dry	Fresh	2.61	3.50
11/17	.65	.25	Sour, yeasty, moldy	55-65°	Dry	3 days	2.59	3.68
11/21	.85	.20	Sour, yeasty, moldy	55-65°	Dry	6 days	2.76	3.68
11/24	.95	.25	Sour, yeasty, moldy	55-65°	Dry	9 days	3.09	3.49
Test 5								
Unpasteurized cream								
12/20	.08	—	Sweet	45-60°	Dry	Fresh	3.65	6.13
12/23	.30	—	Sour	45-60°	Dry	3 days	3.46	6.12
12/27	.75	—	Sour	45-60°	Dry	6 days	3.69	6.24
12/30	.79	—	Sour	45-60°	Dry	9 days	3.60	6.36

The Effect of High Temperature Pasteurization on Vitamin A Potency

A high temperature vacuum type pasteurizer was used by creamery B in processing the cream for butter making. Ordinarily the cream was neutralized with sodium carbonate and sodium bicarbonate to between 0.2 percent and 0.3 percent acidity in a forewarmer. It was

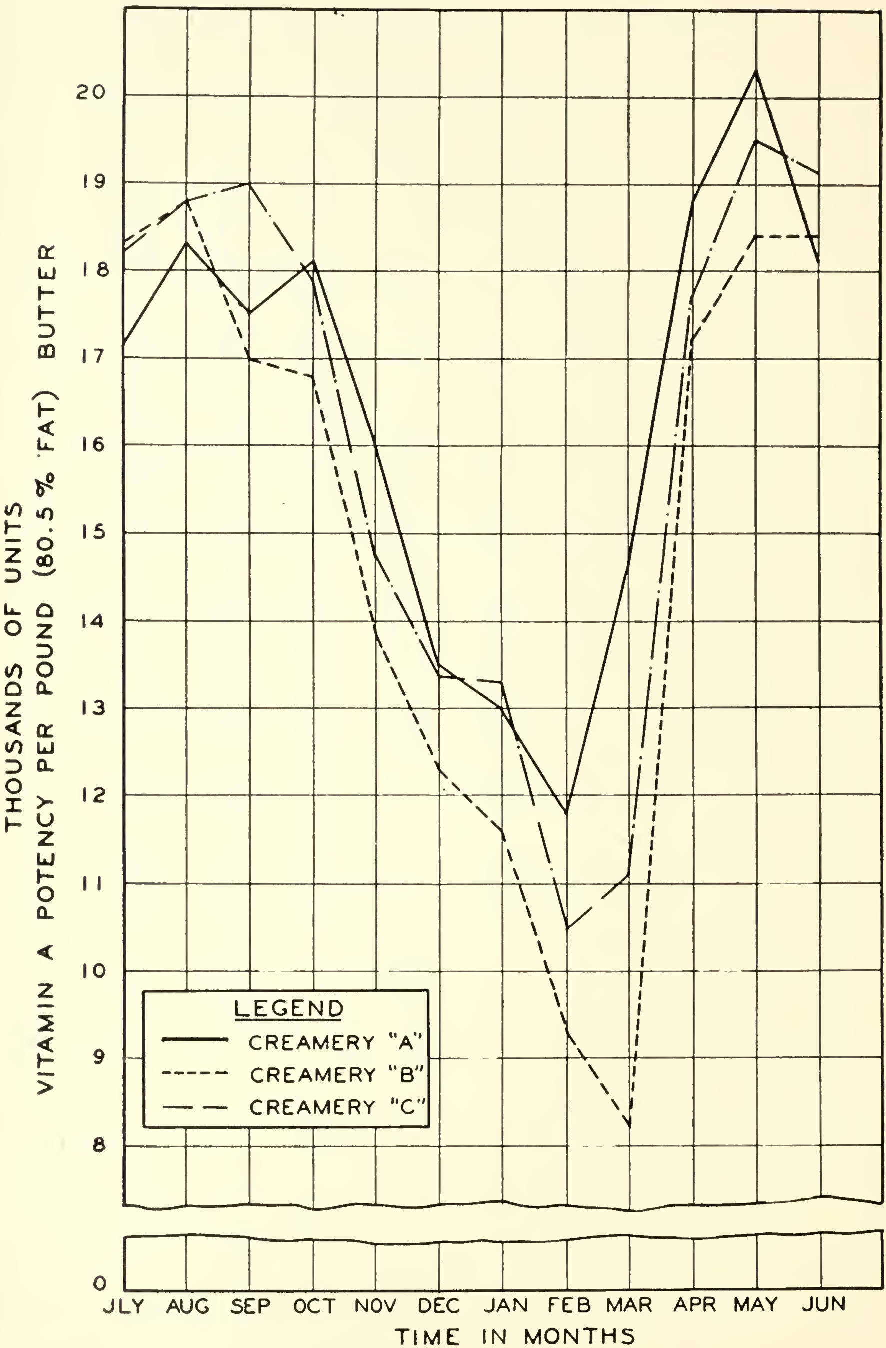

Figure 3. Seasonal vitamin A potency of butter from three Mississippi creameries.

then heated to 90° F. before entering the pasteurizer. The cream was subjected to a steam jet which heated it to 200° to 215° F, then quickly sprayed into a vacuum pan where the temperature dropped to approximately 140° F. This cream then passed over a surface cooler and was cooled to churning temperature. Four check tests were made to learn if this particular process had any effect upon the vitamin A potency of the resulting butter. Samples of the raw cream were taken from the forewarmer before treatment and again off the cooler after being completely processed. The samples of cream were churned and the butter analyzed. The results of this brief study recorded in table 7 indicate that this method of processing had no effect upon the carotene or vitamin A content of the butter studied.

Table 7. Effect of high temperature pasteurization on the vitamin A potency of butter.

Production Period	Sample number	Raw Carotene mcg./gm.	Pasteurized Carotene mcg./gm.	Raw Vitamin A mcg./gm.	Pasteurized Vitamin A mg./gm.
April 16, 1945	1	9.76	10.12	8.28	8.71
	2	10.78	10.67	8.68	8.52
May 1, 1945	3	9.41	10.33	6.91	6.79
	4	10.86	10.42	7.38	7.43
Average		10.20	10.38	7.81	7.83

Summary

1. The butter analysed in this study contained approximately 18,000 International Units of vitamin A per pound from April to October inclusive. The butter examined from November through March contained an average of approximately 12,000 International Units per pound.

The similarity of the vitamin A content of butter produced in Mississippi to the national average as determined from results secured by the 19 participating states is most striking. The U. S. Department of Agriculture Miscellaneous Publication No. 571, "Vitamin A in Butter," records that the summer butter averaged 18,000 International Units of vitamin A per pound while winter butter contained approximately 11,200 units per pound.

2. Approximately seventy percent of the butter made in Mississippi is produced during the months of high vitamin A potency.

3. Holding the butter at 45° F. for one month did not lower the carotene or vitamin A content.

4. Holding the butter at 0° F. for 5 months followed by 30 days storage at 45° F. did not lower the carotene or vitamin A content.

5. The development of varying acidities in cream and subsequent neutralization before pasteurization did not lower the carotene or vitamin A content.

6. The use of high temperature vacuum type of pasteurization did not affect the carotene or vitamin A content.

7. The carotene content of the butter examined showed a much greater seasonal variation than the vitamin A content.

Discussion

The contribution of vitamin A through the medium of dairy products is of major nutritional importance to the consuming public. Figure 1 shows that the lowest level of vitamin A potency of milk products occurs in the winter months when other foods comprising the human diet are also low in vitamin A. It would be most desirable if the vitamin A content of winter butterfat could be held at a higher level.

Koehn, of the Alabama Station found

that the milk from cows placed on a temporary pasture of Abruzzi Italian rye, crimson and white Dutch clover in February, increased in 2 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. An equal increase in vitamin A can be expected from the grazing of any other growing cover crop.

Oats, wheat and vetch, in particular, have become popular in many sections of Mississippi. The Dairy Department of Mississippi State College used a mixture of 1½ bushels oats, ½ bushel wheat, and 15 pounds vetch to the acre; more recently the amount of seed has been increased to 2 bushels oats, 1 bushel wheat, and 15 pounds vetch.

While, from the standpoint of the nutritionist, this increase in vitamin A in dairy products is of particular importance, the actual benefits of direct value to the dairyman extend far beyond the improvement in the quality of milk.

Financial Returns

Numerous tests run by the Mississippi Station have shown that grazing winter cover crops is profitable, and consequently cover crops grazing has been practiced by the Dairy Department for the past 20 years. In a specific test reported by J. S. Moore in the December 1943 Farm Research, 12 acres were disked and planted to oats and vetch in September. By November 10th there was a stand of oats averaging 8 to 15 inches in height. While the dairy herd was already on full winter ration, 52 cows and 18 heavy springers were turned on this field for 15 days. The yield of milk increased 16.3 precent the first week and 24.6 percent during the second week. The value of the increased production, together with silage saved and $31.50 credit for the physical improvement of the springers, were given a minimum estimate of $176.55 that could be attributed to the first 15 days grazing. Ordinarily one or two more grazing periods can be expected depending upon the season.

Feed

Moore reports another test wherein 80 to 90 acres were planted to a mixture of oats, wheat and vetch. By the end of December sufficient grazing had been obtained from these crops to pay all costs of seed, preparation of land, and planting. One field was not grazed after January 1st. The seed was allowed to ripen and the crop was harvested for feed, yielding 1,678 pounds of grain and 2,425 pounds of straw per acre. To secure this same feed value from corn as a grain crop would require a yield of about 30 bushels of corn per acre. The winter grazing crop was grown when the land would otherwise have been idle, required no work after planting, and furnished a good cover crop which protected the soil from erosion during the winter months. A yield of 1¼ tons of hay per acre was secured after fall and early spring grazing. This crop was removed early enough to plant corn. Where the grain was allowed to mature it was followed with sorghum for silage, sagrain for grain or silage, and soybeans for hay.

Green Manure

In the above test a portion of the crop was disked in for soil building. This was done on March 24th, after taking the cows off on March 15th, and amounted to about 5,645 pounds of green manure to the acre. Some of the phosphorus and potash of the soil was probably conserved and changed to a more easily assimilated form, and it was estimated 16½ additional pounds of nitrogen were added to the soil together with organic matter. This organic matter improves the physical condition of the soil, permits greater infiltration of rainfall, and prevents or greatly diminishes soil loss due to water erosion at the most critical period of the year.

Erosion

Russell Woodburn reports that tests at the Mississippi Station show an average loss of 83 tons of soil per acre on a bare plot on a 9 percent slope over a 3-year period. A maximum loss of 141 tons per acre or almost one inch of soil occurred in 1944 due to the severe rainfall. A cotton plot nearby on a slope of 10 percent. with winter vetch cover, lost 25 tons per acre in 1944. This loss was almost entirely during the cotton season from April 1 to October 1. Of further interest is the fact that turning under vetch on other experimental plots permitted ten times more soil loss during the 1944 cotton season than disking in. While the plot having the disked vetch lost 2.3 tons of soil per acre from April to October, the bare plot lost 83 tons during the same period.

Physical Condition of the Cow

Kuhlman, of the Oklahoma Station, states that many dairy cattle in the South receive rations so low in carotene that normal functional performance cannot be attained. This is due to the feeding of large quantities of low grade hay, cottonseed hulls, and lack of good silage. The Oklahoma Station states that 40 to 45 micrograms of carotene per pound body weight is about the minimum amount which will meet the daily requirements of cows of the Jersey breed, permit normal calving and the initiation of a normal lactation period. When the carotene intake fell below this point during the last 90 days before calving, many of the calves were either dead or very weak at birth, the cows developed symptoms of vitamin A deficiency, and some indication of a shortened gestation period was noted.

Acknowledgments

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