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IMPROVED PASTURES and GRAZING CROPS for INCREASED VITAMIN A CONTENT of MILK and BUTTER

High vitamin A content of milk and butter, so important in the human diet, can be maintained throughout the year by green grazing crops for dairy cows

AGRICULTURAL EXPERIMENT STATION
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M. J. FUNCHESS, Director AUBURN, ALABAMA

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IMPROVED PASTURES and GRAZING CROPS for INCREASED VITAMIN A CONTENT of MILK and BUTTER

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VITAMIN A is required by all animals. It is necessary for growth, for normal vision, and for a healthy condition of all body tissues. It is required throughout life, but is needed in largest amounts by children and other young animals during the period of rapid growth. Animals that do not have enough vitamin A soon become unthrifty, and develop inflammation of the eyes, skin, middle-ear, and respiratory tract. Such animals show a lowered resistance to colds and other infections. Night blindness or "moon-blindness" is a common result of vitamin A deficiency in people as well as in farm animals.

Vitamin A is a fat-soluble vitamin. It occurs in such foods as liver, egg-yolk, butter, cream, whole milk, and fish liver oils. It is a colorless substance, but is closely related to carotene, an orange-yellow substance that is found in green plant materials, like turnip greens, collards, alfalfa, clover, green oats, and other leafy forage plants. It also occurs in yellow vegetables such as sweetpotatoes, carrots, and pumpkins. A similar substance occurs in yellow corn. Carotene is the primary source of vitamin A because animals, including the human, are able to manufacture vitamin A from carotene. The total vitamin A value of a diet or ration, therefore, depends upon its content of true vitamin A and carotene.

The dairy cow depends entirely upon the carotene in her ration for her supply of vitamin A. She converts a part of this carotene into vitamin A for body use and for secretion in the milk. A part of the carotene eaten by the dairy cow, however, is secreted unchanged in the milk. In the case of

the Jersey and Guernsey breeds especially, this unchanged carotene imparts a yellow color to the cream and butter and accounts for a significant portion of the total vitamin A value of these products.

Milk, butter, and other dairy products are an important source of vitamin A in the human diet. It is essential, therefore, that the vitamin A content of these products be kept as high as possible throughout the year. In 1939 a research program was started in the Nutrition Laboratory of the Alabama Agricultural Experiment Station to develop a practical method of doing this. The results of this research are reported in the following pages.

RESEARCH at AUBURN

Vitamin A Value of Milk Varies with Condition of Pasture

In 1939 very few farmers in Alabama were using winter grazing crops for their dairy cattle. Permanent pastures of some sort were available in summer, but these for the most part furnished very little grazing material from frost until April. During this period the cows were fed home-grown roughages with either cottonseed meal and home-grown grains or the usual commercial dairy feed. On a few farms sorghum silage was included in the ration. In some herds the cows were dependent almost entirely upon cottonseed meal and hulls in addition to what they could glean from the fields or the frosted permanent pastures.

Since the feeds available during the winter period were very low in carotene, it was logical to expect that the milk and butter produced by these cows would be low in vitamin A. In order to get an accurate measure, vitamin A and carotene determinations of the milk from a control herd were made over a period of one year (1939). The selected herd of purebred Jersey cows was fed according to commonly recommended feeding practices at that time. This experimental herd was kept on permanent pasture throughout the year, and was fed a grain mixture consisting of 1 part of corn, 1 of wheat bran, and 2 of cottonseed meal. During the winter

the cows were given peanut or alfalfa hay and a liberal allowance of sorghum silage. The pasture was better than average carpet grass, containing some lespedeza, hop clover, and white Dutch clover.

The average vitamin A value of the milk from these cows is shown for each month of the year in Figure 1. The height of the bars represents the sum total of the vitamin A and carotene content of the milk expressed in units[1] of vitamin A per quart of milk. This chart shows that there was a great seasonal variation in the vitamin A content of milk produced by cows on a good ration, but restricted to a permanent pasture the year round. The milk was highest in vitamin A in August with a content of 1,590 units per quart. The vitamin A content dropped rapidly in the fall when the pasture failed. It continued to drop after frost to a low level of less than 250 units per quart in February. When the pastures began to turn green in March, the vitamin A content of the milk rose steadily to the summer level.

The results of this experiment showed that milk produced on permanent pastures in Alabama was a good source of vitamin A during the summer months, when the human diet contains an abundance of other vitamin A-rich foods. It was a relatively poor source of this vitamin during the winter, when vitamin A-rich foods are relatively scarce in the human diet.

Temporary Winter Grazing Crops Boost Vitamin A Value of Milk

In order to determine the effect of temporary winter grazing crops on the vitamin A value of milk, a group of cows was transferred from the control herd on the permanent pasture area to a temporary pasture of Abruzzi rye, Italian rye grass, and crimson clover on February 1, 1940. The effect on the vitamin A value of the milk is shown in Figure 2. Within 2 weeks the vitamin A value of the milk had more

[1] In this publication, a unit of vitamin A is defined as a microgram of vitamin A or beta-carotene. This definition is based upon work at this Station, showing that vitamin A and beta-carotene have identical biological values. The separate carotene and vitamin values are given in the Appendix Tables. There are 1,000 micrograms in a milligram, 1,000 milligrams in a gram, and 453.6 grams in a pound.

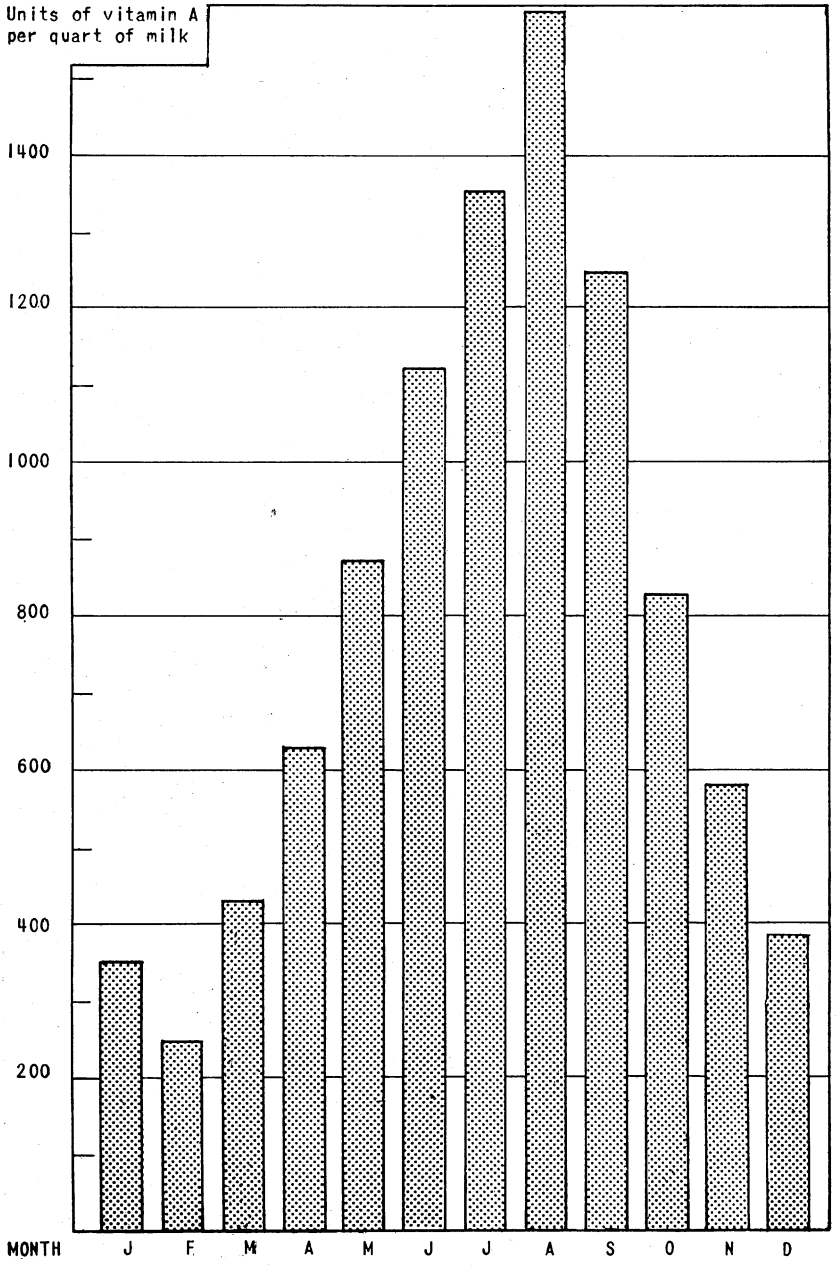


FIGURE 1. Vitamin A content of milk from the control herd on permanent pasture varied with the season. It was high in the summer when the pasture was good and low in fall and winter when the pasture was poor.

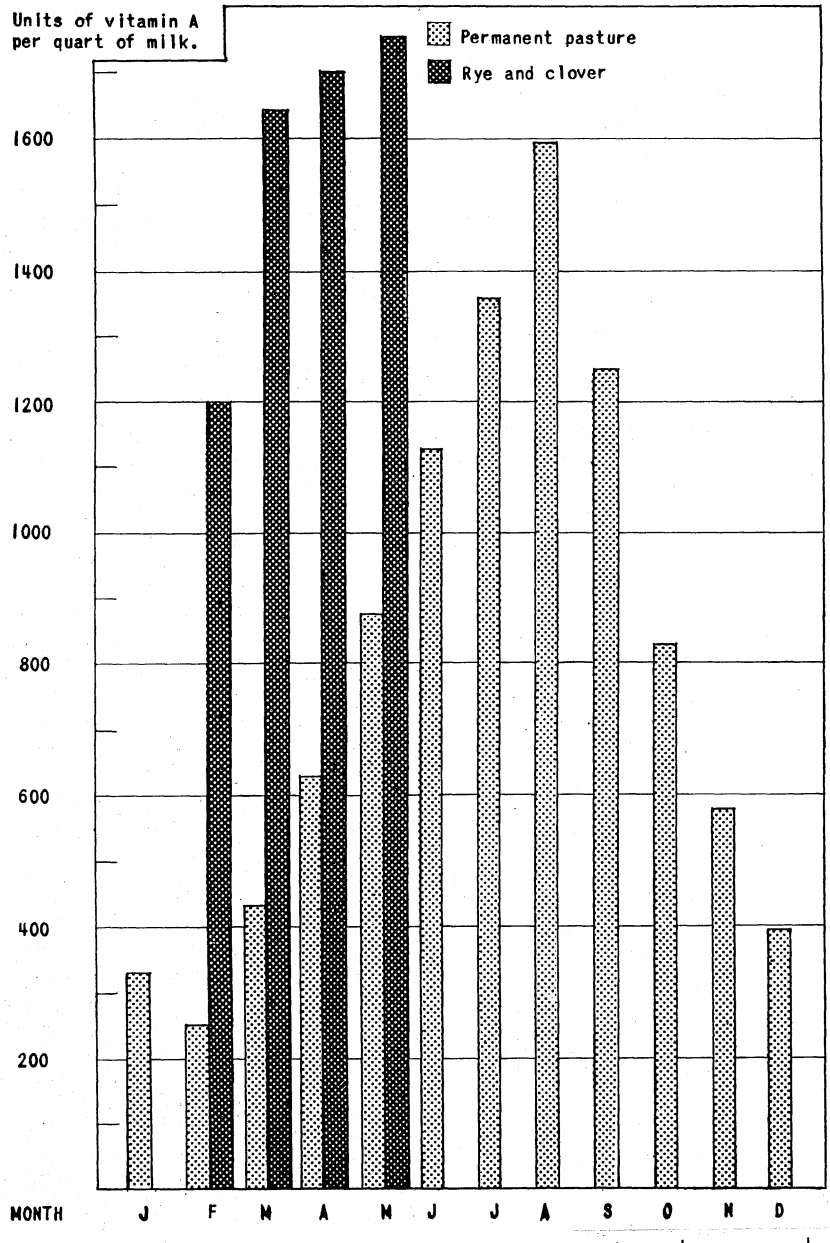


FIGURE 2. Turning some of the cows from the control herd onto crimson clover, rye, and rye grass during the late winter months increased the vitamin A content of the milk five-fold.

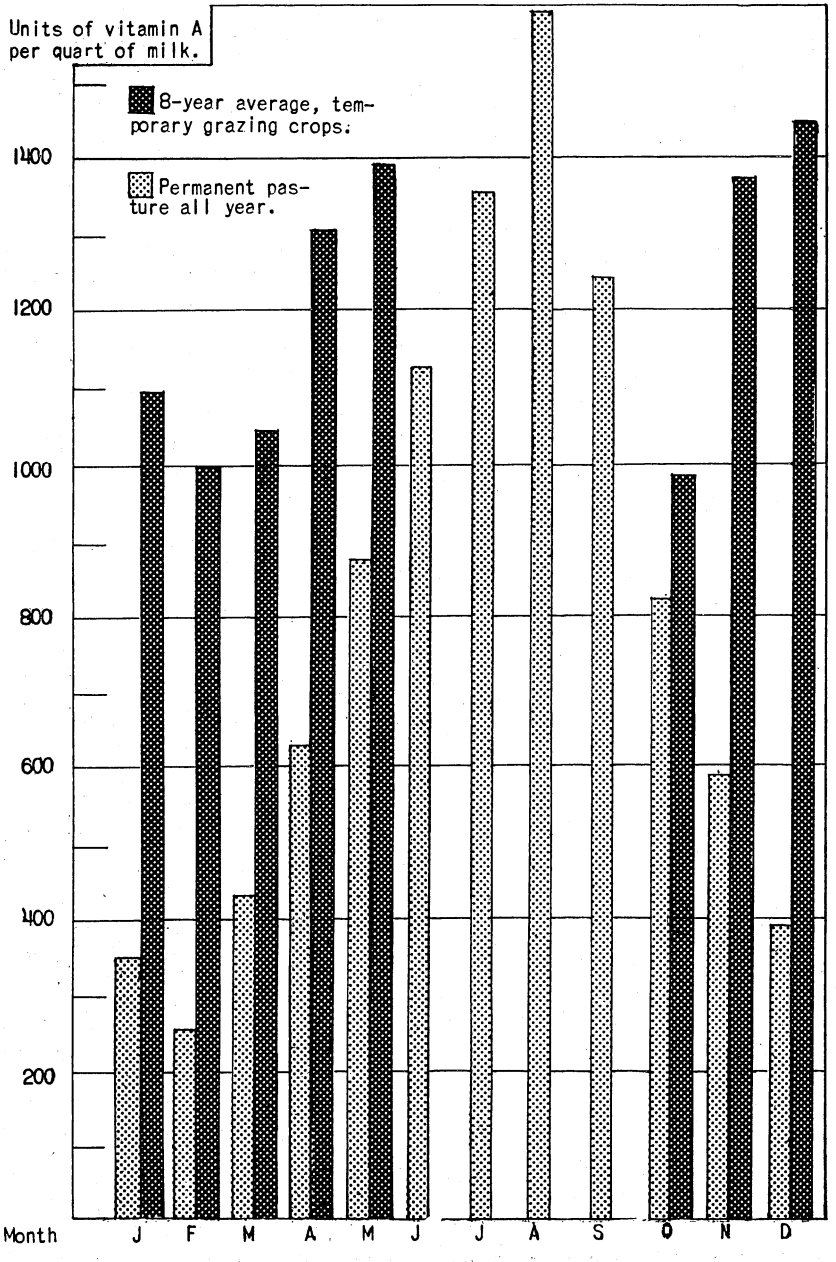


FIGURE 3. Over the 8-year period, 1939-47, cows grazed on oats and crimson clover or crimson clover and rye grass at the Agricultural Experiment Station, Auburn, Ala., produced winter milk that was rich in vitamin A.

than doubled. It continued to increase until it was higher than the value of summer milk produced by the control herd on permanent pasture and five times the value of the winter milk produced by the control herd.

It was apparent from these results that the only feasible way to maintain the vitamin A content of milk at high levels during the winter period was by the use of winter grazing crops. The experiment was extended to find what effects such crops have over a longer period. The crops used were oats and crimson clover or crimson clover and rye grass combined. Averages of the results by months over an 8-year period are shown in Figure 3. Milk produced on winter grazing crops was consistently 2 to 4 times as rich in vitamin A during the winter months as milk produced by the control herd.

Production of Vitamin A-Rich Winter Milk Practical for Small Farm Herds

The results thus far described were obtained from experimental groups of cows on the Agricultural Experiment Station at Auburn. The study was also extended to two small dairy farms near Auburn on which Experiment Station recommendations concerning the use of temporary grazing crops were reasonably well followed. Composite samples of the milk produced by each herd were analyzed monthly for vitamin A content. In Figure 4 is shown the vitamin A content of the milk produced by Herd 1, which grazed oats during the winter months, as compared with the vitamin A content of the milk from the control herd on permanent pasture. The high vitamin A content of the milk produced by Herd 1 during the winter months shows that the experimental results can be applied under practical conditions on Alabama farms.

The vitamin A content of the milk produced by Herd 2 in comparison with that produced by the control herd is shown in Figure 5. Herd 2 grazed oats and crimson clover from late October through April, permanent pasture of Bermuda grass and lespedeza from May through August, and kudzu during September and October. Again the vitamin A content

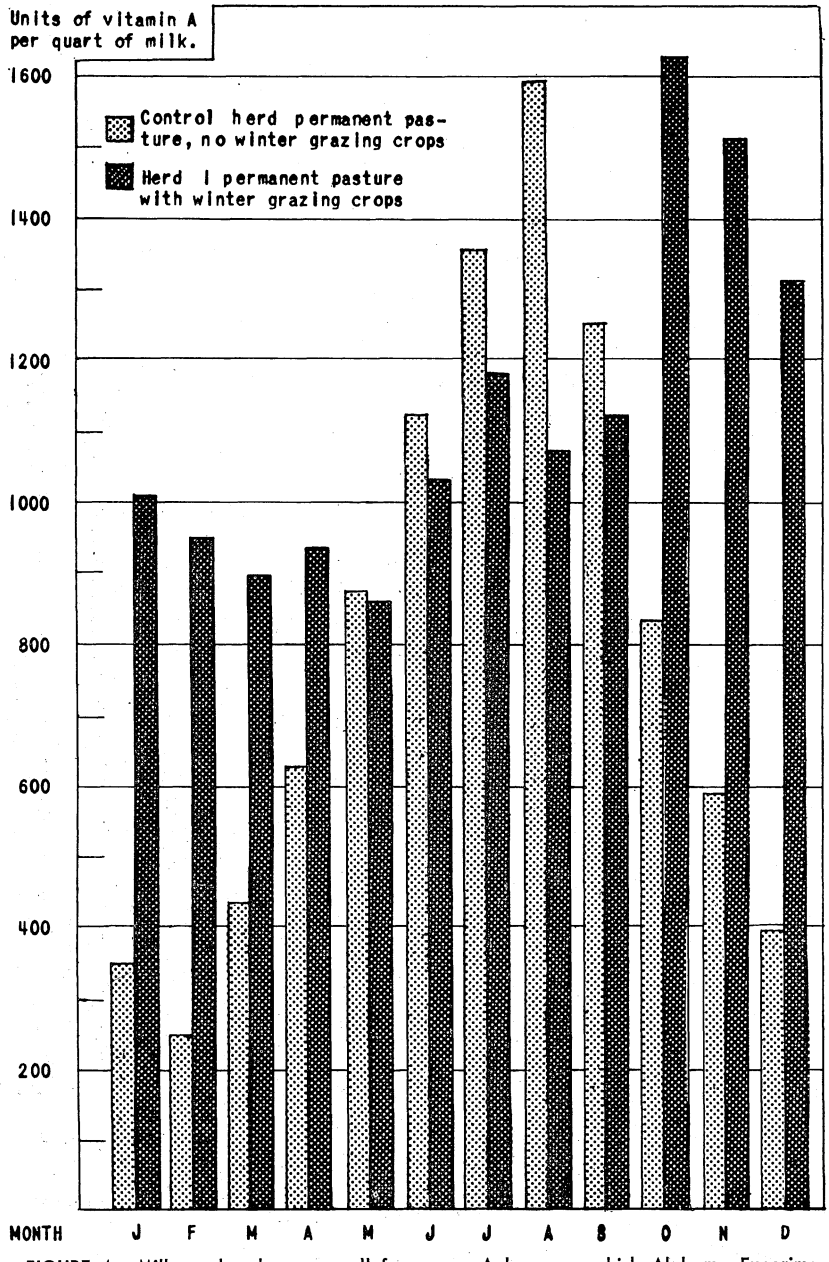


FIGURE 4. Milk produced on a small farm near Auburn, on which Alabama Experiment Station recommendations were followed in 1945, was three times as rich in vitamin A in the winter as milk from the control herd on permanent pasture without winter grazing crops. The summer pasture on this farm was not as good as the winter pasture.

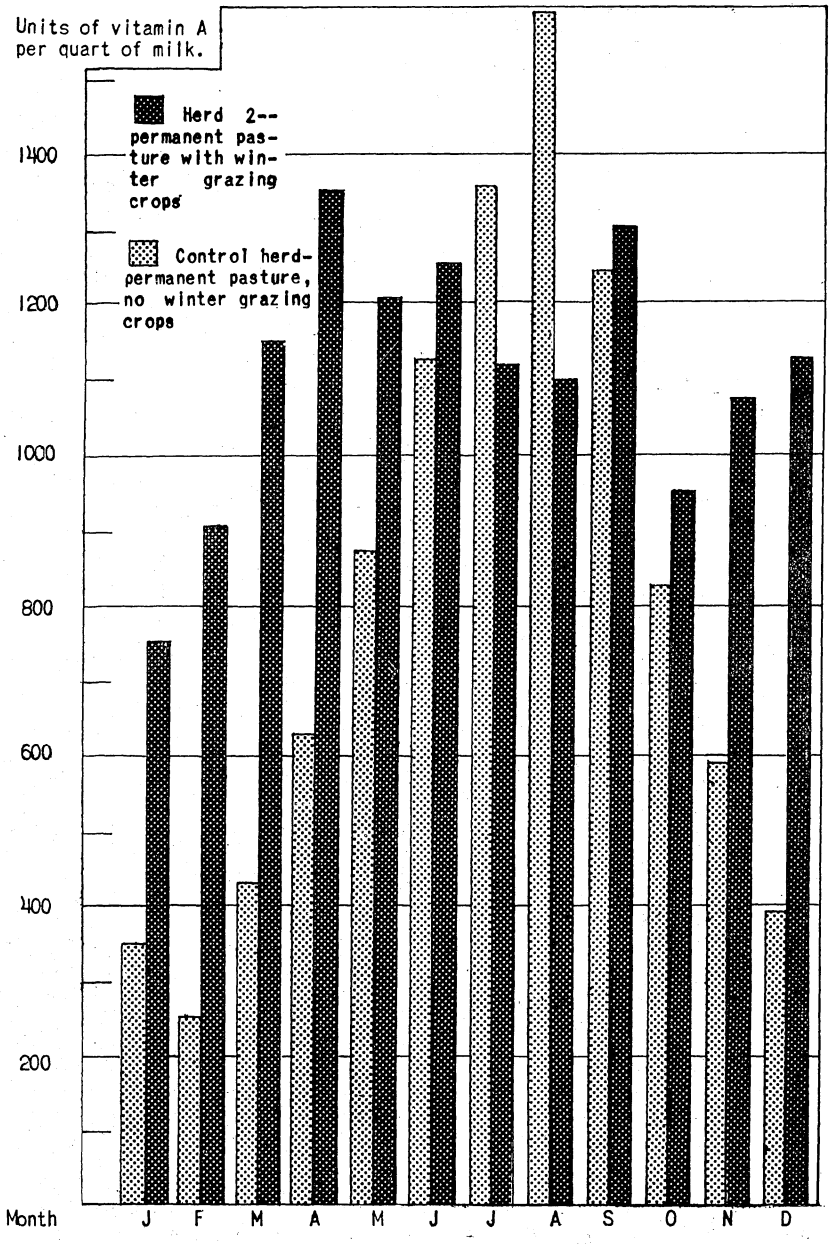


FIGURE 5. Cows on another small farm near Auburn, on which Alabama Experiment Station recommendations for winter pastures were followed in 1945 and 1946, produced milk much richer in vitamin A than that produced by the control herd on permanent pasture without winter grazing crops. Summer pasture on this farm was not very good.

of the milk was much higher during the winter than that of the control herd.

It was found on these farms that the use of temporary grazing crops not only increased the vitamin A content of the milk, but cut cost of production by reducing feed cost and increasing the milk flow. An increase in the acreage of winter grazing crops and some improvement in the timeliness of seeding on these farms should have given even greater responses.

Many Dairy Farms Need Pasture Improvement

That the practice of producing vitamin A-rich milk throughout the year by use of temporary grazing crops was as practical for large herds as it was for smaller ones was demonstated by results obtained from a commercial dairy herd owned by a creamery in Lee County. This herd was maintained on an improved permanent pasture of Dallis grass, lespedeza, and white Dutch clover, supplemented with temporary grazing crops in accordance with Alabama Experiment Station recommendations. The milk produced by this herd was rich in vitamin A, as shown in Figure 6. This milk was taken to the creamery and mixed with a large volume of milk from other local dairy herds. The striking difference between the vitamin A content of the milk produced on the creamery farm and that of the final creamery product after mixing with other locally produced milk is also shown in Figure 6. The fact that diluting the creamery farm milk with other milk produced in the same area lowered the vitamin A content to such an extent shows that many of the dairy farms in this area need a pasture improvement program.

Vitamin A Content of Butter Also Affected by Pasture Improvement

Early in 1943 the Office of Experiment Stations, United States Department of Agriculture, began a nationwide survey to determine the vitamin A content of market butter. The Alabama Station participated in this survey. Because

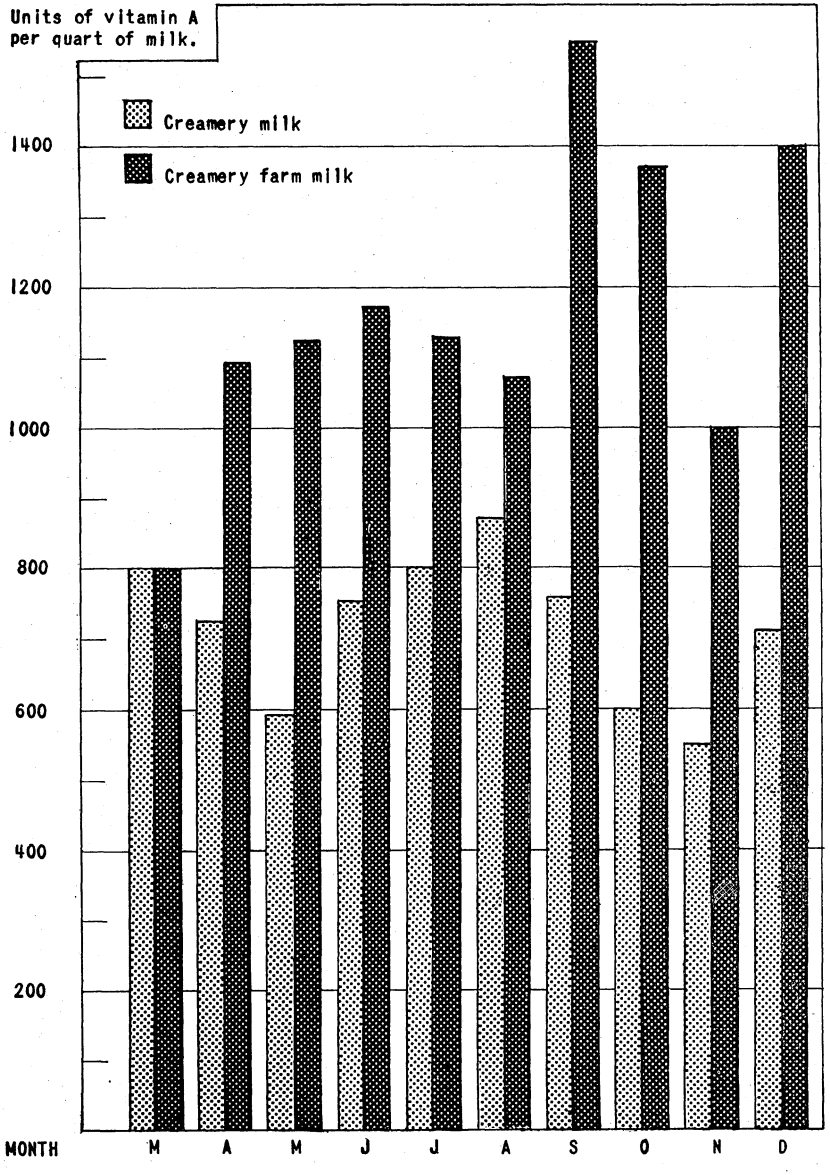


FIGURE 6. A commercial dairy farm operated by a creamery in Lee County produced milk that was rich in vitamin A in 1945 by following Alabama Experiment Station recommendations for pastures and grazing crops. When this milk was mixed at the creamery with other locally produced milk, the resulting product was relatively low in vitamin A. This shows that many of the farms in this locality need pasture improvement programs.

of the significance of the results, the work was continued and expanded by this Station after the nationwide survey had been completed. Samples of butter were purchased monthly on the open market and analyzed for vitamin A and carotene content over a period of 3 years. As many brands of butter as were available at the time of sampling were purchased from local stores, creameries, curb markets and farm butter producers. The butter was divided into two classes: (1) nationally advertised brands of butter that were shipped in from outside of the State, and (2) butter produced locally. Included in the survey were nine brands of shipped-in butter and eight brands, or sources, of butter produced locally. Since this work was undertaken during the War, not all brands were available each month, but a sufficient number were available every month to give a representative sample. The average vitamin A content of the shipped-in butter was compared each month from 1943 to 1946 with that of the butter produced locally.

In 1943 the vitamin A content of the butter produced locally was not much different from that of the shipped-in butter, as shown in Figure 7. The local butter excelled the shipped-in butter in vitamin A content 6 months of the year, but was lower during 4 winter months and 2 summer months.

In 1944, the vitamin A content of the butter produced locally was higher than that of the butter shipped in from other areas during 9 months of the year, as shown in Figure 8. This is a direct result of improved pastures on the farms in this area. The most notable increase occurred during the summer months, which indicated improvement of the permanent pastures. The increase in the vitamin A content of the butter produced in December indicated increased use of temporary winter grazing crops.

During every month of the year 1945, the vitamin A content of the local butter was markedly superior to that of the butter shipped in from outside of the State and averaged about 35% higher for the year (Figure 9). The vitamin A content of the local butter was noticeably higher in 1945 than in 1943 and 1944, particularly during the winter months. This was the result of increased use of improved pastures

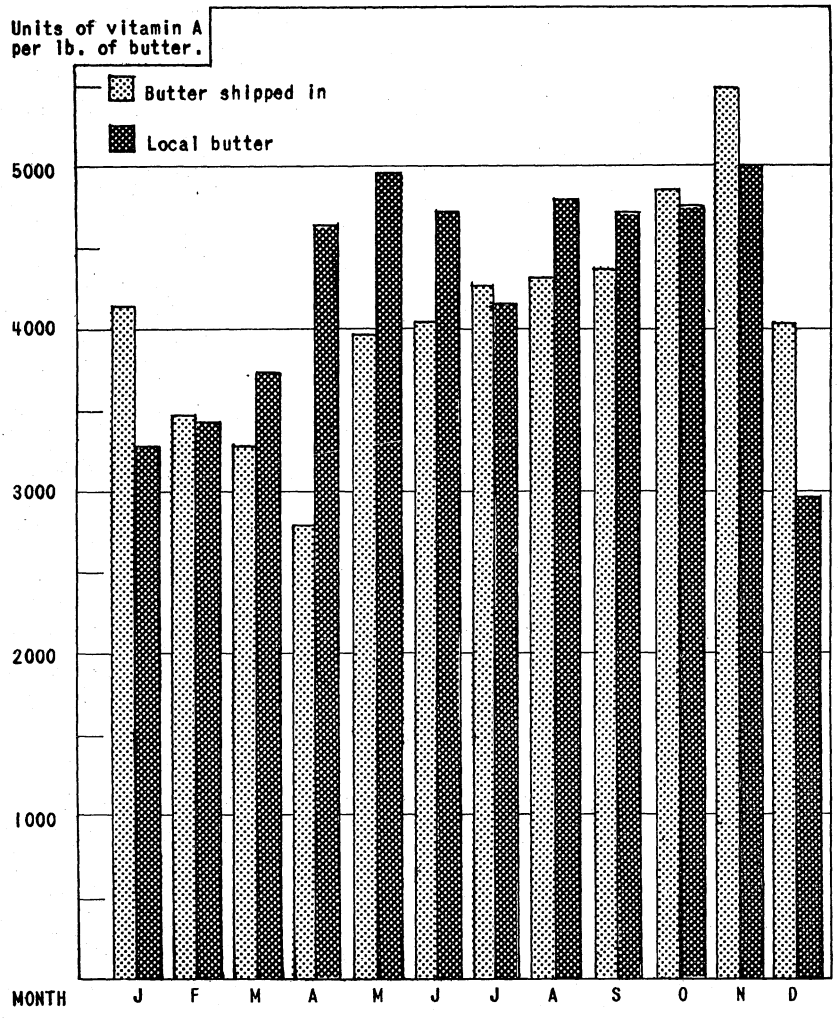


FIGURE 7. In 1943 the vitamin A content of butter produced locally was about the same as that of butter shipped in from other states.

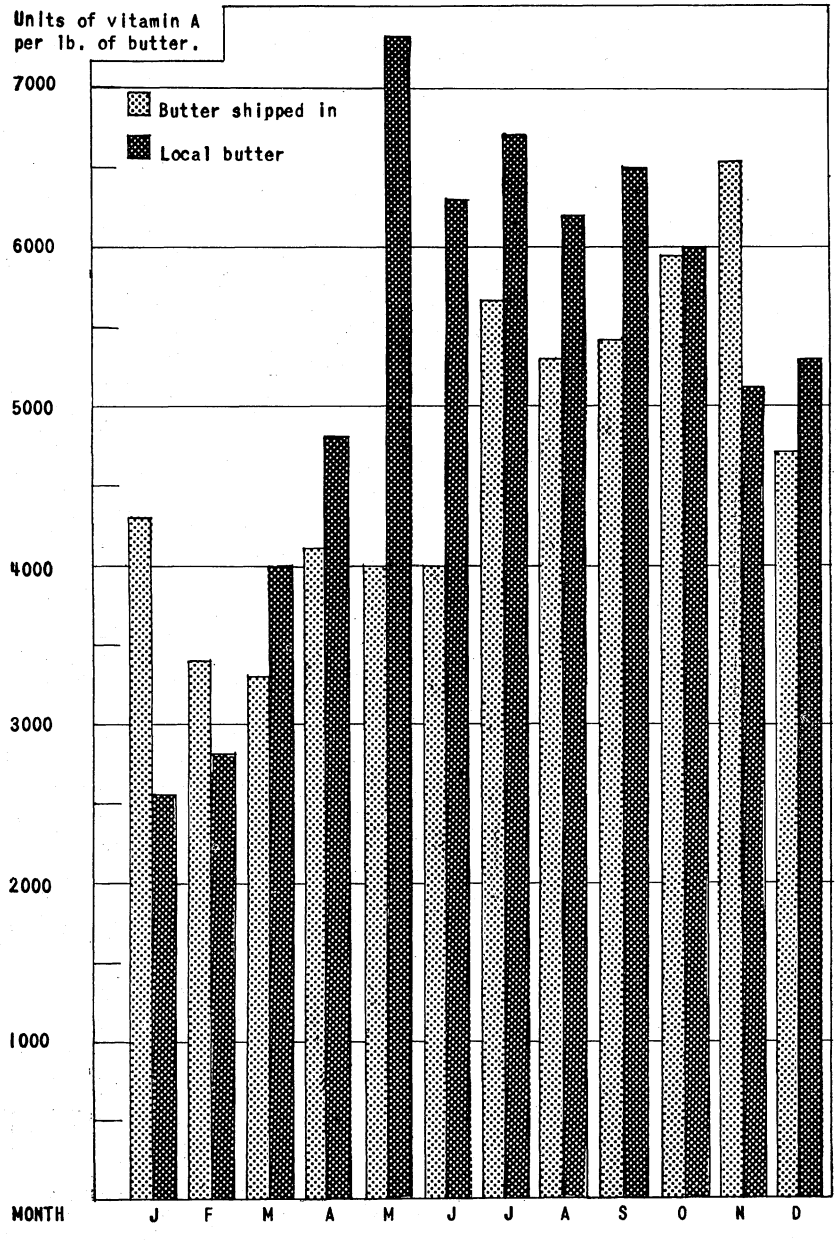


FIGURE 8. In 1944 locally produced butter excelled butter shipped in from outside of the State in vitamin A content during 9 months of the year, indicating that the pasture improvement program in this area was beginning to show its effect.

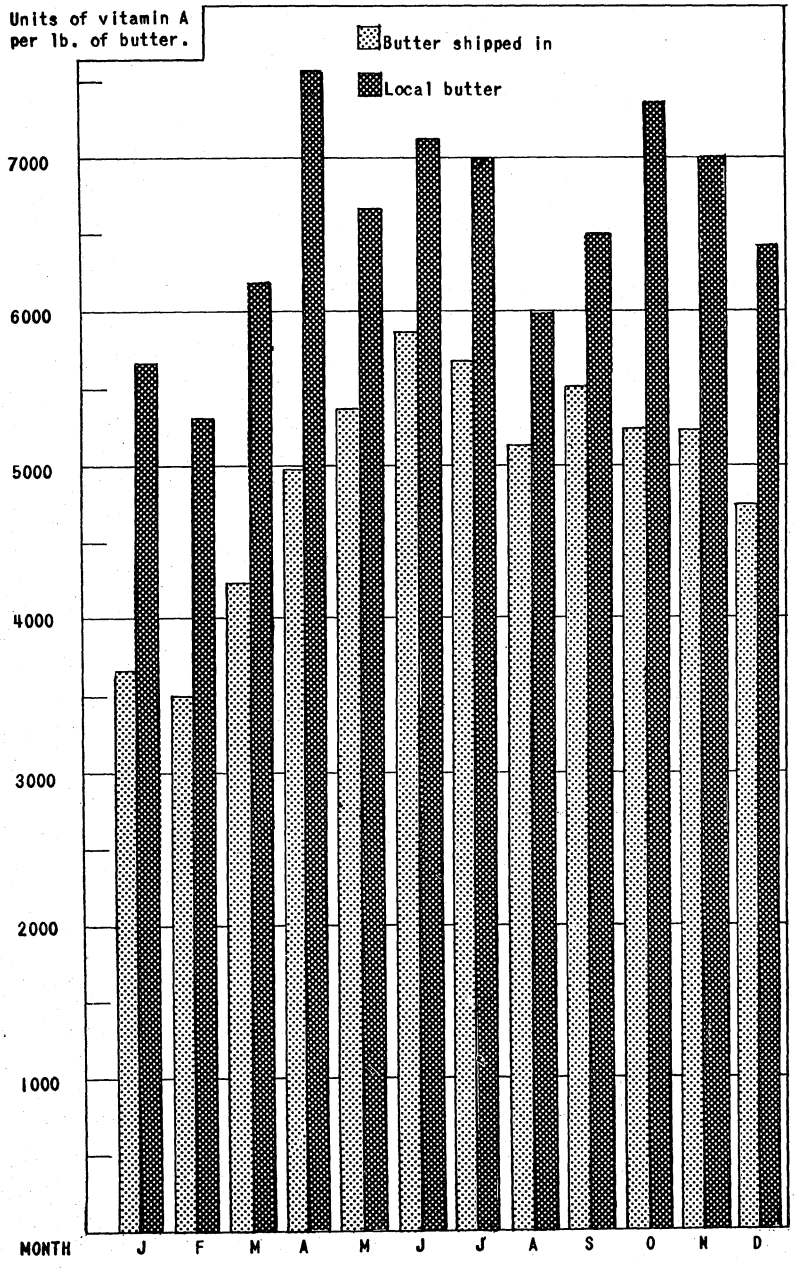
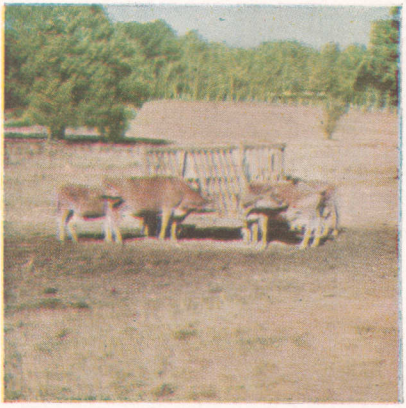


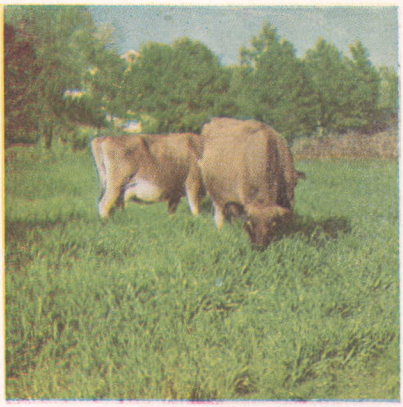
FIGURE 9. Throughout the year 1945 locally produced butter was superior in vitamin A content to butter shipped in from other states and also superior to that of local butter produced in 1943-44. Thus, in 3 years a pasture improvement program has improved the food value of butter.

and winter grazing crops on the farms that produced the local butter.

Relation of Pasture to Yellow Color and Vitamin A in Milk and Butter

Color of farm butter is a good indication of vitamin A content as well as quality of grazing. In Figure 10-A is shown the brown color of the vegetation in the permanent





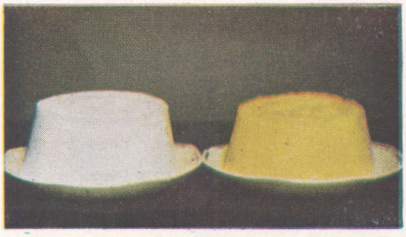


FIGURE 10-A (upper left). Permanent pasture in winter shows no green except pine trees.

FIGURE 10-B (upper right). Oats and crimson clover are used as temporary winter grazing.

FIGURE 10-C (left). White butter is from herd on permanent pasture in Figure 10-A, whereas yellow butter is from herd on oats and crimson clover in Figure 10-C.

pasture in December in contrast to the green color of oats and crimson clover being grazed at the same time and shown in Figure 10-B. When the green color is lost from vegetation, the carotene is also lost.

In Figure 10-C is shown how these contrasts are soon reflected in the color of the butter. The tallowy white butter on the left was produced by the control herd on the permanent pasture in December. It contained only 2,500 units of

vitamin A per pound. The yellow butter on the right was also produced in December, but by one of the small farm herds grazing oats and crimson clover. It contained 7,500 units of vitamin A per pound. Thus, the color of the butter is a good index of the quality of grazing provided for the dairy herd. It is likewise a good index of the vitamin A value of the butter, in the case of farm-produced butter that has not been artificially colored.

Creamery butter usually is artificially colored for the sake of attractiveness of product. Since the colors ordinarily used for this purpose do not have any vitamin A value, the color of creamery butter is not an index of its vitamin A content. When the farmers of Alabama uniformly provide adequate pastures and winter grazing crops for their herds, the artificial coloring of butter by Alabama creameries will no longer be necessary. The butter then will not only have an attractive yellow color, but will also be rich in vitamin A. This is essential if milk and butter are to make the greatest contribution to the diet of people.

Economy of All-Year Grazing Program

It was not practicable to study the economy of an all-year grazing program in these experiments. However, it was consistently observed that there was a significant saving of feed and a marked stimulation of milk production by the use of winter grazing crops. In many cases the cows would refuse dry rations entirely when ample winter grazing crops were available. This was particularly noticeable at the evening feeding. Other studies on the economy of milk production now being conducted by the Alabama Station show that an all-year grazing system is essential to maximum profits in dairy farming. The production of milk and butter having a uniformly high vitamin A value throughout the year, therefore, is consistent with economical production practices.

Further Improvement Possible

The results reported in this bulletin do not on the average represent the greatest possible improvement in the vitamin A

content of winter milk and butter in this area. Since these experiments were started, much has been learned about pasture improvement and the production of winter grazing crops. In the early years of the study, the winter grazing crops were seeded too late for best results. Good preparation of the land, proper fertilization, and early seeding are essential to the success of winter grazing crops. Moreover, an adequate acreage must be provided. The acreage of winter grazing crops was never adequate for the mid-winter period in these experiments.

Permanent pasture used in these experiments was not as good as is now possible and entirely practicable to establish and maintain on the better pasture lands of this area. The fact that higher vitamin A values were obtained for milk produced on winter grazing crops than for milk produced on summer pasture indicates that there is need for further improvement of the summer pasture. The more extensive use of alfalfa to furnish grazing during the September-October period between lush summer pastures and winter grazing crops and for periods of dry weather in the summer would be desirable. Near the close of these experiments, it was found that milk produced on alfalfa pasture in November and December had a vitamin A value of 2,200 to 2,400 units per quart. These are the highest values obtained on any grazing crop.

SUMMARY

A SERIES OF experiments was started in 1939 to determine the seasonal fluctuation in the vitamin A content of milk and butter produced by common dairy farm practices in Alabama, and to study methods for improvement of the vitamin A content during the winter period.

It was found that cows fed a well-balanced ration of concentrates in addition to hay and sorghum silage produced milk in mid-winter that contained less than one-fifth as much vitamin A as the milk produced by the same cows on summer pasture.

In 8 years of experiments with the use of pasture and winter grazing crops for dairy cows, it was found that milk rich in vitamin A could be produced throughout the year by supplementing improved permanent pasture with kudzu or alfalfa for temporary grazing and with winter grazing crops such as oats, crimson clover, and Italian rye grass. The use of such a grazing system was found to be practicable on Alabama farms.

From 1943 to 1945 the vitamin A content of butter produced on the farms studied in Lee County increased steadily as a result of increased use of winter grazing crops. In 1943 the vitamin A content of the local butter was about the same as that of butter shipped in from outside of the State. In 1945 the butter produced locally was higher in vitamin A than the shipped-in butter every month of the year, and was also significantly higher than the butter produced locally in 1943.

The amount of natural yellow color in milk and butter is an index of its vitamin A content in Alabama where the Jersey and Guernsey breeds predominate. Butter that is a rich, orange-yellow color is high in vitamin A, whereas butter that is tallowy-white is relatively low in vitamin A. Color is not always an index of the vitamin A content of creamery butter, which is often artificially colored with substances that contain no vitamin A.

The economy of producing milk and butter of high vitamin A content by the full use of an all-year pasture system is indicated by decreased feed consumption and increased milk yields of cows on good pasture or grazing crops, and by data from other experiments at the Alabama Station.

TABLE 1—CAROTENE AND VITAMIN A CONTENT OF MILK EXPRESSED IN MICROGRAMS PER QUART OF MILK AND GRAPHICALLY PRESENTED IN TEXT FIGURES 1, 2, 3, 4, 5, AND 6.

Month	FIG. 1, 2, 3, 4, 5 Control Herd		FIGURE 2 Grazing Crops		FIGURE 3 Grazing Crops		FIGURE 4 Farm Herd 1		FIGURE 5 Farm Herd 2		FIGURE 6 Creamery Plant		FIGURE 6 Creamery Farm	
	Car.*	Vit. A	Car.*	Vit. A	Car.*	Vit. A	Car.*	Vit. A	Car.*	Vit. A	Car.*	Vit. A	Car.*	Vit. A
January	160	170	-----	-----	673	420	527	488	400	351	-----	-----	-----	-----
February	90	160	750	450	615	390	547	390	556	351	-----	-----	-----	-----
March	210	220	1,230	410	713	322	576	312	781	361	488	312	459	342
April	380	250	1,260	440	957	351	605	322	947	390	390	332	673	420
May	550	320	1,280	480	898	488	498	361	781	429	351	244	634	488
June	730	390	-----	-----	-----	-----	644	381	800	459	439	312	664	507
July	900	460	-----	-----	-----	-----	732	449	732	390	429	371	644	488
August	1,090	500	-----	-----	-----	-----	762	312	781	312	547	322	664	410
September	870	370	-----	-----	-----	-----	644	478	859	449	449	312	917	634
October	500	330	-----	-----	556	420	957	683	537	410	361	244	664	703
November	290	290	-----	-----	781	586	840	673	605	478	293	254	634	371
December	190	200	-----	-----	878	556	635	674	644	478	342	371	547	859

* Car. — carotene.

TABLE 2—CAROTENE AND VITAMIN A CONTENT OF BUTTER EXPRESSED IN MICROGRAMS PER POUND AND GRAPHICALLY PRESENTED IN TEXT FIGURES 7, 8, AND 9.

Month	FIGRE 7 Local		FIGRE 7 Shipped-in		FIGURE 8 Local		FIGURE 8 Shipped-in		FIGURE 9 Local		FIGURE 9 Shipped-in	
	Car.*	Vit. A	Car.*	Vit. A	Car.*	Vit. A	Car.*	Vit. A	Car.*	Vit. A	Car.*	Vit. A
January	1,366	1,934	1,934	2,220	531	2,034	1,394	2,897	2,856	2,792	1,639	2,016
February	1,335	2,084	1,371	2,052	490	2,297	976	2,433	2,906	2,374	1,544	1,934
March	1,516	2,197	1,217	2,102	1,017	2,965	1,053	2,265	3,360	2,806	2,070	2,161
April	2,034	2,592	967	1,820	1,434	3,428	1,571	2,501	4,653	2,942	2,306	2,638
May	2,338	2,597	1,362	2,610	4,313	3,110	1,534	2,424	3,863	2,769	2,810	2,515
June	2,197	2,565	1,589	2,452	3,695	2,606	1,580	2,383	4,163	2,960	3,123	2,733
July	2,097	2,029	2,188	2,052	3,882	2,801	2,615	3,033	4,150	2,837	2,983	2,674
August	2,338	2,429	2,134	2,152	3,378	2,787	2,765	2,511	3,618	2,420	2,547	2,547
September	2,465	2,243	2,084	2,252	3,550	2,955	2,592	2,824	3,636	2,846	2,846	2,660
October	2,515	2,220	2,276	2,592	3,128	2,901	3,133	2,760	4,249	3,092	2,225	2,946
November	2,556	2,447	2,415	3,101	2,497	2,588	2,542	3,995	3,714	3,251	2,211	2,960
December	799	2,143	1,739	2,284	2,656	2,688	2,270	2,433	3,355	3,064	1,899	2,801

* Car. — carotene.