TEXAS AGRICULTURAL EXPERIMENT STATION

A. B. CONNER, DIRECTOR,
College Station, Texas

BULLETIN NO. 629 APRIL 1943

THE VITAMIN A CONTENT OF COMMERCIAL BUTTERS SOLD IN TEXAS

A. R. KEMMERER AND G. S. FRAPS

DIVISION OF CHEMISTRY

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
T. O. WALTON, President

B33—443-4M-L189

[Blank Page in Original Bulletin]

SYNOPSIS

Vitamin A in butters sold in Texas was studied to ascertain how much vitamin A is furnished by butter to the diet. Sixty-two samples of market butters sold in Texas were collected during the year of 1942 and in January of 1943. Their vitamin A potency in Internationl units were calculated from the carotene and spectro vitamin A analyses. Some differences were found among samples collected in the same month, such as from 20.7 to 48.5 units of vitamin A per gram in January 1942. The average vitamin content by months ranged from 31.0 units per gram in April to 42.6 in October. The average for all the samples was 36.9 units per gram.

In normal times, the average annual per capita consumption of butter in the U. S. is 17.6 lbs. This amount of butter would furnish 800 units daily to each adult person or approximately one-sixth of the recommended amount of 5000 units. Since low income groups are unable to purchase as much butter as the high income groups, the low income groups would receive much less than one-sixth of their requirement from butter, while the high income groups would receive more. Vegetables high in carotene, such as carrots, greeens and sweet potatoes are excellent and relatively inexpensive sources of vitamin A and should be eaten liberally by both the high and low income groups. During the present emergency, with an estimated annual per capita consumption of 13 pounds of butter, it is more than ever necessary for the average person to receive most of the vitamin A needed from sources other than butter.

CONTENTS

THE VITAMIN A POTENCY OF COMMERCIAL BUTTERS SOLD IN TEXAS

A. R. Kemmerer, Chemist, and G. S. Fraps, Chief
Division of Chemistry

Butter supplies are not only desirable fat to the human diet but also vitamin A potency. The vitamin A potency is due partly to carotene, a yellow pigment that gives most of the natural yellow color to butter and partly to vitamin A which is a colorless compound. Although much work has been done on the vitamin A potency of milk and butter, little has been done to ascertain the vitamin A content of butter sold and consumed in the United States. Summer-produced creamery butter sold in Washington, D. C., was found (2) to contain 59 U.S.P. units per gram, winter-produced to contain 36.5 units per gram and one sample sold in the winter season contained about 30 units. Other analyses of butter for vitamin A have been made as summarized by Booher, Hartzler and Hewston (2). These represent to some extent the butter being sold, but little extensive work has been done. Information as to the vitamin A potency of butter is needed in order to ascertain its contribution to the diet of the American people.

A national cooperative project to obtain information relative to the vitamin A values in butter was approved by the directors of the Association of Land Grant Colleges in November, 1941. The project was originally recommended by the Committee on Food and Nutrition of the National Research Council to ascertain the actual variation in market butter sold in towns and cities located in different regions of the United States. For these reasons, a study was undertaken of the vitamin A content of butters sold in Texas.

Conditions Which Affect the Vitamin A Potency of Butter

The vitamin A and carotene in butter are derived partly from the vitamin A and carotene stored in the body of the cow and partly from the food consumed during the lactating period. In the intervals between lactations, the cow stores up quantities of vitamin A, chiefly in the liver, especially when she has access to good green pastures. At the beginning of the lactation period, the butter fat in the milk is usually high in vitamin A potency, but unless the feed is high in carotene, the vitamin A in butter fat decreases during the lactation period. This is illustrated by Table 1, taken from the work of Fraps, Copeland, Treichler and Kemmerer (6). The cows received a ration containing 60 per cent of yellow corn at the rate of 2½ pounds per pound of milk produced, and two groups received in addition 3 pounds and 6 pounds respectively of alfalfa leaf meal. The vitamin A potencies of feed and butter fat were determined by biological methods. Neither the yellow corn alone, nor with the 3 pounds and 6 pounds of alfalfa leaf meal, furnished enough carotene to maintain the vitamin A potency of the butter fat at the

Table 1. Vitamin A potency of butter fat in International units per gram

Number of weeks experiment	Feed containing carotene		
	Yellow corn	Yellow corn and 3 pounds alfalfa leaf meal daily	Yellow corn and 6 pounds alfalfa leaf meal daily
0	52	60	74
1	40	40	52
5	17	24	34
9	12	30	28
13	8	17	24
17	5	14	12
Approximate units fed per day--	8,400	204,000	408,000

level found at the beginning of the experiment, but the addition of the alfalfa leaf meal produced butter fat with a higher vitamin A potency than yellow corn alone.

The vitamin A potency of butter has been found to be from 43 to 62 Sherman-Munsell units per gram at the beginning of lactation and to decrease in 17 weeks to 4 units when the cows had been receiving 7000 units of vitamin A daily, to 12 units when receiving 170,000 units and to 10 units when receiving 340,000 units. For butter high in vitamin A potency, containing 65 to 95 Sherman-Munsell units per gram from 750,000 to 1,400,000 Sherman-Munsell units are required in the feed (6). Silage from corn or sorghums, ordinary hays and yellow corn would not produce or maintain butter high in vitamin A, but sufficient green pasture or alfalfa silage or grass silage produces butter of such quality (5, 6). Two cows, producing butter fat containing only 12 Sherman-Munsell units per gram, when placed on pasture produced butter fat in 3 days containing 40 to 50 units. The amounts of both carotene and vitamin A in butter are considerably affected by the feed of the cow, as has also been shown by other work. Moore (14), Bauman and coworkers (1), and Gillam and coworkers (13) found that feed with high carotene content increased both the carotene and vitamin A content of the butter. L'eul and coworkers (3, 4) found that the vitamin A content of butter was increased by feeding shark liver oil. Seven hundred thousand International units of this oil fed daily raised the vitamin A content of butter from 55 to 72 I. U. per gram and 1,400,0000 I. U. produced a butter containing as high as 172 I. U. Shark liver oil, unlike cod liver oil, does not have a depressing effect on the amount of fat produced in the milk. On account of the low utilization of the vitamin A, feeding shark liver oil is not an economical method of introducing vitamin A into food.

The cow does not utilize carotene efficiently since only about 2.5 per cent of the vitamin A potency is transmitted to the butter fat. The approximate relation between the vitamin A potency in feed and the

vitamin A in butter fat after about 9 weeks, in Sherman-Munsell units, is given in Table 2, taken from Bulletin 536 (6).

Table 2. Approximate relation between vitamin A potency in feed and vitamin A in butter fat, after about 9 weeks feeding in Sherman-Munsell units.

Units fed per day	Units per gram in butter
0	8
7,000	10
8,400	8
17,000	17
60,000	14
116,000	12
170,000	25
340,000	23
450,000	28
350,000	45
750,000	65
1,400,000	95

The vitamin A potency of market butter would be less likely to vary as much as in butter produced under experimental conditions, for the reason that creameries usually receive cream from a number of different herds. The differences due to feed and storage of vitamin A in the cow would thus be reduced to a large extent. Market butter is also produced to a greater extent when there is a surplus of milk, presumably in earlier stages of lactation when pastures are good. The vitamin A content of the butter is lower in later stages of lactation. These facts would likewise tend to reduce variations, so that market butter would vary less than those samples produced experimentally. The storage of butter produced in flush seasons would also tend to reduce the average variation.

Experimental

Samples of butter were purchased in Bryan and College Station at several different times of the year. One collection of butter was made in Houston, Texas. A few samples were provided by creameries in various parts of the state and by the A. & M. College Creamery. Since the samples purchased, with a few exceptions, were from national distributors, or from creameries located in different parts of the state, they represent a wide area in the state.

The butter fat was prepared by melting and filtering the butter at 60° C. in order to remove water and salt. Total color, pure carotene, and spectro vitamin A were determined by methods described previously (7) and recorded in parts per million. The difference between the total color, expressed as carotene, and the pure carotene, is the non-carotene color. When the non-carotene color was above 3.0 parts per million the presence of artificial color soluble in ether, which would affect appreciably the quantity of spectro vitamin A, was indicated. In most such cases, the ether-soluble color was determined in parts per million (7), and multiplied by 0.6 to secure the correction to be subtracted from the spectro vitamin A. The presence of artificial color does not affect the determination of pure carotene.

The analyses were calculated to International units of vitamin A, which have the same value as the U.S.P. units, by the formula IU = (S — 0.5) 4 + 1.7 C given in previous published work (8), in which IU is the number of International units, S the parts per million spectro vitamin A, and C the parts per million carotene. This formula was worked out empirically from the chemical and biological analyses of a large number of samples of butter fat (8). The vitamin A was calculated from the butter fat to butter on the assumption that butter contains 82 per cent butter fat.

Discussion of Results

Analyses of the butter fats and the calculated vitamin A potency of the butter fat and of the butter arranged by month of collection are given in Table 3. As could be expected, there are differences in the vitamin A content of samples collected the same month. In January 1942, the vitamin A content of the butter ranged from 20.7 to 48.5 International units per gram, in March the range was 25.8 to 43.0; in April from 27.5 to 52.6; in July, 32.6 to 44.0; in October, 24.2 to 35.1; in November, 29.6 to 36.9, and in January, 1943, 26.2 to 47.7.

Table 3. Vitamin A content of commercial butter.

Month collected	Butter fat pure carotene P. P. M.	Butter fat non-carotene color P. P. M.	Butter fat spectro vitamin A P. P. M.	Butter fat International units per gram	Butter International units per gram
January 1942	8.1	---	10.0	51.8	42.5
	4.3	---	11.0	49.3	40.4
	3.6	---	5.3	25.3	20.7
	5.8	---	8.2	40.7	33.4
	9.8	---	11.1	59.1	48.5
Average (5)	6.3	---	9.1	45.2	37.1
March 1942	4.2	5.4	7.4	34.7	28.5
	5.8	2.9	10.0	47.9	39.3
	5.6	2.1	8.8	42.7	35.0
	8.7	2.8	9.8	52.0	42.6
	3.6	2.1	7.8	35.3	28.9
	5.9	2.2	11.1	52.4	43.0
	3.0	1.4	7.1	31.5	25.8
	4.4	5.6	9.5	43.5	35.7
Average (8)	5.2	3.1	8.9	42.5	34.9
April 1942	6.3	2.5	11.9	56.3	46.2
	9.1	2.7	10.6	55.9	45.8
	11.2	2.4	10.7	59.8	48.9
	10.0	2.7	12.3	64.2	52.6
	5.6	2.7	8.6	41.9	34.4
	7.3	2.7	11.5	56.4	46.2
	3.7	5.2	7.3	33.5	27.5
	5.7	3.9	10.9	51.3	42.1
	4.1	2.0	8.1	37.4	30.7
	7.7	3.1	10.1	51.5	42.2
	7.8	3.0	10.9	53.2	43.6
	7.7	2.9	11.2	55.9	45.8
	10.2	1.4	10.7	58.1	47.6

Table 3. Vitamin A content of commercial butter—continued.

Month collected	Butter fat pure carotene P. P. M.	Butter fat non-carotene color P. P. M.	Butter fat spectro vitamin A P. P. M.	Butter fat International units per gram	Butter International units per gram
Average (13)	7.3	2.9	10.4	52.0	42.6
June 1942	9.8	2.9	8.2	47.5	39.0
July 1942	9.5	2.6	7.6	44.6	36.6
	9.2	2.4	8.1	46.0	37.7
	7.1	5.2	7.4	39.7	32.6
	8.3	4.4	10.4	53.7	44.0
	9.8	2.5	8.7	49.5	40.6
	8.6	3.6	8.4	46.2	37.9
	8.9	4.3	8.4	46.7	38.3
	9.8	3.9	8.3	47.9	39.3
Average (8)	8.9	3.4	8.4	46.8	38.3
August 1942	6.7	4.0	6.7	36.2	29.7
September 1942	7.0	3.0	8.9	45.5	37.3
	7.1	4.4	9.5	48.6	39.9
October 1942	5.4	3.7	7.2	29.1	24.2
	7.8	3.0	9.2	38.9	31.9
	7.7	2.5	7.3	32.6	26.7
	9.4	3.2	9.5	42.1	34.5
	8.8	3.4	9.9	42.6	34.9
	8.5	3.0	9.2	39.9	32.7
	9.6	3.0	8.7	39.8	32.6
	8.0	2.8	10.3	42.8	35.1
	6.3	2.9	8.4	32.3	26.5
Average (9)	7.9	3.1	8.9	37.8	31.0
November 1942	7.4	4.7	7.8	41.8	34.5
	7.5	3.2	8.3	43.9	36.0
	6.7	3.7	7.3	38.6	31.7
	6.4	5.7	7.2	37.7	30.9
	10.0	4.4	7.5	45.0	36.9
	7.0	3.1	7.5	39.9	32.7
	4.5	2.8	7.6	36.1	29.6
Average (7)	7.1	3.9	7.6	40.4	33.2
January 1943	5.1	2.8	9.1	43.1	35.3
	9.8	3.0	7.3	43.9	36.0
	10.3	1.5	9.5	53.5	43.9
	9.1	2.2	9.4	51.1	41.9
	3.5	6.0	7.0	32.0	26.2
	5.2	3.9	7.4	36.4	29.8
	9.3	5.0	11.1	58.2	47.7
	8.2	3.2	10.5	53.9	44.2
Average (8)	7.6	3.5	8.9	46.5	38.1
Average of all (62)	---	---	---	45.0	36.9

Much greater variations have been found in experimental samples as from 5 to 74 International units per gram (Table 1). The averages for each month are relatively uniform, being 37.1 International units per gram of butter fat for January, 1942; 34.9 for March; 42.6 for April; 38.4 for July; 31.0 for October; 33.2 for November and 38.1 for January, 1943. The highest average vitamin A content of 42.6 is in the April

butter and the lowest of 31.0 in October. The average of all the samples is 36.9 International units per gram of butter fat, or 1046 units per ounce.

Some of the butters collected were sweet cream butter, but most of them were made from sour cream. No difference was observed in the vitamin A content of these two kinds of butter, nor is there any reason to expect differences, so they were not separated in the table.

Of the 62 samples, 36 were marketed by distributors, who do not make butter but who purchase it, mix it and market it under their own trade names. These butters may have been produced in other states than Texas, and stored an unknown number of months before they were marketed.

Samples numbering 27 were made by creameries in Texas from milk produced in the same localities. The butters were not necessarily produced in the month in which the samples were purchased. The vitamin A potency of these samples is given in Table 4 arranged according to the month collected. While there are some indications as to differences among localities, the number of samples is too small for definite statements to be made. The vitamin A content of Texas butter averaging 36.9 International units per gram, is, according to the compilation of Booher, Hartzler and Hewston (2) higher than that of Denmark butter sold in London, England, which contained 10 to 20 units per gram; English butter from cows on pasture, containing 18 to 34 units per gram; Holland butter containing 12 to 37 units per gram; London market butter containing 23 to 30 units per gram; and Washington, D. C., retail market butter in winter containing 30. It is about the same as the creamery butter of Washington, D. C., containing 36 units per gram, and less than the summer-produced of 59 units per gram. Of course many individual samples may contain more vitamin A than the Texas average.

Table 4. Vitamin A in Texas butter of known origin International units per gram compared with average of all samples of same month.

Month purchased	Brazos Co.	De Witt Co.	Washington Co.	Brooks Co.	Kleberg Co.	Average of Texas butter	Average all butter
January 1942	21	43	40	--	--	35	37
March	26	39	36	--	--	34	35
April	31	44	--	46-42-46	49	43	43
June	39	--	--	--	--	39	--
July	39	38	--	--	--	39	38
August	30	--	--	--	--	30	30
September	38-39	--	--	--	--	39	39
October	32	35	--	--	--	34	31
November	--	--	--	33	40	37	33
January 1943	--	35	26	35-44-41	--	36	38
Average	33	39	34	41	45	37.3	36.9

The annual per capita consumption of butter in the United States during the last few years has been approximately 17.6 pounds. It is calculated that in the present emergency the civilian population will re-

ceive only about 13 lbs. of butter per capita annually. Seventeen and six-tenths pounds of butter, as sold in Texas, would supply an average of approximately 800 International units of vitamin A potency per day for each person in the United States and 13 pounds would supply approximately 600 units daily. According to the Committee on Food and Nutrition of the National Research Council, an adult person should receive daily 5000 International units of vitamin A. In normal times, the population of the United States would thus receive about one-sixth of its required vitamin A from butter. This is high for a single food. During the present emergency the civilian population will receive about one-eighth of its vitamin A from butter if the average per capita consumption is 13 pounds.

In spite of the fact that butter affords on an average a large amount of vitamin A to the American diet it has the drawback of being an expensive food. People in the low income group can afford to use very little butter. Thus, for this low income group butter affords insignificant amounts of vitamin A. Less expensive sources are greens, sweet potatoes, and carrots (9, 10, 11). Greens supply not only vitamin A but also vitamin C (12). The high income group of people must also depend on other foods for the greater proportion of the vitamin A which they need, especially during the present emergency, when the average of 135 grams of butter required daily to supply 5000 units of vitamin A may be almost impossible to obtain.

Acknowledgment

Credit is due Mr. T. A. Hiett, W. W. Meinke, and Jeanne DeMottier for analyses of the butter. Thanks are also due Mr. W. B. Cook, Agricultural Agent of the Missouri Pacific Railroad, for collecting samples of butter in Houston.

Summary

Sixty-two samples of commercial butters were collected in 1942 and January of 1943. Their units of vitamin A potency were calculated from analyses for carotene and spectro vitamin A, with allowance for the effect of artificial color when necessary. Some differences were found between the samples collected in the same month, such as from 20.7 to 48.5 International units of vitamin A per gram in January 1942. The average vitamin A content by months ranged from 42.6 units per gram in April to 31.0 in October. The average of all samples was 36.9. There are indications that some differences may occur in butter produced in different localities of Texas but the number of these samples was too small to make definite statements. With an average consumption of 17.6 pounds butter per capita, butter would supply about 800 International units per day or approximately one-sixth of the recommended amount of 5000 units per day per adult person. Since low-

income groups are unable to purchase as much butter as those receiving high incomes, the low income group would receive much less than one-sixth of their requirements of vitamin A from butter, while the high-income group would receive more than this quantity. Vegetables high in carotene, such as carrots, greens, and sweet potatoes, could supply the major part of the vitamin A needed.

REFERENCES

1. Bauman, C. A., Steenbock, H., Beeson, W. M., Rupel, I. W. 1934. Fat soluble vitamins. XXXIX. The influence of breed and diet of cows on the carotene and vitamin A content of butter. Jour. Biol. Chem., 105:167.
2. Booher, L. E., Hartzler, E. R. and Hewston, E. M. 1942. Vitamin value of foods, a compilation. Chemical Publishing Co., Inc., Brooklyn, N. Y.
3. Duel, H. J., Jr., Halliday, N., Hallman, F., and Johnston, C. 1941. The effect of vitamin A intake on vitamin A content of butter. Jour. Biol. Chem. 139, 479.
4. Deuel, H. J., Jr., and Nuthall, J. P. 1942. The effect of shark liver oil on the vitamin A content of milk and milk products. Jour. Nutr. 22, 303.
5. Fraps, G. S., Copeland, O. C. and Treichler, R. 1934. The vitamin A requirements of dairy cows. Texas Agric. Exp. Sta. Bul. 495.
6. Fraps, G. S., Copeland, O. C., Treichler, R., and Kemmerer, A. R. 1937. Utilization of vitamin A by dairy cows. Texas Agric. Exp. Sta. Bul. 536.
7. Fraps, G. S., and Kemmerer, A. R. 1943. Determination of carotene and vitamin A in commercial butter. Jour. A.O.A.C. In press.
8. Fraps, G. S., Kemmerer, A. R., and Meinke, W. W., 1941. Relation of chemical analyses of butter to its vitamin A potency. Jour. Assoc. Off. Agr. Chem. 24, 731.
9. Fraps, G. S., and Meinke W. W. 1942. Economical sources of vitamin A potency in human foods. Texas Agr. Exp. Sta. Progress report 764.
10. Fraps G. S. and Meinke W. W. 1942. Economical sources of vitamin A potency in canned foods. Texas Agr. Exp. Sta. Progress report 785.
11. Fraps, G. S., and Meinke. W. W. 1942. Economical sources of vitamin A potency in human foods in July. Tex. Agr. Exp. Sta. Progress report 791.
12. Fraps, G. S., and Meinke, W. W. 1942. Vitamin C sources in Texas foods. Tex. Agr. Exp. Sta. Progress report 810.
13. Gillam, A. E., Heilbron, I. M., Morton, R. A., Bishop, G., and Drummond, J. C. 1933. CXIV. Variations in the quality of butter particularly in relation to vitamin A, carotene and xanthophyll content as influenced by feeding artificially dried grass to stall fed cattle. Biochem. J. 28:878.
14. Moore, T. 1932. Vitamin A carotene. IX. Notes on the conversion of carotene to vitamin A in the cow. Biochem. Jour. 26:1.