SEASONAL FLUCTUATIONS OF THE VITAMIN A AND C CONTENT OF PALESTINIAN MILKS[1]

By KARL GUGGENHEIM

From the Department of Hygiene and Bacteriology, Hebrew University, Jerusalem

(With 3 Figures in the Text)

A STUDY of the seasonal fluctuations of the elimination of vitamin C by the Palestinian population, and hence supply, has been reported in a previous paper (Guggenheim, 1939). It was found that the seasonal curve of vitamin C in the urine differed from that found in Europe, as a consequence of the consumption of citreous fruits produced in Palestine. This paper records a complementary study of the seasonal fluctuations of vitamins A and C in Palestine milk. Milks from an urban, a valley and a hill district have been examined in order to determine the influence of variations in fresh fodder on the vitamin content of the milk, and hence to assess the value of the milks as a source of vitamins in human nutrition.

Procedure

Milks from four sources were examined:

(1) Emek milk from a co-operative settlement in the Valley of Jezreel. This was an evening milk, brought to Jerusalem the following morning and immediately examined.

(2) Kiryath Anavim milk from a co-operative settlement in the hilly region, about 15 km. west of Jerusalem. This was a morning milk, brought to Jerusalem the same day and immediately examined.

(3) Sanhedria milk from a dairy in a suburb of Jerusalem. This was a morning milk, sold and examined the same morning.

(4) Jerusalem pasteurized milk. This was a standardized milk from Kiryath Anavim, of which the bacterial and fat content was tested daily.

The milks from the first three sources were examined two to three times a month during a period of 12–14 months; the pasteurized milk was examined every 2 weeks from October 1938 to March 1939. In each milk sample the fat was estimated by Roese's method, carotene by Kuhn & Brockmann's method, vitamin A content by Carr-Price's method, and vitamin C content by Tillmans's method.

[1] These studies were made possible by a grant from the Nutrition Committee of the Economic Research Institute of the Jewish Agency for Palestine.

RESULTS

I. *Carotene and vitamin A* (Tables 1–4). Marked seasonal fluctuations of the carotene content were found in all milks examined. In the Emek milk the carotene content began to fall in August and to increase in January. In the Kiryath Anavim milk the carotene content began to fall in August, but did not begin to increase until March. In both these milks the variations in the vitamin A content were not significant. In the Sanhedria milk the carotene content began to fall in July and did not begin to increase again until April; in this milk the carotene curve was roughly parallel to that for vitamin A. The highest vitamin A content was found in the milks from the Valley of Jezreel and Kiryath Anavim.

Table 1. *Emek milk—carotene, vitamin A and vitamin C content*

	Fat	Carotene, γ %		Vitamin A, I.U./100 g.		
Month	content %	In whole milk	In milk fat	In whole milk	In milk fat	Vitamin C mg. %
1938 April	4·2	39	940	37	880	0·43
May	4·2	43	1020	41	970	0·27
June	3·8	41	1080	52	1380	1·28
July	—	—	—	—	—	—
August	4·0	18	450	35	870	1·03
September	3·8	13	350	38	1000	0·62
October	3·9	17	450	53	1360	0·77
November	4·2	18	420	51	1210	0·47
December	4·0	16	410	53	1335	0·79
1939 January	3·9	32	810	42	1070	0·47
February	4·1	34	840	41	1000	0·38
March	4·0	37	920	30	760	0·27
Average	4·0	28	699	43	1076	0·61

Table 2. *Kiryath Anavim milk—carotene, vitamin A and vitamin C content*

	Fat	Carotene, γ %		Vitamin A, I.U./100 g.		
Month	content %	In whole milk	In milk fat	In whole milk	In milk fat	Vitamin C mg. %
1938 March	3·0	16	525	28	930	—
April	3·2	26	800	33	1030	0·80
May	3·5	29	840	32	910	0·725
June	2·9	30	1040	39	1330	1·32
July	3·0	31	1050	52	1525	1·825
August	2·9	8	280	25	875	1·52
September	3·2	11	305	38	1180	1·435
October	3·3	8	230	42	1270	1·54
November	3·3	10	300	36	1105	1·815
December	3·4	9	280	33	970	1·09
1939 January	3·6	9	260	38	1045	1·245
February	3·7	12	320	32	875	1·41
March	2·8	18	630	24	870	1·025
Average	3·2	17	527	35	1070	1·31

Table 3. *Sanhedria milk—carotene, vitamin A and vitamin C content*

Month	Fat content %	Carotene, γ % In whole milk	Carotene, γ % In milk fat	Vitamin A, I.U./100 g. In whole milk	Vitamin A, I.U./100 g. In milk fat	Vitamin C mg. %
1938 February	3·7	7	190	18	500	0·475
March	3·5	10	300	15	440	0·70
April	3·4	14	410	29	850	0·93
May	3·7	25	690	42	1130	0·59
June	3·3	21	630	38	1155	1·06
July	3·5	13	360	41	1165	2·29
August	3·3	8	250	30	910	1·31
September	3·4	5	135	22	635	0·905
October	3·5	5	145	14	390	1·20
November	3·4	4	120	16	485	1·18
December	3·1	4	120	12	385	0·615
1939 January	3·0	3	100	14	470	0·95
February	3·5	7	190	17	480	1·04
March	3·3	9	280	15	420	1·325
Average	3·4	10	280	23	672	1·04

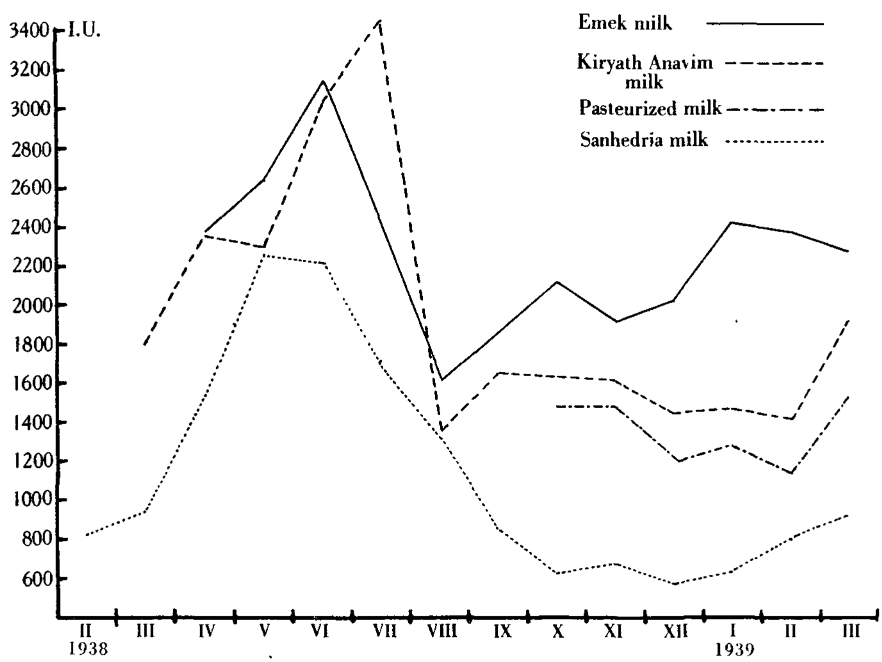

Fig. 1. Seasonal fluctuations of the total vitamin A value of Palestinian milks in International Units (0·6γ carotene = 1 I.U.).

If it is assumed that 0·6 γ of β-carotene corresponds to 1 I.U. of vitamin A the total vitamin A value of milk can be calculated. Fig. 1 gives curves which express the seasonal fluctuations of the total vitamin A contents of milk from all four sources. In every case a diminution of vitamin A content

https://doi.org/10.1017/S0022172400028175 Published online by Cambridge University Press

began about August, but the dates of the subsequent increases differed from January in the Emek milk, to March in the Kiryath Anavim milk, and April in the Sanhedria milk. Inquiry showed that these seasonal variations were related to the proportion of fresh fodder fed to the cows. The Valley of Jezreel provides most green fodder, which is available between January and July. In the hill region of Kiryath Anavim the maximum supply of fresh fodder is not available till March, and then it is less than in the Valley of Jezreel. At the dairy in Sanhedria the cows obtained fresh green fodder only during the second half of the rainy season. In the hilly districts there is no grazing land, and all green fodder has to be transported from the valleys. Transport to Jerusalem is slower and more costly than to Kiryath Anavim.

The curve expressing the total vitamin A content of pasteurized milk runs a course closely parallel to that of fresh Kiryath Anavim milk, which was to be expected since the pasteurized milk also came from Kiryath Anavim. The vitamin A content of the pasteurized milk was less than that of the fresh milk, due probably to some destruction of vitamin A during the process of pasteurization.

The seasonal variation in the ratio of carotene to total vitamin A value, represented in Fig. 2, is of special interest. The average percentage of total vitamin A existing in the form of carotene for the period studied was 50 for Emek milk, 38 for Kiryath Anavim milk and 40 for Sanhedria milk. During the months March to June all the milks contained a relatively higher percentage of carotene and from August to December a relatively lower percentage. July, and January to February, represent intermediate periods, during which the carotene percentage of the Emek milk is higher than the yearly average and that of the Kiryath Anavim and the Sanhedria milks lower. These variations are presumably related to the amount of carotene present in the food. At all times the cow's body apparently tries to maintain an approximately constant level of vitamin A as such. If a large amount of carotene is available, such part as is necessary to maintain this level is converted into vitamin A and the rest is excreted as unconverted carotene. So long as the amount of available carotene does not fall below a threshold value the amount of vitamin A secreted in the milk remains unchanged, as shown by the values obtained for the Emek and Kiryath Anavim milks. If, however, the amount of carotene in the food falls below this threshold value, the vitamin A content of the milk may be appreciably reduced, as in the Sanhedria milk in late summer and in autumn. In other words not all of the carotene ingested is converted into vitamin A. The ratio carotene to total vitamin A may, therefore, serve as an indicator and a more sensitive measure of the nutritional level with respect to provitamin than the amount of vitamin A.

II. *Vitamin C.* As will be seen from the Tables 1–4, the milks from Kiryath Anavim and Sanhedria contain approximately the same amount of ascorbic acid, which is about twice as much as that in Emek milk. The long haul with the accompanying shaking to which Emek milk is subjected

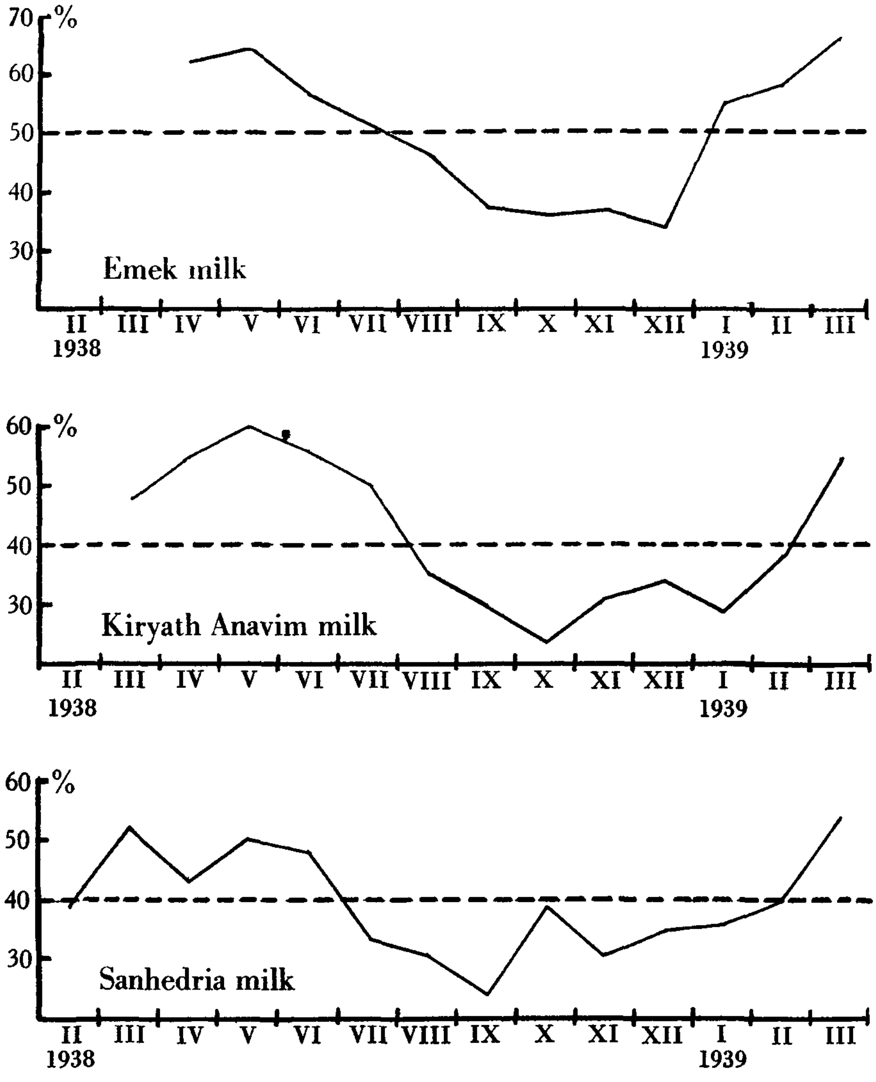

Fig. 2. Percentage of carotene of the total vitamin A values. (Dotted line indicates average for the year.)

Table 4. *Jerusalem pasteurized milk—carotene, vitamin A and vitamin C content*

Month	Fat content %	Carotene, γ % In whole milk	Carotene, γ % In milk fat	Vitamin A, I.U./100 g. In whole milk	Vitamin A, I.U./100 g. In milk fat	Vitamin C mg. %
1938 October	3·2	6	230	36	1110	0·33
November	3·2	8	260	34	1050	0·685
December	3·1	7	225	27	830	0·68
1939 January	3·3	6	170	33	1000	0·23
February	3·2	11	350	17	540	0·605
March	3·4	16	460	25	750	0·29
Average	3·2	9	282	29	880	0·47

https://doi.org/10.1017/S0022172400028175 Published online by Cambridge University Press

apparently destroys a considerable part of this vitamin, probably owing to oxidation.

The curves in Fig. 3 show that there is a seasonal variation in the vitamin C content of milk which does not appear to bear any relation to the type or amount of fodder. Between January and May, Emek milk averaged 0·36 mg. %, and between June and December 0·83 mg. %; the corresponding figures for the Kiryath Anavim milk were 1·045 mg. % between December and May and 1·58 mg. % between June and November; and for Sanhedria milk 0·82 mg. % between December and May and 1·32 mg. % between June and November. Thus, all three milks contained more vitamin C during the second half of the year than during the first.

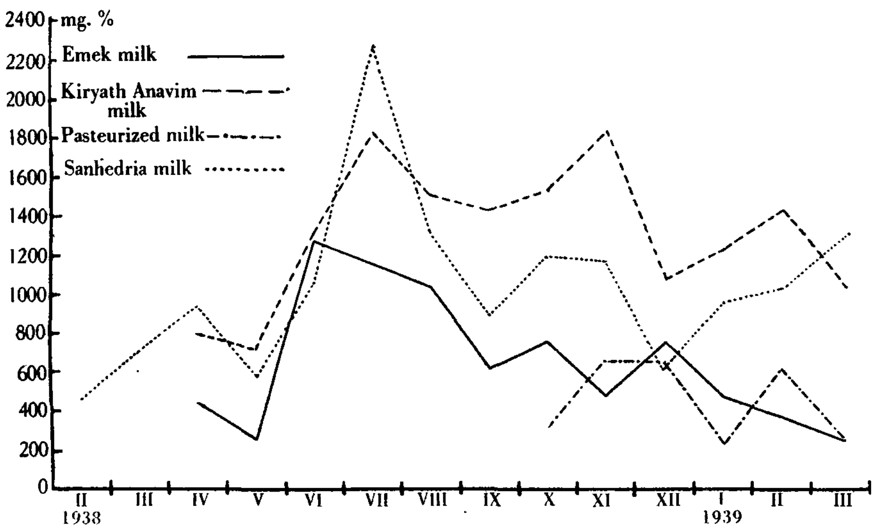

Fig. 3. Seasonal fluctuations of the vitamin C content of Palestinian milks.

DISCUSSION

I. *Carotene and vitamin A.* Fixsen & Roscoe (1938) quote the following values given by European and American authors: stable milk, 145–160 γ % carotene and 740–2610 I.U. of vitamin A per 100 g. milk fat; pasture milk, 290–980 γ % carotene and 2150–3865 I.U. vitamin A per 100 g. milk fat. The values found for Palestinian milk correspond to those for stable milk in other countries. As a matter of fact, in Palestine the cows are stable fed, and even the vitamin A content of the richest milks does not approach that of pasture milk.

Seasonal fluctuations in the vitamin A content of milk have been noticed by other workers. Booth, Kon, Dann & Moore (1933), van Wijngarden (1934), Willstaedt & Witt (1938), Deco (1939), Vronk (1939) and Sharp & Hand (1939) found more vitamin A and carotene in summer than in winter milk, a fact they related to the supply of green fodder. In contrast to these European and American investigators Das Gupta (1937), working in Bengal, found higher vitamin A and carotene values in November to February than in July to October. In India the cattle graze in the winter and are fed with dry hay and straw during the rainy summer season. The relation between pasture or green fodder and vitamin A and carotene is, therefore, a general finding.

Loss of vitamin A as a result of pasteurization has been repeatedly reported. Lundberg (1933) found a loss of about 60% after heating at 63° C. for half an hour. I have not made comparable studies, but a comparison of the figures for the pasteurized and non-pasteurized milks from Kiryath Anavim shows that the loss is considerably less.

II. *Vitamin C.* My results correspond essentially with those of other authors. Fixsen & Roscoe (1938) gave the limits for raw milk as between 0·3 and 2·89 mg.%. The question of seasonal variation has been repeatedly investigated by European and American authors. Some authors report a connexion between such variations and the supply of green fodder. Ferdinand (1936), for instance, working in Germany, found that the values were 0·58–1·68 mg. % between March and April (average 1·1 mg. %) and 0·815–1·8 mg. % in the winter months (average 1·3 mg.%). His figures do not seem to be sufficiently significant to warrant his conclusions. In Riga, Zarins & Putnina (1937) found 0·34–1·19 mg.% in the spring and 0·92–1·69 mg.% towards the end of the summer.

On the other hand, Kon & Watson (1937) found no appreciable difference in the vitamin C content of either stable milk or pasture milk. Similarly, Riddell, Whitnah, Hughes & Lienhardt (1936) found 2·63 mg.% in stable milk and 2·65 mg.% in pasture milk. Whitnah & Riddell (1937) and Riddell & Whitnah (1938) attempt to explain these findings on the basis of feeding experiments with ascorbic acid, which showed a rise in the ascorbic acid content of the blood and of the urine, but no change in the ascorbic acid level in the milk. According to van Wijngarden (1934), West & Wenger (1938) and v. Wendt (1938), the vitamin C content of the milk is independent of the type of fodder.

A seasonal variation similar to the one here reported was observed by Holmes, Tripp, Woelffer & Satterfield (1939) in an investigation on twenty-five cows during a whole year. There were two peaks in February and in October to November in the ascorbic acid excretion in milk, for which these authors were unable to offer an explanation. The Palestine maxima occurred in June and July, seemed independent of the type of fodder and bore no relation to the seasonal variations in the vitamin A content.

That pasteurization destroys the vitamin C in milk to a greater or lesser extent is now well established. In this respect the data given in Table 4 show nothing new. It is, however, important to note that transportation over long distances may cause almost complete loss of this vitamin. This possibility, particularly in hot climates, has already been pointed out by Meulemans & de Haas (1937) from their experience in Batavia.

SUMMARY

1. The vitamin A and vitamin C contents of Palestinian fresh milk from three different sources were determined at regular intervals during the period February 1938 to March 1939. Between October 1938 and March 1939, these contents were also determined in Jerusalem pasteurized milk.

2. The carotene and vitamin A content of Palestinian milk corresponds to that of American and European stable milk. This is due to insufficiency of green fodder in the diet of Palestinian cattle.

3. Emek milk from the Valley of Jezreel contains more carotene and vitamin A than does the Kiryath Anavim milk from a hill district, owing to the better supply of green fodder in the valley. Milk from a Jerusalem dairy contains less carotene and vitamin A than does the milk from the nearby Kiryath Anavim settlement.

4. All the milks examined show seasonal fluctuations in the carotene and vitamin A content. These variations are in direct relation to the supply of green fodder. The secretion of carotene begins to increase in January to April, according to the source of the milk, and begins to fall in August.

5. The average percentage of carotene to the total vitamin A substances (carotene and vitamin A) ranges between 38 and 50. The ratio carotene to total vitamin A varies seasonally and otherwise in accordance with the total vitamin A in the milk.

6. The vitamin C content of Palestinian milk lies in the same range as that of European and American milks.

7. All milks examined contained considerably more vitamin C during the second than during the first half of the year with a peak in June and July. This increase does not seem to bear any relation to feeding practice.

8. The losses of vitamin A and vitamin C found in pasteurized milk correspond with those given by European and American authors.

9. Transportation of milk over long distances may cause almost complete loss of vitamin C.

REFERENCES

BOOTH, R. G., KON, S. K., DANN, W. J. & MOORE, TH. (1933). *Biochem. J.* **27**, 1189.

DAS GUPTA, S. M. (1937). *Sci. Cult.* **3**, 244.

DECO, M. (1939). *C.R. Soc. Biol., Paris*, **130**, 817.

FERDINAND, H. (1936). *Klin. Wschr.* **15**, 1311.

FIXSEN, M. B. & ROSCOE, M. H. (1938). Tables of vitamin content of human and animal foods. *Nutr. Abstr. Rev.* **7**, 823.

GUGGENHEIM, K. (1939). *J. Hyg., Camb.*, **39**, 35.

HOLMES, A. D., TRIPP, F., WOELFFER, E. A. & SATTERFIELD, G. H. (1939). *J. Nutrit.* **17**, 187.

KON, S. K. & WATSON, M. B. (1937). *Biochem. J.* **3**, 223.

LUNDBERG, M. (1933). *Biochem. Z.* **259**, 27.

MEULEMANS, O. & DE HAAS, J. K. (1937). *Ind. J. Pediat.* **4**, 1.

https://doi.org/10.1017/S0022172400028175 Published online by Cambridge University Press

Riddell, E. H. & Whitnah, C. H. (1938). *J. Dairy Sci.* **21**, 121.

Riddell, E. H., Whitnah, C. H., Hughes, J. S. & Lienhardt, H. F. (1936). *J. Nutrit.* **11**, 47.

Sharp, P. F. & Hand, D. B. (1939). *J. Dairy Sci.* **22**, 737.

v. Wendt, G. (1938). *Skand. Arch. Physiol.* **80**, 398.

van Wijngarden, J. C. H. (1934). *Acta brev. neerl. Physiol.* **4**, 49.

Vronk, K. (1939). *Milchwirt. Zbl.* **68**, 65. (*Nutrit. Abstr. Rev.* 1940, **9**, 571.)

West, F. V. & Wenger, J. C. (1938). *Amer. J. Dig. Dis. Nutr.* **5**, 251.

Whitnah, C. H. & Riddell, E. H. (1937). *J. Dairy Sci.* **20**, 9.

Willstaedt, H. & Witt, T. K. (1938). *Hoppe-Seyl. Z.* **253**, 133.

Zarins, E. & Putnina, C. (1937). *Acta Univ. latv.* **3**, 329. (*Brit. Chem. Abstr.* 1937, B, p. 722.)

(*MS. received for publication* 16. IX. 40.—Ed.)