STUDIES OF ANTIOXYGENIC ACTION OF VITAMIN C ON THE CONSTITUENTS OF DRIED WHOLE MILK II. EFFECT OF MUCH ADDED VITAMIN C

STUDIES OF ANTIOXYGENIC ACTION OF VITAMIN C ON THE CONSTITUENTS OF DRIED WHOLE MILK
II. EFFECT OF MUCH ADDED VITAMIN C

By

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In the previous report[1] it was stated that vitamin C added at the rate of 20 mg. per liter before drying milk, calculated on the reconstituted basis, prevents the destruction of vitamin A, B_1 and etc. during drying process and retards the oxidation of the constituents of its dried products during its storage.

We carried out this experiment to make clear the antioxygenic action of vitamin C when it is added to the milk in relatively large amounts.

Experimental Procedure

The standardized milk containing the chemical composition as shown in Tabel 1 was preheated at 76°C for 1 minute and then condensed in an usual vacuum pan at 24.5 – 25 in. of vacuum in the temperature range of 49–53°C.

The concentrated milk was divided into 3 portions; one of the portions was cooled as the control (sample 1), to the second was added *l*-ascorbic acid at the rate of 50 mg. per liter (sample 2) and to the third at the rate of 90 mg. per

Table 1. Chemical composition of the standardized milk.

Water %	Fat %	Protein %	Lactose %	Ash %	Sp. gravity	Acidity %
88.80	2.80	2.98	4.35	0.68	1.0286	0.16

Table 2. Chemical composition of the concentrated milk.

Water %	Protein %	Sp. gravity	Acidity %
60.80	10.43	1 090	0 28

liter (sample 3). The latter two were calculated on the reconstituted basis and cooled. The chemical composition of the concentrated milk is shown in Table 2. The milk was condensed and dried on the same day, and drying was done with the Merrell-Soule spray dryer as in the previous report. Within an hour after drying, the powders were sieved through a 60-mesh screen and packed in this containing about 225 g. per can.

Moisture, fat, protein, lactose, ash, peroxide value, vitamin A and vitamin C were analyzed by the same methods as explained in the previous report[1].

The three samples of the dried whole milk were preserved under the following two conditions: (a) in cans at room temperature and at 37°C; (b) in a vacuum desiccator ($CaCl_2$) at room temperature.

Results

The chemical composition of the three samples of the dried whole milk are shown in Table 3. The destruction of vitamin A and C in the manufacturing process of dried whole milk is shown in Table 4.

Table 3. Chemical composition of the three samples of dried whole milk.

	Control	Sample 2	Sample 3
Moisture %	2.05	2.34	2.17
Fat %	26.05	25.85	26.00
Protein %	26.70	26.78	26.64
Lactose %	39.08	39.03	39.14
Ash %	6.14	6.00	6.39
Acidity cc./100 g.	8.70	8.70	7.80
Vitamin A I.U./100 g.	760	980	920
" C mg./100 g.	6.85	34.30	51.45

Table 4. Reduction of vitamin A and C in the manufacturing process of dried whole milk.

	Control	Sample 2	Sample 3
Reduction of vitamin A in drying process %	28	0	8
Reduction of vitamin C in drying process %	11	32	4

Among the three samples the percentage of destruction of vitamin A was lowest in sample 2. If the percentage of destruction of vitamin A in sample 2 is taken as nul, that in the control was 28 per cent, showing the highest value and that in the sample 3 was 8 per cent. The addition of *l*-ascorbic acid at the rate of 90 mg. per liter is no more effective than that at the rate of 50 mg. Therefore, we believe that the addition of *l*-ascorbic acid in amounts exceeding 20 mg. per liter does not increase the antioxygenic effect.

Table 5. Changes of characters in samples during storage in cans at room temperature and at 37°C.

Storage temp.		Sample No.	Storage (Months) 0	1	2	3	5	6
Room temp.	Peroxide value	Control	0	0	0	0	0	0.19
		2	0	0	0	0	0	0
		3	0	0	0	0	0	0
	Vitamin A I.U./100g.	Control	760	585	420	420	420	420
		2	980	750	600	530	530	530
		3	920	670	500	500	500	500
	Vitamin C mg./100g.	Control	6.85	5.35	3.94	3.50	2.70	3.10
		2	34.30	22.80	20.80	19.60	17.45	20.88
		3	51.45	38.30	33.30	31.17	23.17	29.41
	Oxidized flavour	Control	−	−	+	+	+	+
		2	−	−	−	−	±	+
		3	−	−	−	−	−	±
37°C.	Peroxide value	Control	0	0	0	0.83	0.78	0.51
		2	0	0	0	0	0	0.32
		3	0	0	0	0	0	0.29
	Vitamin A I.U./100g.	Control	760	420	420	350	350	350
		2	980	655	530	530	420	420
		3	920	500	500	500	420	420
	Vitamin C mg./100g.	Control	6.85	3.94	2.88	1.73	1.36	1.71
		2	34.30	18.40	15.40	14.50	10.73	6.71
		3	51.45	31.50	29.87	30.60	21.87	20.77
	Oxidized flavour	Control	−	+	++	++	++	++
		2	−	−	−	−	+	+
		3	−	−	−	−	−	±

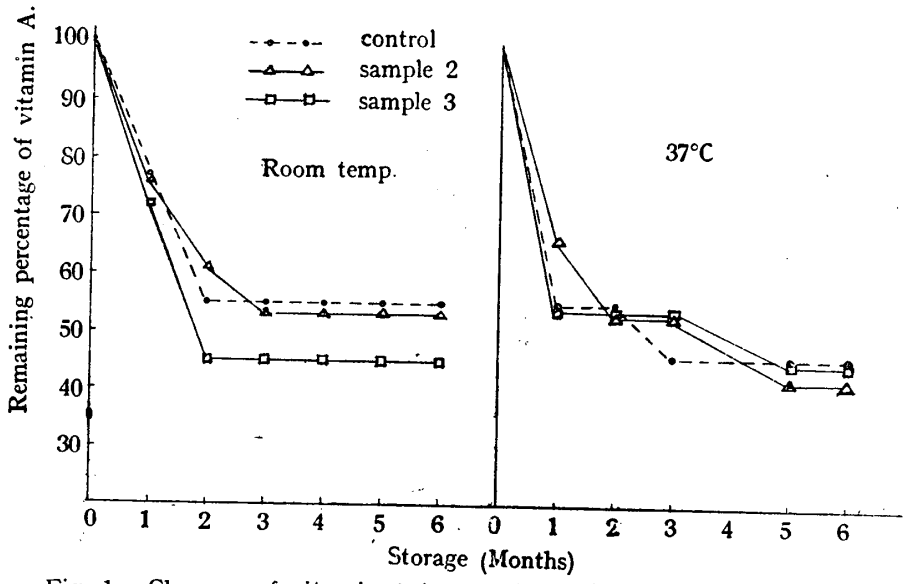
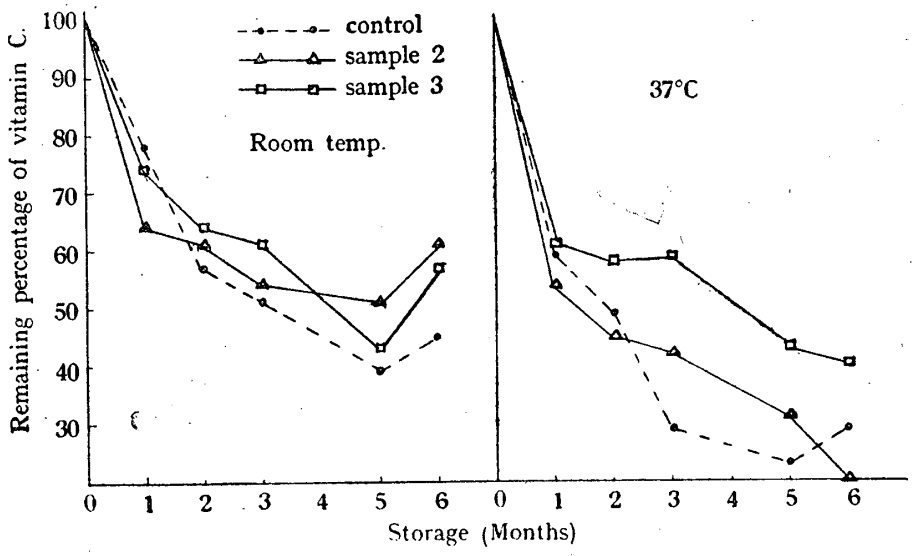


Fig. 1. Changes of vitamin A in samples (dried whole milk) during storage in cans at room temperature and at 37°C.



Eig. 2· Changes of vitamin C in samples (dried whole milk) during storage in cans at room temperature and at 37°C.

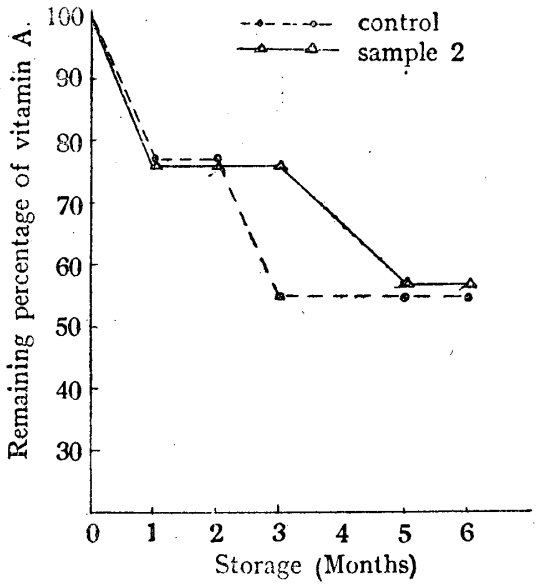


Fig. 3. Changes of vitamin A in samples during storage in a vacuum desiccator at room temperature.

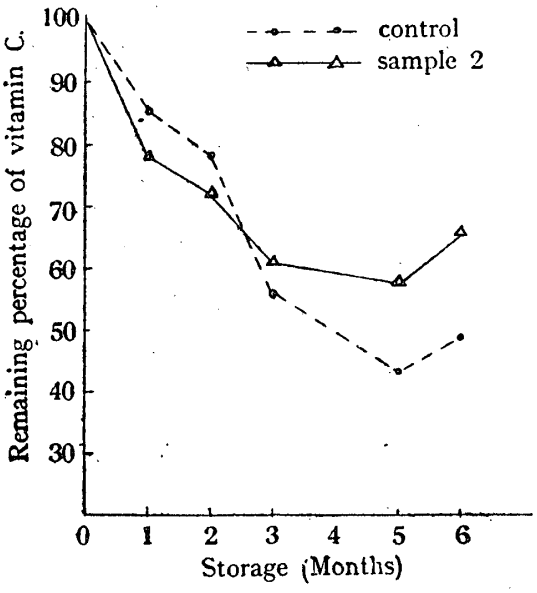


Fig. 4. Changes of vitamin C in samples during storage in a vacuum desiccator at room temperature.

Results obtained in storage in the two conditions.

1. *Storage in Cans at Room Temperature and at 37C°.*

Three samples of dried whole milk packed in cans were stored at room temperature and at 37°C. The results obtained are shown in Table 5. The percentage of the remaining amount of vitamin A and C during storage are shown in Figs. 1

and 2.

2. *Storage in the Vacuum Desiecator ($CaCl_2$) at Room Temperature.*

Cans of powders were opened and stored in a vacuum desiccator ($CaCl_2$) at room temperature and tested. The results obtained are shown in Table 6. The percentage of the remaning amount of vitamin A and C during storage are shown in Figs. 3 and 4.

Table 6. Changes in characters of the samples during storage in a vacuum desiccator at room temperature.

	Sample No.	Storage (Months)					
		0	1	2	3	5	6
Peroxide value	Control	0	0	0	0	0	0
	2	0	0	0	0	0	0
Vitamin A I.U./100g.	Control	760	590	590	420	420	420
	2	980	750	750	750	570	570
Vitamin C mg./100g.	Control	6.85	5.65	5.34	3.87	2.95	3.38
	2	34.30	26.90	24.65	21.06	19.87	22.58
Oxidized flavour	Control	−	−	−	−	+	+
	2	−	−	−	−	±	±

Discussion

K. M. Henry, et al. reported that there is no noticiable loss of vitamin A in the heat treatment of milk and in the manufacturing of dried whole milk and also none in the storage for one year. T. Nakanishi, et al.[1)3)] reported that the vitamin A content of milk was reduced by storage, heat treatment, homogenization and drying of milk and during storage of condensed milk and dried whole milk. R. Sasaki, et al.[4)] reported that vitamin A was destroyed through the various heat treatments and by homogenization. Fujita, et al.[5)] and K. M. Wagner[6)] reported that the vitamin A content of the city milk was much less than that of the fresh raw milk. T. Nakanishi,[7)8)] found that vitamin A of milk was reduced during manufacturing process of butter and churning of milk. Therefore, we believe that vitamin A of milk is destroyed to a certain extent by heat treatment, churning, storage and drying process.

T. Nakanishi, et al.[1)] reported that the addition of vitamin C to the milk before drying protected the destruction of vitamin A of the milk. He[9)] also found that the destruction of vitamin A of milk during storage or churning of milk was reduced to a certain extent by the addition of *l*-ascorbic acid at the rate of 20-50 mg. per liter of milk. Thus, we think that the destruction of vitamin A of milk in various conditions may be prevented by the addition of a certain amount of vitamin C.

In the present experiment, it was found that the addition of 50 mg. of *l*-ascorbic acid exhibited the same protective effect on vitamin A of milk as that of 20 mg. but the addition of 90 mg. was not effective. Therefore, it is believed that the addition of 20-50 mg. per liter of *l*-ascorbic acid may show the antioxygenic action and that of 90 mg. or more may be least in its effect. K. Mori, et al.[10] reported that the addition of vitamin C alone gave no antioxygenic action on vitamin A of margarine but it showed a protective effect with such synergists as tocopherol or citric acid. Thus, we believe that a certain amount of vitamin C may show an antioxygenic action on such constituents of milk as lipid, vitamin A, B_1 and etc. with such synergists as tocopherol, citric acid and other minute constituents in milk.

Summary

The three samples of dried whole milk were manufactured with the addition of none or a relatively large amount of *l*-ascorbic acid (50 and 90 mg.) before drying milk and their effects were examined.

The addition of *l*-ascorbic acid at the rate of 50 mg. per liter of milk exhibited almost the same antioxygenic action to the constituents of milk as that of 20 mg. as described in the previous report[1] but that of 90 mg. had little effect.

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