XXVII. THE VITAMIN C CONTENT OF COW'S MILK

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It has been shown in a previous paper [Kon & Watson, 1936] that vitamin C may be present in milk in two forms, as ascorbic acid and as dehydroascorbic acid. Both are biologically active, but the latter does not react with the indophenol reagent unless treated with H_2S , is labile and undergoes spontaneous decomposition associated with loss of biological activity. Under the action of light the reduced form of ascorbic acid present in milk is reversibly oxidized to dehydroascorbic acid.

The present paper deals with the state in which vitamin C is secreted by the cow and presents estimations of the vitamin C content of herd milk at different times of the year under south of England conditions.

EXPERIMENTAL

A description of the methods used in estimating ascorbic and dehydroascorbic acids in milk will be found in the paper by Kon & Watson [1936].

(1) *The state in which vitamin C is secreted by the mammary gland of the cow*

For the purpose of this investigation it was necessary to obtain milk directly from the udder without any exposure to light. The rubber lining of a teat cup of a milking machine was slipped over the teat and its other end was placed in a milk bottle wrapped in black paper. The milk was then milked into the bottle and the vitamin C titration was carried out at once. All operations were done with the least exposure to light. The results of several estimations are given in Table I which shows that milk as it leaves the normal udder contains only the reduced form of ascorbic acid.

Table I. *The reduced (R) and total (T, reduced and reversibly oxidized) ascorbic acid of milk immediately after milking in the absence of light*

mg. of ascorbic acid in 100 ml.

Cow		Ascorbic acid	
Name	Breed	R	T
Flora 16	Shorthorn	2.30	2.37
Pippin	"	1.86	1.93
Flora 31	"	2.45	2.45
Campion 2	"	2.17	2.17
Rosey 8	Guernsey	2.23	2.31
Rosalie 8	"	2.02	2.02
Average		2.17	2.21

(2) *The vitamin C content of milk at different times of the year*

For the purpose of this investigation "sale" milk¹ was obtained from the Institute's dairy immediately after passing over the cooler, shortly after the morning milking. The milk was from a mixed herd of Shorthorns and Guernseys, which during the time covered by the experiment consisted of 26 Shorthorn and 3 Guernsey cows. All samples were handled in a uniform way with the same amount of exposure to light. Estimations were carried out once or twice a week, but daily measurements were taken for a fortnight after the cows were turned out to grass in spring. The estimations of reduced and total ascorbic acid are given in Fig. 1. There is no evidence of any effect of pasture feeding on the level of

Fig. 1. The vitamin C content of herd milk at different times of the year.

vitamin C in milk. The average figures work out at 2.06 and 2.37 mg./100 ml. for milk from stall-fed cows and 2.06 and 2.35 mg./100 ml. for pasture milk respectively.

(3) *The vitamin C content of colostrum*

The relatively very high concentrations of carotene and vitamin A in colostrum as compared with milk [Dann, 1933; Semb *et al.* 1934] made it of interest to investigate the level of vitamin C in the colostrum secretion.

Table II presents the results of such estimations in the case of 4 cows, while the average values are plotted in Fig. 2.

Fig. 2. The vitamin C content of colostrum, average curves for 4 cows.
--- Total ascorbic acid. — Reduced ascorbic acid.

In three cases out of the four studied the vitamin C content of colostrum is higher than the average for the milk of the Institute's herd. The fourth colostrum contains definitely less vitamin C. The high values drop rather suddenly after

¹ Grade A (T.T.).

Table II. *The vitamin C content of colostrum*

R, reduced; T, total ascorbic acid in mg. per 100 ml.

Days after calving	Lottie 7 Shorthorn		Lottie 9 Shorthorn		Winnie 6 Shorthorn		Valven 2 Guernsey	
	R	T	R	T	R	T	R	T
0	2.34	2.72	1.41	1.62	2.60	3.20	2.20	2.54
1	1.93	2.41	1.79	2.06	2.50	2.97	1.58	1.93
2	1.51	1.75	1.72	1.99	1.93	2.08	1.76	2.11
3	1.31	1.93	1.41	2.04	1.71	2.08	1.69	2.04
4	1.79	2.06	1.76	2.11	1.86	2.23	1.48	1.90
5	1.27	1.94	1.90	2.18	2.26	2.30	1.94	2.18
6	1.41	1.97	1.97	2.11	1.82	2.15	1.83	2.04

2 days at most to a level lower than the normal average. Lack of information does not allow us to say whether this is a transient depression or whether the milks of these particular cows contained permanently less vitamin C. It is evident that the difference between colostrum and milk is much smaller in the case of vitamin C than in the cases of vitamin A and carotene.

(4) *Effect of breed*

Judging from the figures in Tables I and II the vitamin C content of Guernsey milk is the same as that of Shorthorn milk. The few estimations can be taken only as an indication.

(5) *Vitamin C in mastitis*

A solitary estimation of the vitamin C content of the milk secreted by a normal and an infected quarter of the udder of a cow suffering from mastitis has given results sufficiently interesting to be included in this paper. The diseased quarter was found to give milk definitely poorer in vitamin C than that secreted by the normal quarter. The values were 2.19 mg./100 ml. of reduced and 2.48 mg./100 ml. of total ascorbic acid in the normal and 1.44 and 1.87 mg./100 ml. respectively in the infected quarter.

DISCUSSION

The finding that the level of vitamin C in mixed milk is remarkably constant and independent of the season and the nutrition of the cow is in agreement with reports from other laboratories which have made use of the dichlorophenol-indophenol reagent [Harris & Ray, 1935; van Wijngaarden, 1935; Riddell *et al.* 1936].

It is true that Rasmussen *et al.* [1936], who also used the reagent, express the opinion that "after the first two months of lactation, the ascorbic acid content of milk is apparently dependent solely upon the ascorbic acid content of the diet of the cow". This opinion however is not based on experimental evidence, as throughout the experiment the diet of the cows remained unchanged. The authors have obviously not considered the possibility of a synthesis of vitamin C by the cow. They report values for the vitamin C content of milk definitely lower on the whole than those found by us and by van Wijngaarden [1935] and Riddell *et al.* [1936]. It seems probable that their observations have been complicated by exposure of the samples to light, especially as some of them were stated to have developed a cardboard flavour on standing. Marked seasonal variations have been reported by Stoerr [1936], who used the Bezssonoff reagent. These findings have not so far been confirmed.

SUMMARY

1. The healthy mammary gland of the cow secretes vitamin C only in the reduced form. No reversibly oxidized ascorbic acid is found in the milk as it leaves the udder.

2. Under south of England conditions, the season of the year and the nutrition of the cows have no effect on the vitamin C content of herd milk. The average figures for sale milk from a herd composed of about 26 Shorthorn and 3 Guernsey cows work out at 2.01 mg. of reduced and 2.37 mg. of total ascorbic acid per 100 ml. of milk during the stall-feeding period and 2.06 and 2.35 mg./100 ml. respectively on early pasture.

3. The vitamin C content of colostrum is only slightly higher than that of milk.

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