XCVIII. THE EFFECT OF COD-LIVER OIL FEEDING ON THE CALCIUM AND PHOSPHORUS CONTENT OF COWS' MILK.

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THE increase in the vitamin D content of cows' milk effected by the feeding of cod-liver oil is well recognised and can be demonstrated by experiments on rats. Hart *et al.* [1926, 1927] and Harvey [1927] have brought forward evidence to show that in the case of lactating animals the absorption of vitamin D from cod-liver oil or other food or through the agency of sunlight aids under certain conditions, the mineral metabolism, particularly the retention of calcium and phosphorus. As to the effect of the increased absorption of calcium and phosphorus on the quantity of these substances in the milk the results are conflicting. Miller [1926] found, in the case of the cow, a better assimilation of calcium and phosphorus with clover hay than with timothy hay, and also a better assimilation of calcium on high than on low quality protein, but he was unable to detect any definite change in the calcium and phosphorus in the milk. Indeed results like those of Becker, Eckles and Palmer [1927] in which it is shown that the milk of cows suffering from osteomalacia and showing a negative calcium balance did not differ in its calcium and phosphorus content from normal milk would seem to indicate that the calcium and phosphorus content of milk remains constant. On the other hand Harvey [1927], whilst effecting an improvement in the calcium balance of a lactating goat, found that, at least in the late stages of lactation, the percentage and the total calcium in the milk was increased by the administration to the animal of cod-liver oil; and Mattick [1928] claims that the giving of cod-liver oil to milking cows increases the percentage and the total calcium in the milk. The evidence put forward by Mattick is, however, not convincing proof of the tentative statement made in this connection.

In the course of an investigation into the effect of food on butter fat¹ conducted by one of us (E. J. S.) an opportunity offered itself to analyse the milk for calcium and phosphorus during the periods when certain foods, including cod-liver oil, were given. The results obtained were compared with those determined during periods of normal feeding.

¹ To be reported in a separate communication.

EXPERIMENTAL.

Three cows of cross-bred shorthorn type which calved at the following dates—cow 1, October 12th, 1928, cow 2, November 15th, 1928, cow 3, September 10th, 1928—were given a ration which was made up as follows: for maintenance, 1 stone hay, 4.5 lb. sugar pulp (steeped); for production, 3.5 lb. of the following mixture per gallon of milk produced:

0.5 lb. ground nut cake	} 3.5 lb. of this mixture contains 2.5 lb. of starch equivalent and 0.6 lb. of protein equivalent
0.5 lb. cotton seed meal	
0.5 lb. palm nut cake	
0.5 lb. linseed cake	
1.5 lb. bean meal	
1.5 lb. maize meal	
1 lb. oats	

2.5 % mineral mixture (2 parts sterilised bone flour, 2 parts ground limestone, 1 part common salt)

Water was provided twice daily.

The above system of feeding is referred to in the text as normal diet. A complex mixture was included in the production ration with the purpose of providing a suitable basic ration, in order that the effect of adding single oils to it might be determined. The cows were continuously housed during the period of the experiment, milked twice daily, and kept under constant conditions. The constancy of the treatment is shown by the fact that the milk yield of each animal remained practically unchanged for 4 or 5 months. The experiment was divided into six successive periods during which the feeding and treatment were as follows. Period I, normal diet; period II, referred to in graph as olive oil $\frac{1}{2}$ dose, olive oil, 0.5 oz. per 3.5 lb. of meals given (cow 1 received 4 oz.; cow 2, 3 oz. and cow 3, 3 oz. daily); period III, olive oil, 1 oz. per 3.5 lb. of meals given; period IV, cod-liver oil, 1 oz. per 3.5 lb. of meals given (cow 1 received 8 oz.; cow 2, 6 oz. and cow 3, 6 oz. daily); period V, olive oil, 1 oz. per 3.5 lb. of meals given; period VI, normal diet. Calcium was determined in the milk of each cow daily, and a phosphorus determination was made for each cow for each period on a sample of milk composed of aliquot parts of the daily milk yields for the individual cow for the period in question. Calcium was determined volumetrically by precipitation from a solution of the ash of a weighed quantity of milk with ammonium oxalate and ultimately titrating with 0.1 N potassium permanganate; phosphorus was determined in the ash of a weighed quantity of milk by the Pemberton-Neumann method as modified by Richards and Godden [1924]. In each case duplicate analyses were made.

Particulars of the experimental periods and the results of the determinations of calcium and phosphorus in the milk are given in Fig. 1.

The results indicate no change in the percentage of calcium or phosphorus in the milk as a result of substituting cod-liver oil for olive oil in the diet of the cows, and show that the addition of either olive or cod-liver oil to the normal diet similarly made no change in the percentage of calcium or phosphorus in the milk. Day-to-day variations occur in the percentage of calcium, and presumably also in the percentage of phosphorus, but such variations are

Fig. 1.

common to many of the constituents of milk. Their occurrence, however, nullifies the value of comparative results for calcium as obtained from determinations of the calcium content of milk taken at random dates. The total calcium and phosphorus in the milk is almost similar in each period, and in this connection it must be remembered that the milk yield remained practically constant during the different periods. It is worthy of observation that, while, with an unchanging milk yield, the addition of cod-liver oil to the diet effected

no change in the calcium or phosphorus of the milk, it at the same time seriously reduced the percentage of fat therein. This effect of cod-liver oil on milk fat has already been reported [Channon *et al.*, 1924; Drummond *et al.*, 1924; Golding *et al.*, 1926; Golding and Zilva, 1928]. During the experiment the cows, which were in moderately good condition, maintained their weight at a fairly constant figure.

SUMMARY.

The addition of 6–8 oz. of cod-liver oil daily to the diet of milking cows, which were fed on a winter ration including hay, roots and meals, and had reached the fourteenth, eleventh and nineteenth week respectively of the lactation period, did not alter the calcium or phosphorus content of the milk produced.

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