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The Nutritive Value of Colostrum for the Calf

2. The Effect of Small Quantities of the Non-fatty Fraction

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The experiments described in the preceding paper (Aschaffenburg, Bartlett, Kon, Terry, Thompson, Walker, Briggs, Cotchin & Lovell, 1949) have shown that, under our conditions, the factor most essential for the survival of the newborn calf is contained in the non-fatty fraction of colostrum, and that it might be active in very small amounts. It was, therefore, decided to do further experiments with quantities of the non-fatty fraction smaller than the 7200 ml. originally given to each calf. A preliminary experiment indicated that moderately reduced quantities were still fully protective, and the effects of more drastic reduction were then tested on a larger scale. A subsidiary test of the effects of heat treatment on the protective power of colostrum was also made.

METHODS

Preliminary experiment

Each of the last two blocks of Shorthorn and Ayrshire calves in the experiment described on p. 193 of the preceding paper (Aschaffenburg *et al.* 1949) was enlarged by the addition of two calves, one of which was given 3000 ml. (treatment 2A), the other 900 ml. (treatment 2B) of the non-fatty fraction of colostrum instead of 7200 ml. (treatment 2). The quantity of 900 ml. was given in the first feed, that of 3000 ml. during the first 24 hr., otherwise the original procedures were followed.

Main experiment

The experimental details were mostly as already described, but Shorthorn calves only were used, as they appeared slightly less resistant than Ayrshire calves. Instead of

1st- and 2nd-day colostrum, only 1st-day Shorthorn colostrum was collected from eight cows, and the aqueous phase was separated in an ordinary cream separator and not in the Sharples supercentrifuge. After addition of the non-vitaminized margarine the diet was cold-stored in 200 instead of 300 ml. portions, and one blend, prepared as already described (Aschaffenburg *et al.* 1949, p. 189), was used for feeding. The blend contained 1·9% margarine, 17·4% solids-not-fat and 2·21 g. nitrogen/100 ml. The small quantities of the non-fatty fraction were given in the first feed. Twenty-four bull calves were used. The calves in each of six blocks of four received 0, 80, 200 or 400 ml. of the blend, and were then kept on the 'synthetic milk' (Aschaffenburg *et al.* 1949, p. 188) for 3 weeks.

Experiment with heat-treated non-fatty fraction of colostrum

A blend of the non-fatty fraction identical with that used in the main experiment was prepared and heated to 63° for 30 min. Each of three calves received 80 ml. of this material in its first feed.

RESULTS

Preliminary experiment

The results are shown in Table 1.

It will be seen that the reduction in treatment 2B of the quantity of the non-fatty fraction to one-eighth of that previously given had no significant adverse effect on the performance of the calves.

Table 1. *Performance of calves given moderately reduced quantities of the non-fatty fraction of colostrum, compared with that of corresponding calves given the full allowance of 7200 ml.*

	Treatment (no.) and quantity (ml.) given		
Details of calves	2 7200	2A 3000	2B 900
No. used	4	4	4
No. died	0	0	0
Mean performance score* (%)	88 ± 3†	92 ± 3†	82 ± 4†
Mean live-weight gain during first 21 days (lb.)	12 ± 4·2†	13·5 ± 1·5†	9·5 ± 5·8†

* See Aschaffenburg *et al.* (1949). † Values with their standard errors.

Main experiment

The results (Table 2) are quite clear-cut: all the calves given the small quantities of the non-fatty fraction survived. Of the six animals which received no colostral food five died, and there was a strong suspicion that the only survivor had suckled its dam before arrival at the Institute (see Aschaffenburg, 1949). *Bacterium coli* was recovered from the heart-blood, bone marrow, mesenteric lymph nodes, and contents of the small intestine of the five calves that died. Though all calves given colostrum in this experiment survived, the performance scores were lower than that of 81% with the full dose of 7200 ml. obtained in the previous experiment (Aschaffenburg *et al.* 1949).

Table 2. *Performance of calves given in their first feed different quantities of the non-fatty fraction of colostrum, and then the 'synthetic milk' for 3 weeks*

	Treatment (no.) and quantity (ml.) given			
	0	2C	2D	2E
Details of calves	0	80	200	400
No. used	6	6	6	6
No. *died*	5*	0	0	0
Mean performance score† (%)	‡	66 ± 5§	72 ± 4§	67 ± 4§
Mean live-weight gain during first 21 days (lb.)	‖	3 ± 2·3§	4 ± 1·9§	2 ± 0·7§

* The calves died on the 4th, 5th, 3rd, 5th and 4th day.
† See Aschaffenburg *et al.* (1949).
‡ 11% for the only survivor.
§ Values with their standard errors.
‖ 8 lb. for the only survivor.

This was probably because, with the reduced quantities of colostrum, scouring was more frequent and severe. This affected the performance scores (Aschaffenburg *et al.* 1949) directly, and also through the adverse effect on the growth of the calves, especially as, in order to control scouring it was, at times, necessary to cut down the quantity of food offered. The mean live-weight gains for all Shorthorn calves given the non-fatty fraction in this and previous experiments are summarized in Table 3.

Table 3. *Mean live-weight gains of calves given different quantities of the non-fatty fraction of colostrum*

Experimental details	Quantity of non-fatty fraction (ml.)	No. of calves	Mean birth weight (lb.)	Mean live-weight gain during the first 21 days (lb.)
Aschaffenburg *et al.* (1949), p. 193	7200	8	83	14 ± 2·2*
This paper, p. 197	3000	2	80	12
	900	2	84	8
This paper, p. 198	400	6	86	2 ± 0·7*
	200	6	83	4 ± 1·9*
	80	6	77	3 ± 2·3*

* Values with their standard errors.

Although the experiments were not all done simultaneously, the results in Table 3 show that the growth of calves was related to the quantity of the non-fatty fraction of colostrum they received. It will be recalled that in the present experiment only 1st-day colostrum was used which presumably had a higher protective power than the mixture of 1st- and 2nd-day colostrum given in the earlier experiments.

Experiment with heat-treated non-fatty fraction of colostrum

As with the corresponding calves in the main experiment, scouring was severe during the experimental period of 3 weeks, but all three calves survived. Their mean performance score (%) was 61 ± 3 and their mean live-weight increase (lb.) amounted to 2 ± 1·5. The results indicate that heating to pasteurizing temperature did not impair the protective value of the non-fatty fraction of colostrum.

DISCUSSION

The results in Table 2 show that as little as 80 ml. of the non-fatty fraction sufficed to protect calves from fatal scours, though it did not enable them to gain weight normally. It is noteworthy that, with the reservations just made on p. 198, this quantity was of the same order as that estimated to have been present in the crude fatty fraction given to calves on treatment 1 in the previous series of experiments (Aschaffenburg *et al.* 1949). The relatively good performance of those calves first suggested that the protective factor present in the aqueous phase might be active in very small concentrations. However, calves on treatment 1 did not show the poor growth observed in the present experiment; their mean live-weight gain during the first 21 days was 16 ± 2 lb. (Aschaffenburg *et al.* 1949, Table 2). As calves grew equally well on a diet devoid of colostral fat, i.e. the non-fatty fraction of colostrum, provided it was given in relatively large quantities, it seems likely that shortage of a component common to the crude fatty fraction and the non-fatty fraction was responsible for the subnormal growth of the calves that received only a small amount of the non-fatty fraction. It is possible that this component is lecithin which, according to Esh, Sutton, Hibbs & Krauss (1948), is of importance in the nutrition of the newborn calf. Horrall (1935) has shown that skim milk contains about 50% of the total lecithin of milk. His data suggest that in colostrum the lecithin is more highly associated with the fat than in milk. If it is assumed that two-thirds of the lecithin are present in the fat of colostrum, the quantity of the crude fatty fraction given in treatment 1 would contain about as much lecithin as 5 l. of whole colostrum, clearly a more than adequate supply. In this respect 7200 ml. of the non-fatty fraction of colostrum, which also provided for good growth, would be equivalent to *c.* 2·5 l. of whole colostrum. Experiments are now in progress on the effect of lecithin supplements on the growth of calves protected by a small quantity of the non-fatty fraction of colostrum.

Since the work here reported was completed, further experiments, to be published later, have shown that removal of casein and of dialysable components from the non-fatty fraction of colostrum leaves its protective power unimpaired. All our findings, therefore, lend support to the classic views of Theobald Smith about the immunological properties of colostrum, most likely to reside in its globulin fraction. It is possible that, at the same time, colostrum provides the calf with essential components of direct nutritive importance.

SUMMARY

1. Four newborn bull calves received an initial allowance of 3000, and four of 900, ml., of the non-fatty fraction of colostrum described in the previous paper (Aschaffenburg *et al.* 1949), instead of 7200 ml. This was followed for 3 weeks by the standard diet based on dried skim milk. The reductions in the quantity of colostrum given had no marked adverse effect on the performance of the calves.

2. Evidence for the high protective power of colostrum was obtained in a larger experiment in which twenty-four newborn Shorthorn bull calves, grouped into blocks of four, were given in their first feed 0, 80, 200 or 400 ml. of the non-fatty fraction of

colostrum, and were then kept for 3 weeks on the standard diet. Of the six calves deprived of colostrum five died. All the other calves survived.

3. The survivors scoured severely, and gained little weight during the experimental period.

4. Heating to 63° for 30 min. did not impair the protective value of the non-fatty fraction of colostrum.

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The Nutritive Value of Colostrum for the Calf

3. Changes in the Serum Protein of the Newborn Calf following the Ingestion of Small Quantities of the Non-fatty Fraction

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The serum of the newborn calf contains little or no euglobulin and pseudoglobulin I (Howe, 1921*b*). A marked increase in these protein fractions results from the ingestion of colostrum. Similarly, more recent studies, particularly by E. L. Smith (for a summary see Smith, 1948), have demonstrated the absence from the serum of the newborn calf of electrophoretically slow-moving globulins and their appearance following the intake of colostrum. These globulins are identical with the 'immune lactoglobulins' present in colostrum. The properties of these fractions differ slightly but significantly from those of the γ- and T-components found in the serum of the adult bovine (Smith, 1948). With calves receiving large amounts of colostrum the appearance of the 'immune lactoglobulins' in the blood stream can be demonstrated with ease, but it was