CXXXVI. THE INFLUENCE OF THE ADMINISTRATION OF CERTAIN SALTS ON THE YIELD AND COMPOSITION OF MILK.

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INTRODUCTION.

It is a well-established fact that the calcium concentration of blood remains at a very constant level, and that no measurable effects are produced by feeding rations with abnormally high contents of calcium. Recently Stewart and Haldane [1924] have claimed that the calcium content of human blood serum can be altered, within limits, by the oral ingestion of large quantities of certain salts. The objects of the experiments recorded below were to ascertain whether similar alterations could be effected in the calcium content of the blood plasma of lactating cows, and to discover what alterations, if any, were induced in the composition of the milk by this means.

The animal selected for the experiments was a white Shorthorn heifer; she weighed approximately 500 kilograms, and at the commencement of the experiments was in her fifteenth week of lactation, yielding 13 lbs. of milk per day.

Each experimental period was of about one week's duration, the animal being given sufficient time between the experiments to allow of recovery to normal.

The salts used were: (1) for raising the plasma calcium content, calcium chloride and ammonium chloride; (2) for lowering the plasma calcium content, sodium bicarbonate and disodium hydrogen phosphate (Na_2HPO_4). The salts were given in solution as "drenches," the doses being spread over a period of six hours (10 a.m. to 4 p.m.).

During the experimental periods, the cow remained on a normal daily ration, which consisted of $3\frac{1}{2}$ lbs. seeds hay, 30 lbs. silage, 20 lbs. marrow stem kale, 50 lbs. mangels, and $2\frac{1}{2}$ lbs. concentrates. This ration contains approximately 4 ozs. of CaO and 3 ozs. of P_2O_5 .

For convenience we have divided the results into two sections, the first showing the effect of the various salts on the calcium content of the blood plasma, and the second, their influence on the composition of the milk.

CALCIUM CONTENT OF BLOOD PLASMA.

The method of analysis employed has been published elsewhere [Little and Wright, 1925].

A summary of the results obtained is shown in Table I, and in Table II these results are compared with those obtained by Stewart and Haldane on a human subject.

Table I. *Alteration in the Calcium Content of Cow's Blood Plasma.*

Experiment*			mg. Ca per 100 g. plasma
Day 1. CaCl_2	6 oz.	Next morning	9.6
Day 2. "	12 oz.	"	10.1
Day 1. NH_4Cl	8 oz.	—	—
Day 2. "	16 oz.	6.0 p.m. same day	7.35
		Next morning	8.4
Day 1. NaHCO_3	6 oz.	Next morning	9.8
Day 2. "	12 oz.	—	—
Day 3. "	24 oz.	5.0 p.m. same day	9.8
Day 1. Na_2HPO_4	32 oz.	8.0 p.m. same day	9.0

* All doses given between 10.0 a.m. and 4.0 p.m.

Table II. *Comparison of Results.*

Salt	Dose (g. per kg. body-weight)		Percentage rise or fall	
	Human	Cow	Human	Cow
CaCl_2	0.30	0.36	+25	-2
	—	0.72	—	+3
NH_4Cl	0.25	0.48	+10	—
	—	0.96	—	-24
NaHCO_3	0.60	0.36	-20	± 0
	—	0.72	—	—
	—	1.44	—	± 0
Na_2HPO_4 *	0.60	1.90	-20	-8

* Private communication from Dr J. B. S. Haldane.

It will be seen that none of the results is in agreement with those recorded by these two workers. The results are the more striking since in our experiments doses were given which were proportionately and actually far in excess of those quoted by them as adequate to produce marked alterations in the serum calcium content.

At present it is impossible to explain this discrepancy. The results obtained by us can hardly be attributed to analytical errors, for very great care was taken to guard against these: the quantities of plasma at our disposal (varying from 15 to 25 g.), and the good agreement of duplicate determinations were alone sufficient to preclude the possibility of errors of such magnitude. From this point of view the use of a cow as an experimental animal was of considerable advantage.

Further, the more complete results shown in Fig. 1 demonstrate the very consistent results obtained throughout each experimental period.

It appears possible that the different morphology of the alimentary tract of the cow and the different nature of the diet may be responsible for these contradictory results, though such an explanation cannot account for the action of the ammonium chloride. It is also possible that the cow has developed a more efficient mechanism for controlling the level of calcium in the blood, since she is liable to continual loss of large quantities of calcium in the milk. In any event, our work demonstrates that the calcium content of the blood plasma of a lactating cow cannot very easily be altered. This result is contrary to those obtained by Stewart and Haldane for the human subject.

Fig. 1. Effect of administration of salts on the calcium content of the blood plasma.

(Dotted line represents normal value.)

YIELD AND COMPOSITION OF MILK.

In three of the four experimental periods (dosage with calcium chloride, sodium bicarbonate, and disodium hydrogen phosphate) there were no significant alterations either in the yield of milk or in those constituents of the milk which were estimated, *i.e.* fat, total protein, caseinogen, lactose, ash and calcium (Figs. 2 and 3). With regard to other inorganic constituents we have no direct evidence. Measurements have been made of the time of coagulation of milk with rennet, a reaction which we should expect to be a delicate measure of alterations in the "salt balance" in milk. In no case were there any significant alterations in renneting time. There were also no alterations in reaction, as judged by colorimetric tests with bromocresol purple indicator.

In the third period (dosage with ammonium chloride) the changes were profound. The following are the notes recorded during this experimental period.

Fig. 2. Effect of administration of (A) CaCl_2 , (B) NaHCO_3 , (C) Na_2HPO_4 , on the yield and composition of milk.

Fig. 3. Lactation curve, showing effect of administration of salts on milk yield.

"The first day was kept as a control, and no dose given.

"No adverse effects were observed after ingestion of 8 ozs. on the second day (March 17th, 1925).

"On the third day (March 18th) doses were given as follows: at 10 a.m. 6 ozs., at 12 noon 6 ozs., at 2 p.m. 4 ozs. At 3 p.m. the cow showed signs of discomfort. She refused food, was breathing rapidly, and would not rise. At 5.30 p.m. she was still unable to rise and was obviously distressed. At 7.30 she had risen but was not comfortable: there was profuse urination. The milk yield was reduced from 4 lbs. to less than $\frac{1}{2}$ lb. The following morning (March 19th) she was up, but off her feed; her eyes were glazed, but sight appeared normal: the milk yield was almost entirely suppressed. The following day (March 20th) she appeared easier; breathing was normal: the eyes appeared weak, and the left eyelid was swollen. The milk yield was increased. From this time there was a gradual recovery both in condition and in milk yield."

Fig. 4. Effect of administration of NH_4Cl on yield and composition of milk.

It will be noted that on the third day, after ingestion of the large dose (16 ozs.) of ammonium chloride, the milk yield fell to a fraction of the normal

figure (Fig. 4). The composition of the milk, however, remained normal, except for the fat which was slightly low. During the next five milkings, the yield remained low (varying from $\frac{1}{2}$ to $1\frac{3}{4}$ lbs.), but the composition was entirely altered. The fat, protein and ash rose to a maximum at the time of the fourth milking (in which the fat reached 17 % and the protein 7.5 %), but subsequently returned to normal as the milk yield increased. The lactose on the other hand fell to a minimum at the third milking, and then slowly returned to a normal value.

The explanation of these facts is not clear, but the following suggestions are put forward to account for the observed results. The immediate consequence of the heavy dosage was a complete disorganisation of normal metabolism, which resulted in a partial suppression of milk yield, but which caused no alteration in the composition of the small quantity which was secreted. In the two following days, although the quantity of milk secreted had increased, the ammonium chloride exerted its influence as a dehydrating agent [Haldane, Hill and Luck, 1923], and caused by the removal of water a concentration of the constituents of the milk to the extent shown in Fig. 4. The lactose, which is easily diffusible, was re-absorbed into the blood stream, and actually appeared in the milk in lower concentration than normal.

The whole experiment indicates, however, that the methods employed are useless for the purpose for which this part of the work was undertaken, *i.e.* the correlation of the calcium content of blood and milk.

In the first three periods of the experiment (dosage with CaCl_2 , NaHCO_3 and Na_2HPO_4), although very considerable quantities were given, the results proved negative: in the fourth period (dosage with NH_4Cl) the interference with normal metabolism was so great as to cause suppression of milk yield and gross alterations in composition, with consequent vitiation of results.

SUMMARY.

Attempts have been made to alter the calcium content of the blood plasma of a cow by means of large oral doses of certain salts, and the effect of these salts on the composition of the milk has been studied.

The results indicate (*a*) that it is extremely difficult to alter the plasma calcium content by these means, and (*b*) that it is impossible by such means to effect any alteration in the composition of the milk.

With ammonium chloride (16 ozs.) the severe disturbance of normal metabolism, and the dehydrating action of the salt, caused an almost complete suppression of milk yield, accompanied in its later stages by a temporary increase in the concentration of the constituents of the milk.

REFERENCES.

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