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The influence of different Ca and P supplies on the vitamin A, Cu and Mn status of young cattle with additional effects of growth and season

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Summary

The supply of 130 g $CaCO_3$ or 100 g Na_2HPO_4 per animal per day (Ca/P ratios in the rations of 3 and 0.5 respectively) did not significantly influence the growth or the vitamin A, Cu and Mn status of six one-year-old cattle. Some indication for a retarded growth should be perceived in the high P group.

The existence of a direct relationship between lowering of Cu status and a reduced transportation of vitamin A from blood to liver could not be proved. The figures can be reasonably explained by effects of supply of Cu and carotene connected with growth and season.

Insufficient growth and development of cattle is a problem which seems to be connected with various factors. In this respect the supply of several minerals and vitamins is considered to be of major importance. Pending any long term feeding trials, it is desirable to be acquainted with the existing situation.

P-deficiency is assumed to impede the conversion of carotene into vitamin A (Kirchgessner et al., 1966).

Tompsett (1940) and Dick (1952, 1953, 1954) stated that Cu absorption in sheep may be decreased by higher Ca contents in the feed. According to Kirchgessner (1959) more than 0.9 % Ca in the dry matter of the ration leads to negative Cu balances. The rate of dialysis or diffusion of Cu in vitro remained stable up to pH 5.5; above that, however, it greatly diminished, which is assumed to decrease the Cu-absorption in vivo. On rations low in Cu, Huber et al. (1965) found that in dairy cows the release of copper from the liver was smaller when $Ca_3(PO_4)_2$ was added; $CaCO_3$ had no effect.

According to Hawkins et al. (1955) and Grashuis (1957) a high Ca and P content in the ration may cause or increase Mn-deficiency in ruminants. Ruminants, however, are less sensitive to Mn-deficiency than, for instance, birds, which is stated to be connected with differences in basal metabolism and oxidative phosphorylation processes, in which Mn is of great importance (Cotzias, 1962).

More than 2 % $CaCO_3$ in the feed causes a depression in the digestibility of organic matter in ruminants (Colovos et al., 1958; Ammerman et al., 1963; van Leeuwen et al., 1965/1966). This might affect the growth of animals.

According to Wise et al. (1963), Ca/P ratios in the ration, smaller than 1, give a growth- and a digestion-depression in calves. Ratios between 1 and 7 did not give any changes and Ca/P ratios from 7 to 14 again affected growth unfavourably.

The first topic of the present investigation is to study the effect of different quantities of Ca and P in the feed ration of young cattle on the vitamin A, Cu and Mn content in liver and blood plasma.

The results of the experiment with some additional data enable at the same time the study of the behaviour and the mutual effect of Cu, Mn and vitamin A in liver and blood in connection with growth and season.

Experimental

Six about 9-month-old female cattle of the Dutch-Friesian breed were stabled. According to a change over design, three groups of two animals were fed hay and concentrates with extra Ca, extra P and with control pellets during periods of 50 days each.

The barn-dried hay was group-fed, the concentrates in pelleted form were fed individually. The concentrates were composed of 37 parts cottonseed oil meal, 49 parts maize meal and 9 parts molasses. To this were added 6.5 parts $CaCO_3$ and 1 part NaCl for the high Ca group, 5 parts disodium phosphate (anhydrous) for the high P group and 1.4 part $CaCO_3$ and 1 part NaCl for the control group.

Table 1 gives the chemical analyses of hay and concentrates. Table 2 gives the composition of the rations and the intake of different constituents of the ration. The animals were weighed and liver – by biopsy – and blood samples were taken on 25 November 1968 (end of pasture period), 14 January, 4 March and 23 April 1969.

Table 1. Dry matter content and composition of the dry matter of hay and concentrates (without additions of Ca and P).

		Hay	Concentrates
Dry matter	(%)	83.2	83.5
Ca	(%)	0.54	0.19
P	(%)	0.40	0.58
Mn	(ppm)	57	28
Cu	(ppm)	8	17
Carotene	(ppm)	2	0
Starch equivalent	(small units)	45	74
Dig. crude protein	(%)	8.3	19.8

Table 2. Intake of some ration constituents in the different treatmentgroups and composition of the total ration.

		High Ca	Control	High P
Intake of hay per animal per day	(kg)	4.6	4.6	4.6
Intake of concentrates per animal per day	(kg)	2.0	2.0	2.0
Intake of Ca per animal per day	(g)	76	35	24
Intake of P per animal per day	(g)	25	25	44
Ca in dry matter of total ration	(%)	1.39	0.64	0.43
P in dry matter of total ration	(%)	0.46	0.46	0.81
Ca/P ratio of total ration		3.0	1.4	0.5

The liver samples were analysed for Mn, Cu and vitamin A content, the blood plasma for vitamin A and occasionally Cu. After completion the experiment, when the animals were again at pasture, the vitamin A content of liver and bloodplasma was determined a few times. The Mn determinations were made by neutron activation analysis.[1] The other analyses were made by classic chemical methods.

Results

Table 3 gives the average results of the experiment. The mean values do not indicate significant influences of the different treatments. Animals on high P show a tendency ($P < 0.10$) to retarded growth (compare Wise et al., 1963).

Vitamin A, Cu and Mn contents of liver show a general and significant decrease with time (period means). In autumn the animals have a better Cu status than at the end of the stabling period.

The average weight gain of the animals during the experiment was 780 g per day.

Table 4 gives correlation coefficients between growth and changes in vitamin A, Cu and Mn levels in liver and blood plasma during the experiment. Table 4 shows

[1] Our special thanks are due to Dr Ir H. A. Das of the Reactor Centre Netherlands at Petten.

Table 3. The average results per treatment and per period.

Treatment	Body weight (kg)	Plasma vit. A I.U./ 100 ml	Liver		
			vit. A I.U./g	Cu µg/g	Mn µg/g
Extra Ca	278	128	112	128	12
(Negative) control	276	122	114	138	13
Extra P	272	120	136	173	12
	(*)	n.s.	n.s.	n.s.	n.s.
First day of stabling period	198	154	494	226	—
After 50 days	232	126	185	197	14
After 100 days	280	126	113	142	10
After 150 days	315	119	65	100	12
	***	n.s.	**	**	*

Analysis of variance: (*) $P < 0.10$; * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Table 4. Correlations between growth and changes in vitamin A, Cu and Mn levels of liver and bloodplasma during the experiment (differences between initial and final observations).

	Liver		Bloodplasma		Growth
	Cu	Mn	vit. A	Cu	
Liver vitamin A	+0.82*	+0.25	+0.92**	+0.93***	—0.59
Liver Cu		+0.30	—0.81*	+0.95***	—0.91**
Liver Mn			—0.37	+0.26	—0.25
Bloodplasma vitamin A				—0.89**	+0.53
Bloodplasma Cu					—0.81*

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

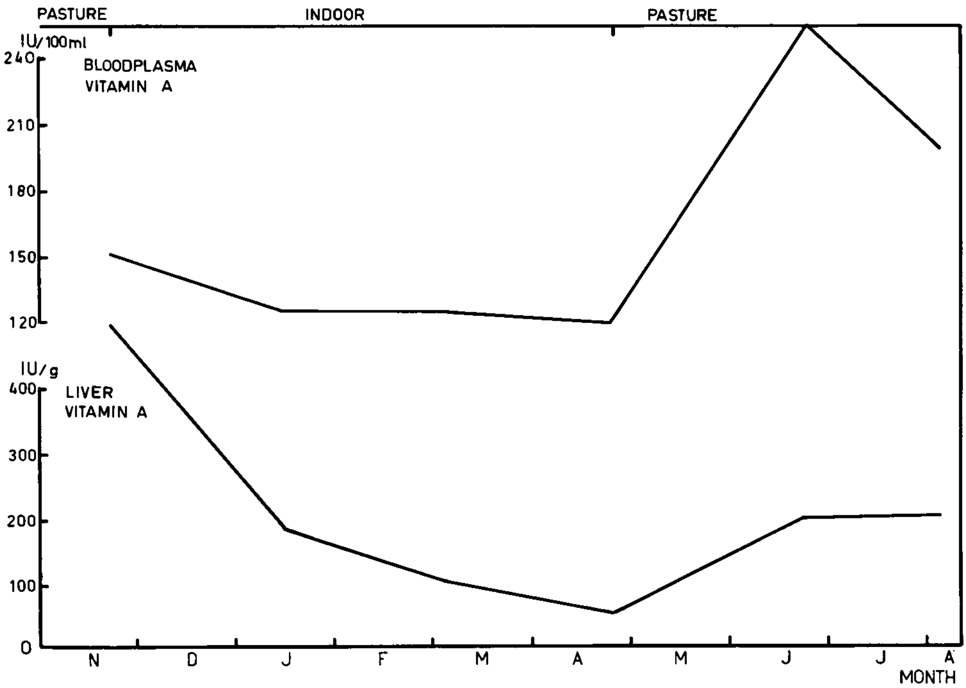

Fig. 1. The trend of the vitamin A contents of bloodplasma and liver during grazing and stabling periods.

that growth goes with a significant fall in the Cu status (r = –0.91 and –0.81) contrary to the vitamin A and Mn status. It thus seems that Cu is more closely connected with growth than vitamin A or Mn. A fall in the Cu content of blood plasma and liver goes with a fall in the vitamin A content of liver (r = +0.93 and +0.82) and remarkable enough with an increase in the vitamin A content of blood plasma (r = –0.89 and –0.81).

Besides, a fall in Cu status seems to be reflected in plasma as well as in liver (r = +0.95).

Fig. 1 shows the trend of the vitamin A-content of blood plasma and liver in the pasture and in the stable. This first of all reveals that, during the stabling period, the vitamin A-status is considerably lower than during the grazing period. It also seems that in autumn, a high vitamin A content in liver goes along with a relatively 'low' vitamin A content in blood plasma whereas early in the grazing period a very high vitamin A content in the plasma was recorded together with a relatively 'low' vitamin A content in the liver.

Discussion

A hypothetical explanation for the correlation between a 'low' Cu status of the animal and a high vitamin A content of blood plasma or a 'low' vitamin A content of liver is given by literature data as follows.

Simek et al. (1961) and Moore et al. (1964) state that in pigs and in rats Cu deficiency interferes with vitamin A storage in the liver. Owen et al. (1965) mention that, in sway-back kids, animals with the lowest Cu-status have the highest vitamin A content of the blood. The above-mentioned authors discuss the possibility of a biochemical blockade or a reduced transportation of vitamin A to the liver caused by a low Cu status. In our opinion the mentioned problem can also be explained by considering the supplies of Cu and carotene and the influence of growth.

Animals with a high weight gain need more Cu and vitamin A than normal ones. If the supply of Cu and carotene is insufficient, the body stores (liver and blood, respectively) shall soon be depleted. Before this situation occurs, intake or conversion of feed components shall also be better with these animals. This explains the higher vitamin A content of blood plasma especially in springtime, with high carotene contents of young grass (young grass has a negative influence on the Cu status too).

The effect of growth or increasing age of young animals with an adequate supply of Cu and carotene is reflected in a lower Cu level of the liver and a higher Cu level of blood plasma (Van der Grift, 1955). The vitamin A contents of liver and blood plasma become higher under these circumstances (Abrams, 1966). These facts and assumptions give a reasonable answer on the findings in our experiments.

Table 3 shows that the animals of the high Ca-group, with the highest body weights – though not significantly – have the lowest Cu and vitamin A contents of liver and the highest vitamin A content of blood plasma. This is in agreement with our explanation, the more so as no Cu or vitamin A deficiency is involved. In connection with vitamin A, Perry et al. (1962) state 23 I.U. vitamin A per g fresh liver to be a normal value for one-year-old fattening bulls, above which value extra vitamin A no longer results in growth improvement.

Abrams et al. (1962) mention 40 I.U./100 ml plasma to be the minimum limit for a normal vitamin A status of (young) cattle.

Apart from the vitamin A status, the supply of carotene was far from adequate in our winter ration. According to Kirchgessner et al. (1966) one-year-old cattle would need about 45 mg carotene, while the animals in our experiment did not even get 10 mg carotene per day.

The Mn content of the livers of our animals corresponds with the data given by Cotzias (1962), viz. 10–15 μg per g d.m. of liver. The Mn supply was more than 15 ppm in the dry matter of the rations so that, according to Bentley et al. (1951) Mn deficiency is out of the question. Additional Ca or P did not considerably effect the Mn content of the liver.

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