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Clinical, Chemical, and Hematological Parameters in Cattle Kept in a Cadmium-Contaminated Area

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In cattle exposure to cadmium may effect various clinical abnormalities such as loss of appetite, anaemia, poor growth, abortions and teratogenic lesions (Block, 1977; van Bruwaene et al, 1984; Doyle, 1977; Miller et al, 1967; Neathery and Miller, 1976; Powell et al, 1964; Wright et al, 1977) or may pass without clinical abnormalities (Johnson et al, 1981;Lampere et al, 1984; Schenkel et al, 1982; Sharma et al, 1982; Vreman et al, 1982; Wentink et al, 1988). Considerably less is known about the effects of chronic exposure to low levels of cadmium on clinical, chemical and haematological parameters. In rats it has been demonstrated that intoxication by cadmium can hinder the resorption of iron, resulting in an iron deficiency anaemia (Huebers et al, 1987). With respect to the way cattle can ingest cadmium from the environment, a relationship was demonstrated between cadmium content of the organs and soil cadmium content (Tielen, 1983). This demonstrates that, raising roughage on cadmium contaminated soil or in fields treated with cadmium containing fertilizers like for instance sewage sludge (Johnson et al, 1981), can lead to accumulation of cadmium in the cattle in question.
This study aims to investigate whether a low, chronical exposure to cadmium effects changes in some haematological, clinical and chemical parameters in cattle.

MATERIALS AND METHODS

Blood was sampled from six groups of 15 clinically normal MRY cows kept on six different farms situated in a cadmium and zinc contaminated area, De Kempen, the province of North Brabant, The Netherlands (Tielen, 1983). As a control, blood was sampled from three groups of 15 clinically normal MRY cows kept on three different farms situated in a non contaminated area in the same province. Housing, feeding, management and health were as usual in The Netherlands. All cows used for this experiment were the same as far as breed, age, ration and stage of lactation are concerned. Blood samples always were taken at a fixed time after feeding. Urine was collected using a catheter, ruminal fluid was sampled using a stomach tube and feces samples were collected rectally. Concentrations of cadmium, calcium, copper, iron, magnesium, zinc and urea as

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well as iron binding capacity and iron saturation were determined in blood samples collected in heparinized vacuum tubes (Vacutainer). For the estimation of the haemoglobin concentration, packed cell volume, white blood cell count and differential count, blood was collected in tubes containing Na_2 EDTA as anticoagulant. Serum was used for the determination of serum total protein, serum protein spectrum, β-hydroxybutyrate concentration and the activities of lactate dehydrogenase (LDH), sorbitoldehydrogenase (SDH) and gamma glutamyl transferase (Y-GT). Blood glucose concentration was measured in samples collected in tubes containing sodium fluoride and oxalate as anticoagulants. The blood, milk, urine, ruminal fluid and faeces samples were transported to the laboratory immediately after collection and most analyses have been carried out within 48 hours after collection. For the determination of cadmium, calcium, copper, iron, magnesium and zinc the samples of plasma, ruminal fluid and urine were kept at -20°C until analysis. The analytical procedure for the estimation of cadmium in the different samples was described earlier (Wentink et al, 1988). The betahydroxybutyrate concentration was determined after the procedure of Bergmeyer, 1974, and the other parameters as described by Breukink et al, 1974.

RESULTS AND DISCUSSION

The cows kept in the cadmium contaminated area did not show any abnormalities at the time the samples were taken and neither did they before or after that period. No cases of anaemia, loss off appetite, poor growth, abortions, teratogenic lesions or renal failure were detected during clinical inspection of the six herds in the cadmium contaminated area.

Table 1. Cadmium contents in ruminal fluid, urine and feces and zinc content in ruminal fluid and milk of cows.

	Cd contaminated area (n=83)	Control area (n=44)	Statistical significance
Zn in ruminal fluid (ppm)	2.86 ± 0.22	1.74 ± 0.21	$p < 0.005$
Zn in milk (ppm)	3.91 ± 0.29	4.13 ± 0.15	NS
Cd in ruminal fluid (ppb)	0.73 ± 0.04	0.50 ± 0.03	$p < 0.0005$
Cd in urine (ppb)	0.08 ± 0.02	0.14 ± 0.04	NS
Cd in feces (ug/g.dm)	2.35 ± 0.12	0.88 ± 0.03	$p < 0.0001$

Mean values and their standard error of the mean are given (NS = not significant, $p > 0.05$).

Table 1 shows that in ruminal fluid and feces of cattle kept in the cadmium contaminated area, more cadmium and also more zinc was present than in the corresponding samples of cattle from the control area. These observations are in agreement with the findings of Tielen, 1983 who has clearly demonstrated the cadmium and zinc contamination in soil in this area De Kempen. No doubt the high cadmium and zinc concentrations originate from the local zinc refi-

ning industry that has been active for more than 50 years now (Tielen, 1983). Table 1 furthermore shows that the metal contamination of the area De Kempen did not give rise to increased cadmium levels in the urine or increased zinc levels in the milk of the cows. This probably means that cadmium and zinc absorption from the food were low in these animals. Wentink et al, 1988 reported that only about 0.1% of the orally administered cadmium dose post mortem was found in the liver and kidneys of the heifers from their experiments.

Tabel 2. White bloodcell count (WBC), lymphocyte count (lymph.c.), neutrophil count (neutr.c.), eosinophil count (eos.c.) and the ratio neutrophyl/lymfocyte (neutr./lymf.) in the blood of cows.

	Cd contaminated area (n=83)	Control area (n=44)	Statistical significance
WBC (giga/L)	6.38 ± 0.17	6.39 ± 0.20	NS
eos.c. (giga/L)	0.79 ± 0.05	0.87 ± 0.07	NS
neutr.c. (giga/L)	2.41 ± 0.13	2.23 ± 0.13	NS
lymf.c. (giga/L)	3.16 ± 0.11	3.28 ± 0.12	NS
neutr./lymf.	0.87 ± 0.06	0.72 ± 0.05	NS

Mean values and their standard error of the mean are given (NS = not significant, $p > 0.05$).

The data presented in the tables 2,4,5 and 6 show that the values measured for the different clinical chemical parameters in both the control area and the cadmium contaminated area lie within the ranges of the normal values. Still there are small but statistically significant differences. This is especially true for the mean concentrations of urea, beta hydroxybutyrate, total protein and glucose. Probably these differences are the result of minor variations in food supply in the two areas. With respect to an eventually negative effect of an increased cadmium intake on appetite, the results demonstrate that food intake was adequate in both areas (Payne and Payne, 1987). No doubt, the somewhat increa-

Tabel 3. Total protein concentration (tot.prot.) and percentages of albumin, α-globulin, β-globulin and Y-globulin in the blood of cows.

	Cd contaminated area (n=83)	Control area (n=44)	Statistical significance
tot.prot. (g/L)	75.61 ± 0.66	79.91 ± 0.89	$p < 0.0005$
albumin (%)	47.43 ± 0.69	49.21 ± 0.61	NS
α-globulin	11.08 ± 0.22	10.99 ± 0.21	NS
β-globulin	8.59 ± 0.15	8.28 ± 0.12	NS
Y-globulin	32.94 ± 0.66	31.63 ± 0.66	NS

Mean values and their standard error of the mean are given (NS = not significant, $p > 0.05$).

Tabel 4. Concentrations of urea, glucose and β-hydroxybutyrate(BHB) in the blood of cows.

	Cd contaminated area (n=83)	Control area (n=44)	Statistical significance
urea (mmol/L)	5.97 ± 0.23	7.06 ± 0.22	$p < 0.005$
gluc.(mmol/L)	3.42 ± 0.03	3.54 ± 0.03	NS
BHB (mmol/L)	0.44 ± 0.02	0.54 ± 0.04	$p < 0.05$

Mean values and their standard error of the mean are given (NS = not significant, $p > 0.05$).

Tabel 5. Activities of lactate dehydrogenase (LDH), sorbitol dehydrogenase (SDH) and Y-glutamyltransferase (Y-GT) in the blood of cows.

	Cd contaminated area (n=83)	Control area (n=44)	Statistical significance
LDH (U/L)	1407 ± 30.19	1309 ± 30.02	$p < 0.05$
SDH (U/L)	4.45 ± 0.31	3.71 ± 0.24	NS
Y-GT (U/L)	19.37 ± 0.83	18.98 ± 0.59	NS

Mean values and their standard error of the mean are given (NS = not significant, $p > 0.05$).

Tabel 6. Concentrations of calcium, magnesium, copper and zinc in the blood of cows.

	Cd contaminated area (n=83)	Control area (n=44)	Statistical significance
Ca (mmol/L)	2.26 ± 0.03	2.25 ± 0.02	NS
Mg (mmol/L)	0.94 ± 0.01	0.92 ± 0.02	NS
Cu (mmol/L)	14.89 ± 0.31	14.68 ± 0.37	NS
Zn (mmol/L)	15.10 ± 0.28	14.11 ± 0.30	$p < 0.05$

Mean values and their standard error of the mean are given (NS = not significant, $p > 0.05$).

sed mean plasma zinc concentration in the cows kept in the cadmium contaminated area results from the higher intake of zinc by the cows.

Finally the values of blood parameters concerning red blood cells and haemoglobin content in cadmium exposed and control animals are shown in table 7. The values of iron concentration, iron binding capacity and iron saturation were lower in the blood samples of cadmium exposed cows. Also the packed cell volume and haemoglobin concentration were lower in the animals from the cadmium contaminated area. These findings are in accordance with literature (Huebers and Huebers, 1987; Morrison and Quarterman, 1987) on effects of heavy metals on iron status and haemoglobin content in the blood of animals. As already mentioned before, the cadmium pollution in the Dutch area The Kempen is coupled to an increased zinc content in that area. This excess of zinc, when entering cattle together with cadmium, reduces the toxic effects of cadmium (Lamphere et al,1984; Sharma et al, 1985). Although the cadmium burden of cattle in the

Tabel 7. Iron concentration, iron binding capacity (FeBC), iron saturation (FeSa), packed cell volume (PCV) and haemoglobin content (Hb) in the blood of cows.

	Cd contaminated area (n=83)	Control area (n=44)	Statistical significance
Fe (µmol/L)	23.23 ± 0.57	28.09 ± 0.69	$p < 0.0001$
FeBC (µmol/L)	60.71 ± 0.76	66.70 ± 1.04	$p < 0.0001$
FeSa (%)	38.51 ± 1.02	42.45 ± 1.18	$p < 0.05$
Hb (mmol/L)	6.47 ± 0.07	7.02 ± 0.10	$p < 0.0001$
PCV (L/L)	0.31 ± 0.01	0.33 ± 0.01	$p < 0.001$

Mean values and their standard error of the mean are given (NS = not significant, $p > 0.05$).

area The Kempen is not very high and even detoxification by increased zinc intake from the environment may take place (table 1), this report proves cadmium effects on some clinical biochemical and haematological parameters of the cattle in question.
The data of table 7 also indicate that iron absorption might be affected by cadmium, resulting in decreased blood hemoglobin levels. Still the mean blood hemoglobin levels found in the cows kept in the cadmium contaminated area were within the ranges of the normal values.

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