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Macroelement Deficiency in Dairy Cows Taking into Account Their Physiological State in the Region of Southern Podlasie

Niedobory makroelementów u krów mlecznych z rejonu południowego Podlasia z uwzględnieniem ich stanu fizjologicznego

The maintenance of the proper state of health, productiveness and fertility to a great extend depends on the appriopriate mineral supply (among them such macroelements as Ca, P, Mg, Na and K). Highly productive animals are characterised by particularly high requirement of minerals and the tendency to mineral deficiency in the period of intensive lactation [12, 13].

To determine the amount of essential minerals in case of ruminants monitoring research should be carried out in the scheme: soil-plant-animal, as their mineral balance depends on the location of the farm as well as biogeochemical conditions [10]. Deficiency or excess of minerals in soil and plants lead to their deficiency or excess in animal organisms and result in biochemical disorders and function disturbance as well as structural changes in body tissue and organs [1, 7, 8, 13].

The aim of the one-year research was to evaluate the mineral balance of dairy cattle through the analysis of the trophic scheme: soil-fodder-animal organism. The concentration of such elements as Ca, P, Mg, Na and K was determined taking into account the physiological state of cows.

MATERIAL AND METHODS

The research was carried out on 4 dairy farms „A", „B", „C" and „D" (average size, 12 cows) in the region of southern Podlasie. The herds contained cows of Black-and-White breed, aged from 4 to 5 years, with similar raising parameters but various physiological states. At each farm 6

cows (3 lactating and 3 dried off) were chosen for detailed research. Soil samples were collected once from a 15 cm deep layer (with the help of a probe) at the height of the vegetation period. The content of minerals was determined with ASA method. The feeds were sampled regularly upon their introduction into dietary units (during the year) following the rules of sample representativeness. The content of minerals Ca, Mg, Na, K was determined with ASA method, while the content of P according to Fiske-Subbarow. Blood was collected from ugular vein 4 times: 60 days before breeding, 10–14 days before breeding, after the first month of lactation and after the second month of lactation. The content of Ca, Mg, Na and K in blood serum was determined with flame spectrophotometer ASA – Unicam 939, while the content of phosphorus according to Fiske-Subbarow method. The numerical data was analysed statistically using Microsoft® Excel 2000 and Statistica 5, Version 97 software. Mean values were compared with the aid of Student's test.

DISCUSSION

The content of essential minerals in plants considerably depends on their content in soil in a particular region [9].

Podzol or so called light soil with pH between 6.0–6.1 prevailed on the studied farms. The amount of minerals in soil on the studied farms is compared in Table 1.

Table 1. A comparison of the results of reaction (1M KCL) and mineral composition of grassland soil on farms A, B, C, D

Farm	Type of soil	n	pH	Statist. measures	Ca	P	Mg	K
					g/kg d.m.			
A	Podzolic from clayey forms	10	6.0	$\bar{x}$	11.75	1.81	1.56	2.37
				SD	1.57	0.37	0.26	0.99
B	Podzolic from clayey forms	10	6.0	$\bar{x}$	10.98	1.07	1.52	1.93
				SD	1.63	0.42	0.23	0.96
C	Podzolic from sandy forms	10	6.1	$\bar{x}$	12.22	1.49	1.44	1.98
				SD	1.26	0.19	0.18	1.16
D	Podzolic from sandy forms	10	6.1	$\bar{x}$	13.33	1.28	1.82	2.54
				SD	2.16	0.10	0.35	0.82

n – number of bulk samples, $\bar{x}$ – mean values, *SD* – standard deviation

The research into P and Mg and the data from the research of other authors [2] proved that the analysed soils had low content of these elements. The amount of Ca and K in the studied samples was within the accepted standards for soils in middle eastern Poland [1]. The chemical analysis proved low content of P and Mg in the region of southern Podlasie. The concentration of Ca, Na and K in the studied feeds satisfied the requirements of the cattle (Tab. 2).

Table 2. A comparison of the level of macroelements in the feeds for the cattle on farms A, B, C, D (g/kg d.m.)

Type of studied feeds	n	Statist. measur.	Ca				P				Mg				Na				K			
			Farm symbol																			
			A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Corn silage	10	$\bar{x}$	6.41	7.32	8.54	7.97	1.88	1.95	1.53	2.12	1.25	0.98	1.74	1.52	1.84	1.92	2.00	2.19	14.28	13.88	12.94	13.96
		SD	1.80	2.12	3.21	2.84	0.41	0.52	0.34	0.63	0.54	0.63	0.44	0.73	0.44	0.33	0.72	0.64	0.87	1.15	2.52	2.24
Pasture forage	10	$\bar{x}$	8.81	10.62	10.93	10.85	1.19	1.10	1.02	0.98	0.91	0.81	1.02	0.83	1.88	1.84	1.86	1.89	10.74	10.69	11.26	10.84
		SD	1.13	0.86	1.94	1.43	0.38	0.47	0.23	0.20	0.22	0.20	0.22	0.16	0.20	0.18	0.22	0.34	0.53	1.04	2.46	0.90
Farm produced concentrate	10	$\bar{x}$	12.00	12.10	13.00	12.85	7.00	6.23	6.09	6.76	4.33	3.87	3.89	3.96	5.74	5.34	5.69	5.42	15.71	14.30	14.20	13.52
		SD	1.29	1.27	1.02	1.37	0.90	1.01	0.81	1.02	0.68	0.23	0.28	0.46	0.39	0.61	0.99	0.58	1.55	0.94	1.10	0.75
Meadow hay	10	$\bar{x}$	9.51	10.15	10.29	11.29	2.34	2.36	2.36	2.38	1.04	0.77	0.69	0.71	1.87	1.62	1.76	1.58	13.96	15.16	14.21	14.09
		SD	1.06	1.47	0.91	1.00	0.44	0.41	0.37	0.33	0.51	0.21	0.19	0.17	0.34	0.55	0.45	0.44	1.51	1.17	1.75	2.01
Barley straw	10	$\bar{x}$	2.01	2.25	1.92	2.84	0.63	0.53	0.88	0.43	0.33	0.41	0.54	0.41	0.88	0.94	1.00	1.12	6.00	7.44	6.51	5.84
		SD	0.67	1.23	0.41	2.82	0.22	0.12	0.25	0.12	0.24	0.13	0.12	0.35	0.25	0.12	0.25	0.35	2.99	3.15	2.55	2.23

n – number of bulk samples, $\bar{x}$ – mean values, *SD* – standard deviation

The level of Ca in the blood serum of cows on the studied farms was within the physiological values 2.25–3.03 mmol/l [14]. According to other authors' research Ca deficiency in cattle was not revealed [7, 11]. Only slight excess of Ca was observed in dried off cows on farms B, C and D. However, the amount of Ca varied significantly between two groups (lactating cows and dried off cows) (Fig. 1). The excess of Ca in dried off cows is problematic as it may cause breeding disorders in the first period of lactation [7].

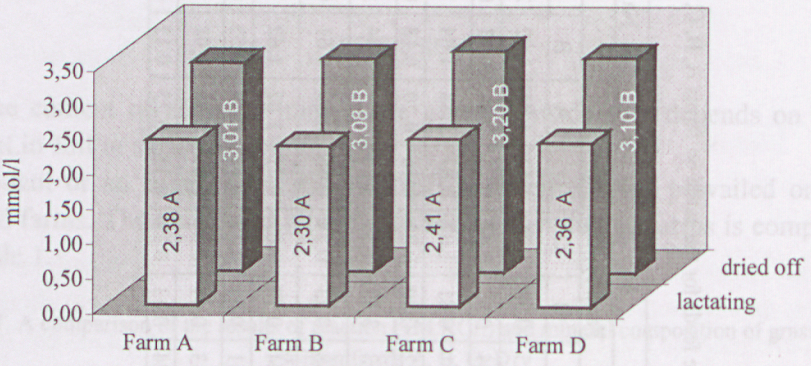

Fig. 1. Average amount of Ca in blood serum of cows taking into account physiological groups
^{A,B} Significant at $P \leq 0.01$

The concentration of inorganic phosphorus in blood serum was at low level or below the optimum value (1.0–2.71 mmol/l) [14]. The reason for the low content of P in blood serum could be its insufficient amount in feeds. The dependence of P level in blood on its amount in feeds was proved by Dymnicka [4], Kruczyńska and Mocek [7] as well as Saba *at al.* [8]. As in case of Ca, statistically significant differences in the content of P were revealed between lactating cows and dried off cows (Fig. 2).

The research carried out by Chudoba-Drozdowska [3] reveals that cows in the last period of gestation and in the first period after breeding are susceptible to phosphorus deficiency the most, a which suggests the dependence of phosphorus level in blood on physiological periods. In addition, a high amount of Ca in the feeds and consequently a high ratio of Ca to P especially in the period of high gestation lead to disorders of homeostatic mechanisms and might be the

reason for low content of inorganic phosphorus in blood serum [5]. P deficiency on the territory of Poland is quite common and was proved by the research of other authors [1, 7].

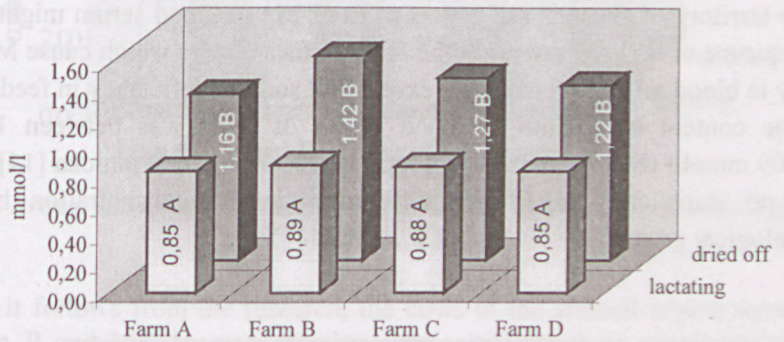

Fig. 2. Average amount of P in blood serum of cows taking into account physiological groups.
^{A,B} Significant at $P \leq 0.01$

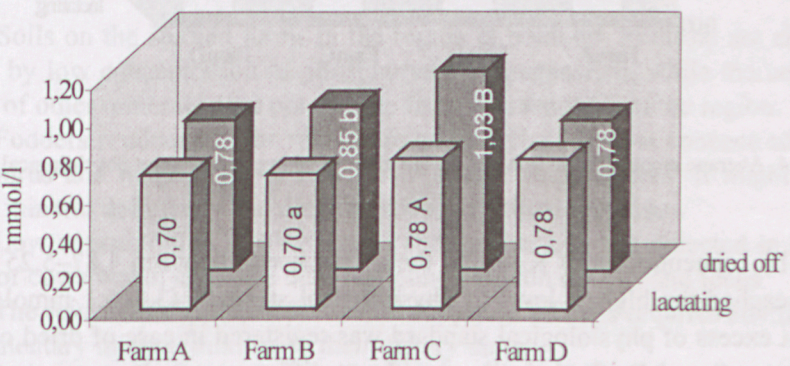

Fig. 3. Average amount of Mg in blood serum of cows taking into account physiological groups.
^{A,B} Significant at $P \leq 0.01$; ^{a,b} Significant at $P \leq 0.05$

The appropriate value of magnesium according to Winnicka [14] is between 0.78–1.23 mmol/l. In the research in most cases the content of Mg reached the lowest physiological value or was below 0.78 mmol/l. Only in dried off cows on farm C its content exceeded 1.0 mmol/l (Fig. 3). Similar results concerning the amount of Mg in blood serum were received by Saba *at al.* [8], Tymczyna *at al.* [12] and Bis-Wencel [2], which proves common Mg deficiency in dairy cattle on the territory of Poland. The low content of Mg in blood serum might be the consequence of its low content in the feeds. Other factors which cause Mg deficiency in blood might be potassium excess and sodium deficiency in feeds [13].

The content of sodium in blood serum of cows was between 137.08–142.09 mmol/l (Fig. 4) and was appropriate according to Winnicka [14]. There were no statistically significant differences in Na concentration between physiological groups.

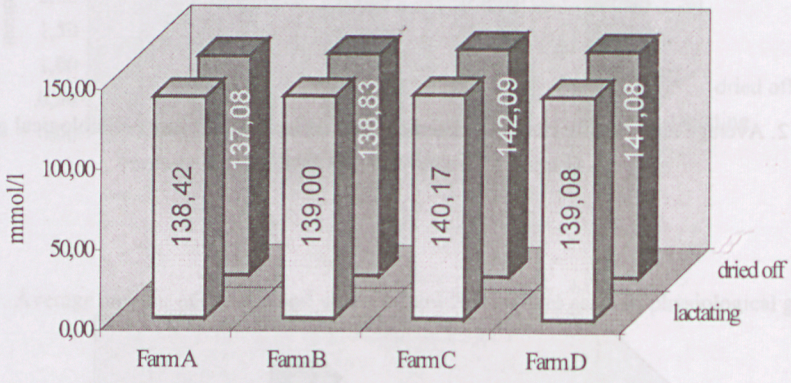

Fig. 4. Average amount of Na in blood serum of cows taking into account physiological groups

The concentration of K during the research was between 4.87–5.25 mmol/l and reached the highest level of physiological standard (3.8–5.1 mmol/l) [14]. Slight excess of physiological standard was registered in case of dried off cows on farms C and D. Statistically significant differences in K concentration between physiological groups were observed only in herd C (Fig. 5). According to the research of other authors [2, 6] carried out in different regions of Poland, potassium deficiency was not observed either in blood serum or in the feed. What is more, its concentration often exceeded the reference value. It could be the result of its easy assimilation by the animal organism as well as usage of the fodder manured by nitrogen-potassic fertilisers.

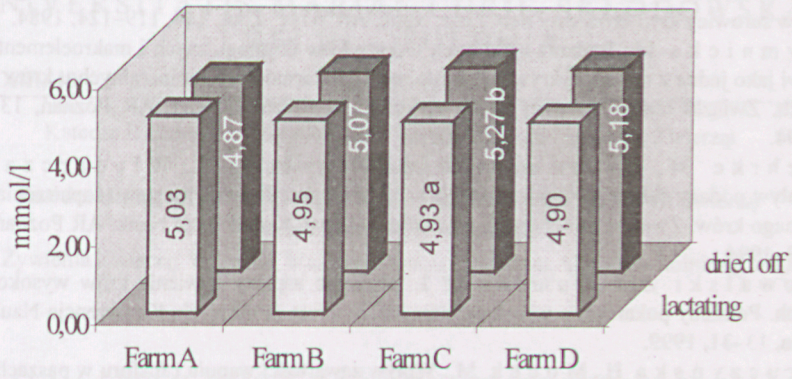

Fig. 5. Average amount of K in blood serum of cows taking into account physiological groups
[a,b] Significant at $P \leq 0.05$

As it follows from the research, the cows in the studied region were deficient in P and Mg. In case of other macroelements their concentration was within the physiological standards. The reasons for that are supposed to be the content of feeds, reactions between particular minerals as well as physiological state of cows. The received results might signal the possibility of different disorders in animal organisms because of mineral deficiency. Therefore, the addition of mineral mixture to dietary units seems to be essential.

CONCLUSIONS

1. Soils on the studied farms in the region of southern Podlasie are characterised by low concentration of phosphorus and magnesium, while the concentration of other minerals does not deviate from the standards in the region.

2. Fodders produced in the region are characterised by low concentration of phosphorus and magnesium in relation to animal requirements. It might have caused mineral deficiency and disproportions in animal organism.

3. Low concentration of phosphorus and magnesium was detected in blood serum of cows which confirms their low concentration in soils and feeds.

4. The revealed inappropriate mineral supply of animals requires addition of supplementary mineral mixture to their dietary units.

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STRESZCZENIE

W czterech stadach krów mlecznych A, B, C, D, rozmieszczonych na terenie południowego Podlasia, przeprowadzono badania dotyczące stanu zaopatrzenia mineralnego krów w oparciu o poszczególne ogniwa łańcucha troficznego, tj. gleby–pasze–zwierzęta. W surowicy krwi krów wykonano oznaczenia zawartości Ca, P, Mg, Na i K, uwzględniając przy tym stan fizjologiczny krów. Stwierdzono, że u krów z badanego regionu występowały niedobory mineralne, dotyczące zawartości P i Mg. Uwarunkowane to było składem zadawanych pasz oraz wzajemnym oddziaływaniem zachodzącym między poszczególnymi elementami mineralnymi, a także stanem fizjologicznym krów. Konieczne wydaje się więc uzupełnianie deficytów makroelementów w dawkach pokarmowych dla zwierząt.