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EFFECT OF PULSED ELECTROMAGNETIC FIELDS ON HEMATOLOGICAL AND BIOCHEMICAL BLOOD INDICES AND MILK PRODUCTION IN SHEEP

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ABSTRACT

The studies were conducted on lactating ewes. Stimulation with a pulsed electromagnetic field generated by BEMER 3000 VET was carried out for 4 weeks. The basic hematological and biochemical blood indices were determined, including the activity of ALT and ALP, the levels of glucose, total protein, cholesterol, triglycerides, total calcium, inorganic phosphorus, electrolytes (Na^+, K^+, Cl^-) and the parameters of the acid-base equilibrium.

Milk production and composition, and the growth rate of lambs were determined as well. The sheep subjected to the above stimulation showed slight changes indicating increased intensity of lipid metabolism and activity of the respiratory center, and stability of the electrolyte equilibrium and water balance. The ewes examined showed also a growing tendency as concerns the milk yield, which was confirmed by a considerably higher growth rate of lambs, observed from the 2nd to 70th day.

Key words: electromagnetic fields, sheep, hematological and biochemical blood indices, lactation, milk composition

INTRODUCTION

Bioelectrical phenomena, underlying all vital functions of living organisms (1, 3, 9) are determined by metabolism-controlling mechanisms. The interactions between external fields (including the terrestial magnetic field) and internal electromagnetic ones result in release of the so called activation energy of potential substrates, making them ready to enter into reactions (4). These mechanisms may be regulated by means of specific external electromagnetic fields, thus affecting life functions (4, 5, 6, 11, 13, 15). Such a possibility is offered by the device BEMER 3000, producing a broad-banded pulsed electromagnetic field. Its application leads, among others, to normalization of tone on the cell membrane, activation of ionic pumps, stimulation of synthesis of ATP and proteins, restoration of capillary circulation, increased blood saturation with oxygen (4, 9, 13). It follows that the system BEMER 3000 can be used as a biotechnological method of increasing animal productivity.

The aim of the present studies was to check its possible application to sheep. They included preliminary tests performed during lactation, whose objective was to determine the physiological reaction of ewes to a pulsed electromagnetic field generated by BEMER 3000 VET.

MATERIAL AND METHODS

10 lactating ewes aged 2 - 5 years (6 of the Finnish Landrace breed and 4 Polish Wrzosówka breed) constituted the experimental material. They were divided into two equal groups by the analogue method, I - control and II - experimental. Each group consisted of 4 ewes nursing of single lamb and 1 ewe with twins.

The experimental ewes were subjected to stimulation with a pulsed electromagnetic field generated by mats of the device BEMER 3000 VET, put on animals' backs. The stimulation was carried out once a day for 18 minutes, between 8 o'clock a.m. and 10 o'clock a.m., from the 2nd to 28th day of lactation. The levels from 1 to 3 were applied, 6 minutes for each.

The parameters of the signal emitted by BEMER 3000 VET are protected by patent. The magnetic induction increases by 1/3 at successive levels, reaching the maximum value of 35 μT.

The animals were kept in a sheep house and fed according to the relevant standards. The analysis concerned: basic hematological and biochemical blood indices in ewes on the 28th day of lactation, body weight of ewes and lambs on the 2nd, 28th and 70th day post partum, production and composition of milk on the 28th and 70th day of lactation.

Blood samples were collected from the jugular vein. Hematological examinations included the determination of: the counts of red blood cells (RBC), white blood cells (WBC) and blood

plates (PLT); the value of hematocrit (HCT); the hemoglobin content (HBG); the mean volume of red blood cells (MCV); the mean hemoglobin mass in a red blood cell (MCH) and the mean hemoglobin concentration in a red blood cell (MCHC). They were conducted using a hematological analyzer Hemocel 1600. Biochemical analyses of the blood serum comprised the determination of: the levels of glucose – the oxidase method, total protein (a biuret reaction), cholesterol, triglycerides, inorganic phosphorus, calcium – the kinetic method, by means of a biochemical analyzer Synchron CX5 Delta (Beckman Instruments International); the activity of alanine aminotransferase (ALT) and alkaline phosphatase (ALP); a ionogram (Na^+, K^+, Cl^-) - the ion-selective method, using analyzer Easy Lyte Plus; the parameters of the acid-base equilibrium (pH, pCO_2, HCO_3, BE – base excess or deficiency) – by means of analyzer Ciba Corning 248.

Daily milk production was determined on the basis of control milking, conducted in the morning, 12 hours after lamb feeding. Milk was taken from the right half of the udder, while the left half was sucked by a lamb. The amount of milk obtained in this way was multiplied by 4 to determine the daily production. The percentage of dry matter, fat, protein and lactose, and the count of somatic cells per ml, were determined in milk applying apparatus Combi Foss 6000.

The index of milk yield (Wm) was determined on the basis of the body weights of lambs aged 2 (MC_2) and 28 (MC_{28}) days, and the amount of milk obtained during control milking on the 28th day of lactation, using a formula given by Szczepański et al. (14):

$$Wm = (MC_{28} - MC_2) \times 5 + \frac{\text{amount of milk from control milking (ml)}}{10}$$

The results were elaborated statistically in a computer program Statistica.

RESULTS

The hematological analyses showed changes in the blood of the experimental ewes (Table 1), i.e. an increase in the count of white blood cells, red blood cells, blood plates and the level of hemoglobin. However, they were inconsiderable only, and were not confirmed statistically.

Table 1. Hematological blood indices in ewes on the 28th day of lactation

Indices	Group			
	I		II	
	Mean	S. D.	Mean	S. D.
WBC (10^9/l)	10.33	1.19	11.65	0.87
RBC (10^{12}/l)	8.32	1.22	9.02	0.86
HBG (g/l)	94.50	9.98	102.00	4.55
HCT (l/l)	0.298	0.034	0.308	0.014
PLT (10^9/l)	304.50	142.10	407.25	184.17
MCV (fl)	35.75	1.50	34.25	1.71
MCH (pg)	11.45	0.60	11.32	0.56
MCHC (g/l)	319.00	8.91	330.50	3.71

The biochemical examinations (Table 2) indicated a decrease in the levels of glucose, total protein and cholesterol, and an increase in the content of triglycerides in the experimental sheep. Again, the differences were slight and statistically insignificant.

The indices of the mineral balance (Ca and inorganic P) did not show any fluctuations. A lower value of the ionogram was noted in ewes subjected to stimulation; in the case of Cl^- ions it turned out to be statistically significant ($P \leq 0.01$).

Table 2. Biochemical blood indices in ewes on the 28th day of lactation

Indices	Group			
	I		II	
	Mean	S. D.	Mean	S. D.
Glucose (mmol/l)	3.12	0.18	2.95	0.50
Protein (g/l)	65.33	9.23	60.35	4.10
ALT (IU/l)	18.35	7.05	17.70	5.95
ALP (IU/l)	93.83	53.87	90.15	25.44
Cholesterol (mg/dl)	88.9	6.31	83.28	13.99
Triglycerides (mmol/l)	0.172	0.068	0.220	0.046
Ca (mg/dl)	9.97	0.65	10.00	0.82
Inorganic P (mg/dl)	5.57	1.47	5.57	0.96
Na^+ (mmol/l)	145.98	4.56	140.40	6.45
K^+ (mmol/l)	5.20	0.62	4.83	0.13
Cl^- (mmol/l)	115.1^A	0.87	111.9^B	1.95

A,B - values differing significantly at $P \leq 0.01$

As regards the acid-base equilibrium (Table 3), the experimental sheep demonstrated a tendency towards compensated alkalosis. This was reflected by a significant ($P \leq 0.01$) increase in blood pH, a decrease in pCO_2 and in the level of bicarbonates and base excess. These changes were accompanied by compensatory growth in pO_2, increased (%) blood saturation with oxygen (O_2SAT) and a decrease in the total CO_2 content of the blood plasma ($ctCO_2$).

Table 3. Acid - base balance parameters in ewes on the 28th day of lactation

Parameters	Group			
	I		II	
	Mean	S. D.	Mean	S. D.
pH	7.417^B	0.016	7.455^A	0.026
pCO_2 (kPa)	6.12	0.44	5.26	1.08
pO_2 (kPa)	4.25	1.54	8.33	6.89
HCO_3^- act (mmol/l)	28.95	2.04	26.88	6.05
BE (B) (mmol/l)	3.65	1.72	2.70	5.25
O_2 SAT (%)	58.13	23.48	78.50	16.12
$ctCO_2$ (mmol/l)	30.35	2.10	28.05	6.33

A,B - values differing significantly at $P \leq 0.01$

The results characterizing the milk yield indicated wide variation of the traits analyzed. The groups were too small to show the significance of differences between them. However, certain tendencies were observed, which could be connected with the experimental factor applied.

It was found that stimulation with pulsed electromagnetic fields allowed to reduce the effect of lactation on the experimental ewes. This was confirmed by a lower decrease in their body weights in the period from the 2nd to 70th day of lamb feeding – 5.95%, compared with 15,50% in the control group (Table 4). Moreover, a higher milk yield was observed in these ewes. This positive influence of pulsed electromagnetic fields on milk production was reflected by both a higher (by 11.71%) index of milk yield and higher daily production, determined on the basis of control milking on the 28th and 70th day of lactation (Table 5).

Table 4. Body weight of ewes and milk yield

Specification	Group			
	I		II	
	Mean	S. D.	Mean	S. D.
Body weight (kg) on the:				
2nd day post partum	36.25	2.36	33.63	3.40
28th day post partum	35.00	2.52	32.25	2.99
70th day post partum	30.63	5.62	31.63	4.03
Milk yield (kg)	86.50	7.67	96.63	6.59

Table 5. Milk production and composition on the 28th and 70th day of lactation

Specification	Group							
	I				II			
	28th day of lactation		70th day of lactation		28th day of lactation		70th day of lactation	
	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
Daily milk production (ml)	620.00	121.11	490.00	180.00	720.00	113.14	610.00	315.59
Milk composition (%):								
dry matter	13.24	1.00	12.95	0.83	13.76	0.80	15.28	2.41
fat	3.40	1.05	3.09	1.02	3.76	1.41	4.45	1.77
protein	3.83	0.27	4.40	0.26	4.40	1.03	5.49	1.51
lactose	5.55	0.09	4.86	0.30	4.96	0.81	4.61	1.00
Number of somatic cells in 1ml of milk (10^3/ml)	214.75	78.23	168.25	66.17	247.50	187.33	153.50	66.40

As concerns the composition of milk from the experimental ewes, it was characterized by higher contents of dry matter, fat and protein, and a slightly lower level of lactose, in both lactation periods analyzed.

The differences in the quality of quantity of milk resulted in changes in the body weight gains of lambs (Table 6). They were higher in the experimental group, mainly between the 28th and 70th day, and the index of growth rate turned out to be highly significantly higher over the

whole experimental period, compared with the control group. As a consequence, the body weights of lambs whose mothers were subjected to stimulation, although lower at the beginning, after 70 days were similar to the body weights of control lambs.

Table 6. Body weight and daily gains of lambs

Specification	Group			
	I		II	
	Mean	S. D.	Mean	S. D.
Body weight (kg) at the age of:				
2 days	2.66	0.46	2.24	0.63
28 days	6.32	093	5.92	1.34
70 days	12.14	1.52	12.06	2.70
Daily gains (g) in the period:				
2 - 28 days	140.80	22.47	141.80	45.02
28 - 70 days	138.60	16.01	146.20	23.81
2 - 70 days	139.60	17.60	144.40	31.58
Growth rate (%) in the period:				
2 - 28 days	81.02	7.97	89.03	5.31
28 - 70 days	62.79	5.09	69.61	7.46
2 - 70 days	128.30^{B}	6.54	137.67^{A}	5.84

A,B - values differing significantly at $P \leq 0.01$

DISCUSSION

The hematological and biochemical indices analyzed in the studies were similar for both groups, and remained within the physiological norms for this species (7, 16).

The hematological changes observed in the blood of the experimental ewes were inconsiderable and it would be difficult to relate them to stimulation with electromagnetic fields.

A slight decrease in the cholesterol content, accompanied by an increase in the level of triglycerides, suggests higher intensity of lipid metabolism, resulting from the stimulation. Such changes in the parameters of the biochemical equilibrium were reported by Marcinowski and Kubiak (8). A decrease in the concentration of ions, especially K^{+} and Cl^{-} (which exceeded the upper normal range in the control group), indicates a stabilizing effect of the stimulation on the cholesterol and water balance. The influence of pulsed magnetic fields (maximum intensity – 0.07 mT) on the level of electrolytes in the blood serum was observed by Serafin et al. (12). They reported a significant increase in the concentration of potassium and magnesium in people subjected to this therapy for 24 days, 8 minutes twice a day. An increase in the potassium content, including hyperkalemia, accompanied by hyponatremia,

was also noted by Banaszkiewicz et al. (2) during their research on rats. These animals were treated with a pulsed magnetic field (intensity 10 mT) and infrared laser radiation for 10 days, 10 minutes once a day. The results of these investigations show a correlation between the effect obtained and the type of electromagnetic signals, their parameters and stimulation program.

Changes in the acid-base equilibrium resulted from renal compensation of respiratory alkalosis, connected among others with increased elimination of bicarbonates and reduced base regeneration in the kidneys. Tendencies towards alkalosis were also noted in previous studies concerning the period of early pregnancy in sheep (10). However, this was the case of mild metabolic alkalosis, which is a physiological phenomena in all ruminants. The changes observed during lactation indicate higher activity of the respiratory center, which could be caused by the stimulation applied.

The research results show that the stimulation had no negative effect on lactating ewes and corresponded with a low (similar in both groups) content of somatic cells in milk. This confirms the results obtained by Kafka (4) and Michaelis (9), indicating a stabilizing influence of BEMER 3000 impulses on the homeostasis.

The data characterizing milk production and composition in both groups analyzed suggest a positive effect of pulsed electromagnetic fields on the course of lactation and milk quality. It is also important that the experimental ewes still maintained their advantage on the 70th day of lactation, which could be connected with the stimulation applied during the first 28 days after parturition. This correlation indicates more intensive metabolism in these sheep, and is consistent with the results of investigations showing higher intensity of biochemical processes, especially protein synthesis, caused by BEMER 3000 signals (4, 9). Their authors claim that better circulation, and first of all increased blood oxygenation, are here of primary importance. Cells are supplied with more oxygen – the main activator of metabolism.

The results obtained should be verified for larger groups of experimental animals, characterized by lower standard deviations. The stimulation program applied in the present studies interfered in the technological process to a very low degree. It is possible that the use of a different program, e.g. with stimulation carried out twice a day, may turn out more effective. Further work will go in this direction.

CONCLUSIONS

1. The hematological and biochemical research results show that the pulsed electromagnetic fields had no negative effect on lactating ewes.
2. The sheep subjected to the above stimulation showed slight changes indicating increased intensity of lipid metabolism and activity of the respiratory center, and stability of the electrolyte equilibrium and water balance.
3. The ewes examined showed a growing tendency as concerns the milk yield, as well as content of dry matter, protein and fat in their milk.

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