SELECTED ELEMENTS OF METABOLIC PROFILE
AND CONDITION STATE OF DAIRY CATTLE ON FARMS
OF DIFFERENT MANAGEMENT SYSTEMS AND METHODS
OF FODDER APPLICATION

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Abstract

The effect of the three most frequent systems of management and methods of fodder application on the development of disorders in the mineral and energetic metabolism as well as the dysfunction of parenchymatous organs in the herds of dairy cattle in central Lublin region was investigated. The studies were conducted on 180 clinically healthy cows, the Lowland Black-and-White and HF breeds, as well as their crossbreds, of the highest milk yield in autumn and winter seasons of 2003–2005. Numerous elements bespeaking the existence of strict correspondence between the studied parameters and the systems of management and the methods of feed application were found out. The most advantageous, both with respect to the condition and metabolic parameters of blood were the farms with the system of tethered maintenance and mechanized method of feed application.

Key words: cattle, husbandry methods, energetic metabolism, mineral metabolism.

Nowadays the farms in Poland carrying out dairy production are developing very dynamically, especially concerning the cattle stocking rate and the quality of the genetic material. The effect is constantly increasing mean daily as well as yearly production of milk. The received production results enforce better and more accurate balancing of nutrition and simultaneous re-organizing of the systems of maintenance and taking care of animals. Quickly progressing intensification of the production without systematic control of the management and feeding systems may frequently result in various types of metabolic disorders. In the case of highly productive cows such changes, especially the first lactation phase, occur in the sub-clinical form, which results in economical losses difficult to determine. In the longer period, while intensifying, they are manifested by different clinical symptoms or else numerous reproduction problems (1, 3, 6, 10, 14, 16, 20, 21, 24, 26, 32).

Despite constantly improving the methods of energetic balancing of nutritional doses, the problem of energetic disorders is still noted, and these mainly concern the cows of the highest milk yield (4, 8-10, 13, 20). Their occurrence leads not only to decreased quality and milk production, but to the development of severe, sub-clinical and clinical disease forms (ketosis and fatty liver syndrome), which result at times even in sudden collapse of animals. What is more, the disorders of this type intensify pathological changes in the mineral metabolism, such as milk fever, hypomagnesaemic-ketose syndrome, and others. They may incite negative changes in parenchymatous organs which, in turn, affect physical efficiency of an organism, and especially the intake and assimilation of individual elements of the nutritional dose (1, 3, 4, 8, 10, 20, 26, 27, 32).

Among the most frequent mineral disorders noted in dairy cows of high productivity, despite the progress in the knowledge of their prophylaxis, there are various forms and types of hypocalcaemia, hypomagnesaemia, hypophosphataemia and also different forms, especially subclinical ones, of Cu, Zn, Fe, Se and I deficiency (7, 11-13, 16, 19, 21, 23, 29, 31). The occurrence of clinical effects of the above-mentioned disorders is often preceded by various kinds of problems concerning the reproduction, the decrease in the number and quality of the produced milk as well as composite changes in different organs, and especially parenchymatous ones. The intensification of the changes in the mineral metabolism may cause sudden death of animals or their elimination from the herd (4, 7, 16, 20, 22, 23, 29).

In our opinion, there is lack of the studies which, apart from concentrating on the problem of diagnostics of metabolic disorders in the organisms of highly productive cows, would aim at causative analysis considering the management and method of feed application. We are ready to believe, on the basis of several years’ studies, that each system produces...
different conditioning and intensification of the changes concerning the clinical image as well as the development of metabolic disorders, especially of the subclinical ones. The above assumption has become the basis to carry out the studies on the effect of 3 most often used maintenance systems and methods of feeding on the incidence of the disorders in mineral and energetic metabolism as well as the function of parenchymatous organs in dairy cows from herds in the Lublin region.

**Material and Methods**

The research was conducted on 10 farms with 20 to 100 dairy cows of HF and the Lowland Black-and-White breeds, as well as their crossbreds. The experiment covered 180 clinically healthy cows of the highest milk productivity in the herd in autumn and winter periods of 2003 – 2005. The chosen animals 3 – 8 years of age were characterized by milking productivity of 30 to 45 l milk daily. In all tested herds feeding was based on the following fodder: corn or corn silage, hay-silage from grass, hay, full-portion feeds of 18 to 20% protein, concentrate from home production (based on wheat, triticale, barley and the supplement of premix), straw, beet pulp as well as mineral-vitamin supplement applied at the amount depending on the milk productivity, as recommended by nutritional consultants of various companies supplying fodder and premixes.

The investigated farms were divided into three groups depending on the system of management and feeding methods. In the first group (I) there were the herds of dairy cows, in which the breeders kept animals tethered and the whole bulk of the fodder was hand-applied. The second group (II) were the farms where the animals were tethered and all bulky feeds with the basal concentrate were finely crumbled and applied from a mash trolley. On such farms an additional dose of concentrate depending on the amount of milk yield was hand-applied. In the third group (III) there were the farms with the loose housing system where the concentrate was applied from the fodder base and the bulky feed plus mineral supplements, finely crumbled and mixed – from a mash trolley.

The blood was sampled into test tubes from each animal from the external jugular vein: with the addition of heparin in order to determine total and ionized Mg and Ca, K, Na, and free fatty acids (FFA) in the plasma, and without anticoagulants to obtain the serum for the determination of the activity of alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (AP), glutamate dehydrogenase GLDH as well as the concentration of bilirubin, total protein, glucose, urea, inorganic P, Cu, Zn, and Fe. The blood was transported cool till the moment of centrifugation, yet not longer than 3 to 6 h, and the obtained serum and plasma were kept in – 22°C until the determination was performed. At the moment of each blood sampling, the clinical state of the cows, method of fodder application, management system, milk productivity as well as tending the animals were analysed.

The level of total Ca, total Mg, and Na was determined by the atomic absorption spectrophotometry using PERKIN ELMER - 4100 apparatus, ionized fraction of Ca and Mg by the method of ion selective electrodes using AVL 988-4 apparatus, the level of inorganic P using the Cormay diagnostic set for UV/VIS Marcel s 330 spectrophotometer. The level of FFA was tested by the Fronta and Doyle method, whereas the activity of AST, ALT and AP using the diagnostic set of ALPHA DIAGNOSTICS and Epoll-20 photometer, the level of bilirubin by the Jędrasik and Cleghorn method using the SPEKOL apparatus, and the level of urea by the enzymatic Human GmbH colorometric test and UV/VIS Marcel s 330 spectrophotometer.

The results of biochemical tests were statistically analysed, using the t-Student test with the Statistica 5.0 PL programme. The calculations were made at the significance level $\alpha \leq 0.05$ and $\alpha \leq 0.01$.

**Results**

During the two-year cycle of observation and clinical examinations in all the groups of farms, significant differences were seen in relation to the condition of cows and the incidence of clinical and subclinical forms of metabolic diseases. On the farms with hand application of fodder (group I), all animals, including cows selected for the studies, were generally characterised by very good condition, often with fat deposition. The animals on these farms, as it was found out following the examination, often suffered from the diseases connected with the disorders in mineral metabolism (milk fever, downer syndrome) and various forms of indigestion (most frequently acute and chronic acid indigestion). The clinical studies in many cows revealed pathological changes of various degrees in the lower parts of the limbs. In the group II, the cows of high production parameters were characterized by good condition. The clinical examinations revealed small number of traumatic changes of the hindlegs. On the farms of this group individual cases of parturient paresis were observed. In the group III the condition of the cows with the highest milk productivity was the worst of all the studied groups of the animals. During clinical examination a large number of various injuries was visible, from the simplest damage of body integument and joint dislocation, to incomplete tearing off teats or various forms of oedema in the area of hoof. In this group, there occurred numerous cases of sending animals for emergency slaughter and sudden death.

The biochemical results obtained in the course of the studies are presented in the two tables.
Table 1

Selected biochemical parameters of energetic metabolism and parenchymatous organ function

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group I X ± SD</th>
<th>Group II X ± SD</th>
<th>Group III X ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALT IU/l</td>
<td>24.66 A 7.05</td>
<td>28.66 B 7.67</td>
<td>29.43 B 7.58</td>
</tr>
<tr>
<td>AST IU/l</td>
<td>71.46 Aa 19.59</td>
<td>81.63 AbC 25.86</td>
<td>85.47 BbC 20.77</td>
</tr>
<tr>
<td>AP IU/l</td>
<td>57.84 Ac 29.34</td>
<td>53.12 a 16.26</td>
<td>61.22 bc 22.17</td>
</tr>
<tr>
<td>Bilirubin µmol/l</td>
<td>4.10 a 2.18</td>
<td>3.90 a 1.83</td>
<td>4.43 a 1.83</td>
</tr>
<tr>
<td>Urea mmol/l</td>
<td>4.24 A 1.90</td>
<td>4.32 A 1.65</td>
<td>5.35 B 1.79</td>
</tr>
<tr>
<td>Total protein g/l</td>
<td>74.45 AaC 7.41</td>
<td>72.30 Aa 6.19</td>
<td>78.52 BbC 8.61</td>
</tr>
<tr>
<td>FFA µmol/l</td>
<td>345.83 AaC 240.05</td>
<td>525.27 Ab 450.37</td>
<td>313.62 BbC 132.97</td>
</tr>
<tr>
<td>Glucose mmol/l</td>
<td>3.43 a 0.51</td>
<td>3.42 a 0.53</td>
<td>3.46 a 0.61</td>
</tr>
</tbody>
</table>

a, b, c; A, B, C – relevant differences between particular groups (α ≤ 0.05); (α ≤ 0.01)

Table 2

Concentrations of selected elements

<table>
<thead>
<tr>
<th>Element</th>
<th>Group I X ± SD</th>
<th>Group II X ± SD</th>
<th>Group III X ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Ca mmol/l</td>
<td>2.24 a 0.22</td>
<td>2.37 b 0.13</td>
<td>2.32 b 0.21</td>
</tr>
<tr>
<td>Total Mg mmol/l</td>
<td>1.06 Aa 0.17</td>
<td>1.14 BbC 0.17</td>
<td>1.05 AaC 0.19</td>
</tr>
<tr>
<td>K mmol/l</td>
<td>3.94 Aa 0.56</td>
<td>4.14 A 0.53</td>
<td>3.90 Aa 0.56</td>
</tr>
<tr>
<td>Na mmol/l</td>
<td>143.65 Aa 4.83</td>
<td>142.61 AaC 4.21</td>
<td>140.35 BbC 4.21</td>
</tr>
<tr>
<td>P mmol/l</td>
<td>1.86 AaC 0.35</td>
<td>2.01 Ab 0.38</td>
<td>1.79 AbC 0.30</td>
</tr>
<tr>
<td>Ca++ mmol/l</td>
<td>1.14 a 0.11</td>
<td>1.21 b 0.08</td>
<td>1.21 b 0.10</td>
</tr>
<tr>
<td>Mg++ mmol/l</td>
<td>0.70 A 0.15</td>
<td>0.74 A 0.05</td>
<td>0.82 B 0.12</td>
</tr>
<tr>
<td>Cu µmol/l</td>
<td>15.03 a 2.42</td>
<td>18.18 b 4.15</td>
<td>16.98 b 4.28</td>
</tr>
<tr>
<td>Zn µmol/l</td>
<td>14.68 a 3.43</td>
<td>14.87 a 2.38</td>
<td>14.28 a 3.03</td>
</tr>
<tr>
<td>Fe µmol/l</td>
<td>21.43 a 8.69</td>
<td>19.96 b 6.25</td>
<td>18.78 b 6.47</td>
</tr>
</tbody>
</table>

Legend: see Table 1

Discussion

Biochemical analysis of blood in all types of farms showed the incidence of various levels of disorders in the energetic metabolism, the functioning of parenchymatous organs as well as locomotion system. In the tested herds, increased levels of GLDH, exceeding the value of 10 IU/l, which may manifest the previous or current destructive process in the parenchymatous organs (liver and pancreas), and also indirectly energetic disorders in the period prior to the investigations, especially at parturient period (Table 1). However, it ought to be stated that on the farms of groups II and III, the changes of the biochemical background had the character of the current pathological process. In the cows of group II, where the cows were tethered (bulky fodder given from the mash trolley, concentrate – by hand), significantly increased levels of AST and ALT also connected with higher values of FFA (Table 1) were observed. Such a state, at hand application and relatively very good appetite of the animals, may testify faulty adaptation of the dose of the concentrate in relation to the production capacity of the animals. In group III of the farms with free movement of the animals and free access to bulky feed and normative amount of the concentrate in the basal fodder, apart from the increased values of GLDH, significantly higher values of ALT and AST than those of the normative ones were found out, as well as than the values found in group I cows. Results of the clinical observations may indicate that the stated biochemical changes in the blood of the cows of this group were to a great extent probably the result of the developed disorders in the locomotion system as well as the possibility of excessive burdening of parenchymatous organs with the fodder, especially the concentrate, or reduced appetite. The other part of the conclusions may result from the highest values of
values were reported by Stojevic et al. (31) and Bires et al. (5). Such situation was the result of the application of fodder of high protein content, especially the protein of high absorption in the further segments of the digestive tract. The general assumption of such an activity is not only the enrichment of the organism itself in protein, but mainly the tendency to obtain the milk of high protein content, which is connected with greater profitability of the production (2).

On all farms, generally low concentrations of both total and ionized Ca were noted. However, only in the group of the farms with the tethered housing and hand application of fodder (group I), the levels of this element (total Ca – 2.24 mmol/l; Ca²⁺ –1.14 mmol/l) were lower than the accepted physiological standards and they differed significantly in comparison with the two other types of farms (22, 24, 33). It should be observed that in some herds from group I even 75% of the studied animals showed higher or lower deficiencies of this element, whereas in the other groups this proportion did not exceed 40%, as a rule. In the other two groups mean Ca values were close or only slightly lower than the levels presented by other authors for clinically healthy animals (5, 14, 22, 24, 28, 31, 36).

The levels of plasma ionized and total Mg, inorganic P, K, and Na (Table 2), despite slight differences between individual group of farms, was well within the generally accepted standards. The values similar to our results noted for the cows of the highest levels were noted in the studies also by Bires et al. (5), Hejtasz (14), Kovac et al. (21), Moore (24), and, partially, also Zdelar-Tuk et al. (36), who additionally found out very low levels of P at the peak of lactation. The fact that in group III the values slightly exceeding the top physiological standard were noted for ionized Mg in 40% animals may testify to the disorders concerning this element. Most frequently, such changes may indicate the disorders in the metabolism and especially in the immunity of animals (18, 28).

The levels of Fe, Cu and Zn in cows of all the studied groups were characterized by generally low values (Table 2). Especially low values were noted for the levels of Fe in groups III and II. In individual herds 50 to 80% of cows showed the values significantly lower than physiological levels of this element, which was especially visible on the farms of group II. Such low values were reported by Stojevic et al. (31), too. The lowered Fe and Cu levels, especially on the farms of group III were accompanied by the symptoms of anaemia expressed as the paleness of mucous membranes. In this group of the farms also the lowest values of Zn level were noted, which may cause the higher number of inflammatory changes in the hooves. The presence of the normal Zn and biotin levels in the organisms of ruminants conditions the physiological state of hooves, thus the possibility of the right motor competence and assuming the right position at taking up fodder (15, 17, 35).

The conducted observation and biochemical studies allow for general conclusions. Under the conditions of central Lublin region, the farms with tethered housing and the mechanical method of feed application, prove to be the most positive, both considering the condition and metabolic indexes of cow blood. On the mentioned-above farms, negative changes in the condition state of the cows and biochemical image were much less intensive comparing with the other two groups of farms. On the farms with the hand application of fodder, despite theoretically good balancing nutrition, often too great care or incommensurability in applying fodder led to excessive fat deposition and the disorders in the balance of mineral components. In lose housing herds with balanced and mechanical system of fodder application, many cows were characterised by poor condition state and the presence of sub-clinical and clinical forms of metabolic diseases. The occurrence of the mentioned changes are significantly influenced by organizational and life conditions of animals.

References