INFLUENCE OF MINERAL AND FATTY ACID DIET SUPPLEMENTATION ON THE ENERGY BALANCE IN MARES IN PREGNANCY AND LACTATION PERIODS

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Abstract

The objective of the studies was to evaluate the influence of a natural preparation supplemented with unsaturated and saturated fatty acids on the clinical features and some biochemical indices in the mares in the last trimester of pregnancy and the first lactation months. The preparation efficacy was assessed in the prophylaxis of energy balance disturbances, with a special concern given to hyperlipaemia in horses. The preparation decreased the concentration of triglycerides (TG), total cholesterol, and cholesterol high density and low-density lipoprotein fractions. No significant changes were recorded in the levels of free fatty acids (FFA) and glucose. In the group of mares without the dietary addition, the TG and FFA levels exceeded the upper limits in some animals. The preparation had a beneficial effect on the energy balance in mares at the enhanced energy metabolism period.

Key words: mare, pregnancy, diet, hyperlipaemia, feed additives.

The fatty acids metabolism from the aspect of energy imbalance in horses, especially at the outset of the last trimester of pregnancy and up to 8-10 weeks of lactation period, is not fully elucidated. This period is characterised with a marked foetus growth, mare preparation for delivery, beginning of lactation, and nursing of the newborn foal. At that time, apart from mare living demands, there are recorded increased requirements for energy, protein, and minerals conditioned by the fast growing foetus. As a consequence of the enhanced metabolism at that time, in particular a confirmed energy deficit at protein excess, dysorexia may appear with concomitant hyperlipaemia.

This state develops as the effect of hyperlipaemia occurrence and progressing of hyperlipidaemia due to some disturbances of feed intake, primary and secondary metabolic changes, or infections that lead to the negative energy balance. The primary hyperlipidaemia may be associated with obesity (adiposis), gestation, lactation, transportation, lowered feed intake (fasting), or some other stressors. The secondary one may be a consequence of worm infections, laminitis, hypocalcaemia, primary hepatopathy, pancreatitis, stomach and intestines ulceration, and colon constipations. The occurrence of this condition is observed in about 3-5% of all animals in the USA, Australia, and West Europe, but the mortality rate reaches 40-50% of the affected patients, sometimes also 100% (depending on primary cause) (1, 7, 15, 24).

Hiperlipaemia in pregnant mares may evoke premature delivery of a weak foal or dead foetus. It is characterised by an increase in serum triglycerides level above 5.5 mmol/dm$^3$ associated with a high concentration of total cholesterol, very low-density lipoprotein (VLDL) and low-density lipoprotein (LDL) cholesterol, as well as that of free fatty acids (FFA). A decrease in plasma glucose concentration is also reported (1, 7, 15, 22, 24, 25, 27).

One of the crucial preventive procedures in equine hyperlipaemia is the application of balanced energy-mineral preparations, containing a great amount of plant fats. Regardless of the fact that carbohydrates are a basic dietary source of energy, recently numerous papers all over the world indicate that dietary fat composition may affect the lipid metabolism in horses. Hambelton et al. (14) and Geelen et al. (10) showed that soybean oil was a safe and efficient source of energy for exercised horses, it normalised serum enzyme activity, reduced cholesterol concentration, and evoked increase in glycogen level in the liver and muscles (14). Medium-chain fatty acids in the diet evoked a considerable increase in a serum triglyceride level, whereas a soybean oil addition caused a marked decrease in the
concentration of the compound (6, 9, 12). In other papers, the same authors did not record any differences in concentrations of triglycerides, cholesterol, or FFA in horses supplemented with soybean or palm oil (13). Generally, the authors agree that a high fat diet, in comparison to low fat one, markedly decreased a blood triglyceride concentration (9, 11, 14, 19). Moreover, Geelen et al. (10) found that soybean oil supply brought about the increased activity in lipoprotein lipase as well as a decrease in the concentration of total cholesterol, high-density lipoprotein (HDL) cholesterol, and phospholipids in serum.

The aim of this work was to assess the influence of supplementation with unsaturated and saturated fatty acids combined with minerals on the energy balance in mares in the last trimester of pregnancy and early lactation.

Material and Methods

The investigation was carried out on 25 heavy-breeding mares, aged 4–12 years, obtained from four breeding farms in Eastern Poland. They were randomised into control (n=14) and experimental (n=11) groups, each group contained the mares from nine months of gestation up to two months after delivery. The horses were kept at natural farm maintenance conditions, on the straw litter, and a similar feeding system was used. The animals were fed good hay ad libitum, and crushed oats and barley were given twice a day in an amount of 3 kg/animal. The mares were also supplemented with a carrot (1 kg/mare daily). The animals had free access to water - the stables were equipped with automatic water dispensers. The mares in the experimental group were additionally supplied with a natural humus-mineral preparation (Humobentofet, Tronina PHW Raków, Poland) with 20% addition of vegetable oils, containing 80% of unsaturated fatty acids (oleic, linoleic, and linolenic acid) and 20% of palmitic acid. The preparation contained 21.63% of total fat and 1.96% of water. The total energy value per 1 kg of this preparation was declared as 8 MJ EM (1.912 kcal/kg). The amounts of minerals in preparation dry matter was: Ca- 3 g/kg, P2O5- 6 g/kg, Mg- 3 g/kg, K- 0.29 mg/kg, Na- 2 g/kg, Si- 22.89 dk/kg, Al2O3- 69 g/kg, as well as over 30 other elements (Fe, Se, Zn, Cu, I, Co, Mn, Cr etc.), which occur as naturally chelated, bioavailable complexes (4).

The above-mentioned preparation was given to the experimental group of mares twice a day at the amount of 250 g mixed with grain. Blood samples were collected from the external jugular vein for two months, one month, and two days before the term of parturition and one and two months after delivery. The material was sampled always at the same time, between 7:00 and 9:00 a.m. before feeding. The plasma level of triglycerides (TG) and HDL cholesterol was determined spectrophotometrically, concentration of FFA – according to Dole method (5), and HDL cholesterol – with the precipitation method. The plasma LDL cholesterol amount was calculated according to Friedewald formula (17), and plasma glucose was estimated using a spectrophotometer UV/VIS Marcel 330.

The results were analysed statistically using the programme STATISTICA 5.0 PL.

Results

In the group of mares, whose diet was supplemented with the preparation, there was noted a statistically significant decrease in plasma triglycerides concentration during the whole experimental period. The supplementation with unsaturated and saturated fatty acids had a marked influence on the energy balance indicators. The mean values at the last sampling were lower and statistically significant in comparison to the other samplings (Table 1). Moreover, this parameter was significantly lower in the experimental group in comparison to the control at prenatal period and early lactation. Mean concentrations of plasma triglycerides in the control at the time-points of blood collection were 0.86±0.40 µmol/dm3 and 1.20±0.46 µmol/dm3, respectively, that markedly exceeded physiological limits (20).

A diet rich in fatty acids did not affect the FFA levels in both groups of horses (Table 1), whereas in single mares of the control group at the prenatal period, this parameter was detected to be above the limit (mean value reached 327.81±111.62 µmol/dm3).

A total cholesterol concentration showed a variable tendency within a group of mares, which were fed the supplemented feed (Table 1). The levels were increasing until the delivery, whereas during lactation its concentrations fell under the values obtained at the beginning of the experiment. The levels recorded one and two months following parturition were significantly statistically lower in comparison to the values obtained during lactation period in control mares. On the other hand, the HDL cholesterol concentrations showed a decreasing tendency during the experimental period in the group of horses supplemented with preparation (the initial value was 1.84 mmol/L and the final one – 1.66 mmol/L) (Table 1). There were no differences in the control group. Horses, which were fed using the grain with addition of vegetable oil showed a significant decrease in LDL cholesterol concentration in the first months of lactation in comparison to the levels obtained in the prenatal period, whereas the initial and final values of this parameter in the control group remained at the same level.

No significant effect on glucose concentrations was observed after the supplementation with the mineral-energy preparation (Table 1).
### Table 1
Dynamics of changes of energy balance indices at the successive samplings

<table>
<thead>
<tr>
<th>Parameter/units</th>
<th>Control group</th>
<th>Experimental group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-2</td>
<td>-1</td>
</tr>
<tr>
<td>FFA µmol/dm³</td>
<td>X</td>
<td>177.34*</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>42.04</td>
</tr>
<tr>
<td>Triglyceride mmol/dm³</td>
<td>X</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.12</td>
</tr>
<tr>
<td>Total cholesterol mmol/dm³</td>
<td>X</td>
<td>2.81</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.51</td>
</tr>
<tr>
<td>HDL cholesterol mmol/dm³</td>
<td>X</td>
<td>1.84</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.31</td>
</tr>
<tr>
<td>LDL cholesterol mmol/dm³</td>
<td>X</td>
<td>0.70*</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.18</td>
</tr>
<tr>
<td>Glucose mmol/dm³</td>
<td>X</td>
<td>5.28</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>1.32</td>
</tr>
</tbody>
</table>

-2, -1 months before delivery, 0 perinatal period, +1, +2 months after delivery;
* P<0.05; ** P<0.01 significance of differences between control and experimental group at the same sampling time
abcd P<0.05; ABCD P<0.01 significance of differences between parameters within the experimental group
Discussion

There is a great amount of polyunsaturated fatty acids (linoleic and linolenic) in the preparation, which was used as a diet supplement in our experiment. Sunflower oil, soybean, rapeseed, or corn oil are the natural sources of these acids. Many authors revealed that these acids may cause a fall of the concentrations of triglycerides, total cholesterol, LDL cholesterol, and, on the other hand, may cause a rise in the activity of blood lipoprotein lipase (3, 10, 16, 21, 23). The authors applying a soybean oil supplement in animal diet have noted TG concentration decline (6, 8, 9, 21). Moreover, Duhlmeier et al. (6) discovered that giving soybean oil to overweight ponies also recorded a significantly fast drop in TG values in comparison to the group that were fed only a carbohydrate diet. That may indicate a favourable impact of a fat diet on a horse organism, which is predisposed to energy metabolism disorders, especially hyperlipaemia. The above-mentioned facts and the data obtained in our experiment confirm the hypothesis that in many cases a more valuable source of energy proves to be vegetable fats rather than carbohydrates. However, an extensive fat diet in horses may also lead to a decreased glucose tolerance (6, 9, 10, 18, 21).

There are some papers, which did not show any influence of soybean or palm oil (mainly saturated fatty acids) on plasma TG concentrations (10, 13). Dietary supplementation with palm oil that contains mainly medium-chain fatty acids (MCT) instead of soybean oil in horses evoked a considerable growth of serum concentrations of TG and VLDL cholesterol (12). The preparation used in our experiment did not affect markedly the FFA concentrations. Halleebek and Beynen (13) reported no influence of soybean or palm oil on the plasma FFA levels. However, Duhlmeier et al. (6) found that on supplementing the ponies’ diet with a 10% soybean oil additive observed a significant decrease of this parameter. Our investigations showed the increased triglyceride and FFA plasma concentrations in some mares, which were not supplied with the preparation. This fact may indicate that these animals were predisposed to some disturbances of energy metabolism at that period. This type of hazard was not noted in the mares from the experimental group. The preparation caused a decline in neither the total cholesterol nor HDL and LDL cholesterol. This effect may be a consequence of the metabolic activity of polyunsaturated and monounsaturated fatty acids (oleic) that decrease total cholesterol concentration and LDL cholesterol but evoke the increase in HDL cholesterol concentrations (2, 3, 16). Different results were reported by Geelen et al. (8, 9) where soybean oil addition resulted in an increase in the concentration of total cholesterol, HDL cholesterol, and phospholipids, and in the activity of lipoprotein lipase. However, Halleebek and Beynen (13) did not show any effect of soybean or palm oil on the levels of total cholesterol, HDL, or LDL cholesterol. The decline of LDL cholesterol concentrations reported in our investigation can be partly explained with the assumption that the liver converts polyunsaturated fatty acids to ketone bodies that undergo the burning process in the muscles, unlike the saturated acids, which convert into VLDL and LDL cholesterol (2). No dietary effect of palmitic acid recorded in our experiment may be explained using a theory that saturated fatty acids evoke the increase in the concentration of total cholesterol and LDL cholesterol (3, 16, 26). The addition of the oleo-mineral preparation had no significant effect on glucose level whereas it is well documented that excess fat supplementation may cause the diminished glucose tolerance and insulin resistance (21). Resuming, the preparation had a beneficial effect on the energy balance indices in mares. Vegetable oil supply may constitute a substantial component of prophylaxis against the energy balance disorders in mares during the highest hazard period.

References

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