

Evaluation of lipid indices and their effect on progesterone concentration in lactating and dry cows^{*)}

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Summary

The aim of this study was to evaluate the content of lipids and their effect on progesterone concentration in the blood serum of cows. Experimental material was sampled from lactating and dry cows (41 specimen) of Polish Holstein-Friesian breed Black and White sub-species cattle, aged 3 to 6 years (lactation month 4-6 and pregnancy month 9, respectively) in two different maintenance periods, i.e. in summer and winter. In blood samples for analyses, triglycerides (TG), phospholipids (PL), total cholesterol (Cht) and its HDL fraction were determined using a Biomerieux reagent kits and a Kontron 92 UV-VIS spectrophotometer. LDL fraction of total cholesterol was calculated from the following equation: $LDL [mmol/L] = Cht - HDL - TG/2.2$. Progesterone concentration was determined by radioimmunoassay. The results were subject to statistical analysis by means of a Statistica 6.0 computer software package. Analysis of variance (Anova) was performed at significance from the external jugular vein in the morning hours. The blood serum concentrations at a level of $p \leq 0.05$ were carried out. Pearson's coefficient of correlation (r) was calculated to determine relationship between the examined lipids and progesterone. A significantly higher triglyceride concentration (0.32 mmol/L) was found in the blood serum of dry cows when compared to the lactating ones. The lactating cows had a higher content of phospholipids in both examined maintenance seasons. The content of total cholesterol and its HDL and LDL fractions was higher in both examined groups in summer. Blood serum progesterone concentration in both seasons was higher in the pregnant cows. Most of the positive dependencies between the concentration of studied lipids and progesterone concentration were found, especially in dry cows in winter.

Keywords: cows, lipids, progesterone, lactation, pregnancy

Lipid metabolism disturbances constitute a large health and production problem in cattle. They unfavourably affect cow fertility, liver function and progesterone secretion (5, 7, 9, 18, 19). Lipid metabolism evaluation is conducted based on examination of the content of lipid indices in blood serum. Most frequently, they were analyzed according to the physiological stage of cattle (11, 14), as well as age (6, 15) and feed ration type (3). In ruminants, determination of the intensity of development and the composition of respective lipoprotein fractions is particularly authoritative (18).

The periparturient period is the time when metabolic processes in female animals proceed intensively and metabolic conversion is readjusted. Anabolism prevails during gestation and the dry period, whereas during

lactation the change consists in the increase of catabolism intensity, which is reflected in metabolic conversion indices in these two periods. Lipid metabolism disturbances in cows in the periparturient period may affect the level of progesterone in the blood (19).

The present study was conducted on 41 cows with the aim of evaluating relationships between blood lipid composition and progesterone serum blood levels in cows during lactation and the dry period in two maintenance periods, i.e. in summer and winter.

Material and methods

Examinations covered 41 cows of Polish Holstein-Friesian breed Black and White sub-species cattle, aged 3 to 6 years. Considering the maintenance season and their physiological status, they were divided into appropriate groups, i.e. group A (lactating cows, 10 animals) and group B (dry cows, 15 animals) in summer and group A₁ (lactating

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cows, 7 animals) and group B₁ (dry cows, 9 animals) in winter. The lactating cows were at lactation month 4 to 6, whereas the dry ones at pregnancy month 9.

In summer, the lactating cows were given in their daily ration as follows: 30 kg alfalfa forage, 10 kg maize silage, 2 kg meadow hay and 10 kg brewer's draff (fermentation industry's fodder) supplementing *ad libitum* the maize silage. Depending on their milk yield, the cows were also given a concentrate mixture, i.e. with milk production over 15 kg, a cow received 1 kg concentrate mixture per 2 kg produced milk. The concentrate mixture comprised: 50% ground grain, 20% wheat bran, 20% sugar beet pulp and 10% dried grass meal. In winter, the daily feed ration was composed of 50 kg maize silage (with ears), along with a 10% addition of ensiled sugar beet leaves, 3 kg meadow hay, 7 kg brewer's draff and salt licks. A concentrate mixture was given in the amount of 0.5 kg per each kg of milk over 15 kg daily milk yield. The dry cows were additionally receiving dicalcium phosphate.

Blood for analyses was sampled from the external jugular vein in the morning hours. In blood serum, the content of triglycerides (TG), phospholipids (PL), total cholesterol (Cht) and HDL-cholesterol was determined using a bioMérieux reagent kit, while the absorbance reading was made on a UV-VIS Kontron 92 spectrophotometer. The LDL-cholesterol was calculated from the following equation: LDL (mmol/L) = Cht - HDL - TG/2. Progesterone concentration was determined by radioimmunoassay (Immunotech IM 1188).

The obtained results were subject to statistical analysis by means of Statistica 6.0 computer software package. Analysis of variance (Anova) was performed at significance level $p \leq 0.05$. In order to determine the interrelationship between the examined lipids and progesterone, a Pearson's coefficient of correlation (r) was calculated (20).

Results and discussion

Table 1 shows mean concentration of selected lipid profile parameters and progesterone levels in blood serum of lactating and dry cows in summer and winter. Most values were within the physiological range (21), except for a slightly elevated triglycerides (TG) concentration in summer.

In summer statistically higher values were observed in phospholipid and HDL concentration of lactating cows. In dry cows we obtained higher values in triglycerides and LDL in the same period. The remaining parameters vary insignificantly.

In winter statistically significant values were observed in total cholesterol and HDL concentrations of lactating cows, and in the progesterone level in dry

Tab. 1. Lipid profile and progesterone concentration in blood serum of lactating and dry cows in summer and winter ($\bar{x} \pm SD$)

Parameters studied	Summer		Winter	
	A $\bar{x} \pm SD$	B $\bar{x} \pm SD$	A ₁ $\bar{x} \pm SD$	B ₁ $\bar{x} \pm SD$
Triglycerides [mmol/L]	0.23 ± 0.07	0.32* ± 0.09	0.26 ± 0.02	0.21 ± 0.05
Phospholipids [mmol/L]	3.56* ± 0.73	2.37 ± 0.19	1.76 ± 0.44	1.26 ± 0.26
Total cholesterol [mmol/L]	4.75 ± 0.40	4.65 ± 0.49	3.28* ± 0.98	2.51 ± 0.36
HDL-cholesterol [mmol/L]	3.35* ± 0.35	2.14 ± 0.67	2.0* ± 0.30	1.64 ± 0.32
LDL-cholesterol [mmol/L]	1.30 ± 0.48	2.34* ± 0.60	1.27 ± 0.73	0.78 ± 0.31
Progesterone [ng/mL]	2.74 ± 2.61	3.34 ± 1.49	2.63 ± 2.16	9.58* ± 2.76

Explanations: A, A₁ – lactating cows; B, B₁ – dry cows; *differences statistically significant at $p \leq 0.05$ between lactating and dry cows in the same period

Tab. 2. Correlation coefficients (r) between analyzed lipids and progesterone concentration in blood serum of the examined cows

Relationship	Summer		Winter	
	A	B	A ₁	B ₁
Triglycerides v. progesterone	0.13	0.52	-0.05	0.25
Phospholipids v. progesterone	0.06	-0.35	0.08	0.88
Total cholesterol v. progesterone	0.11	0.35	-0.34	0.82
HDL-cholesterol v. progesterone	-0.20	-0.05	-0.15	0.30
LDL-cholesterol v. progesterone	0.23	0.28	-0.55	0.63

Explanations: as in Tab. 1.

cows. Moreover, HDL concentration was elevated in both study periods in lactating cows.

Table 2 shows coefficients of correlations between analyzed lipids and progesterone concentration in the blood serum of cows. The coefficients of correlations and the relationships were evaluated based on Guilford's classification (10). Higher coefficient correlation values were obtained in dry cows in both periods. The highest positive and important correlations were found between progesterone and phospholipids, total cholesterol, LDL in winter and between progesterone and triglycerides in summer in dry cows. On the other hand, the highest negative correlation was found between progesterone and LDL in winter in lactating cows.

Triglyceride concentration is affected by the physiological status of the organism. The data available in literature refer to changes in this indicator during pregnancy and the periparturient period (9, 18). The concentration of these lipids is mainly connected with changes in the concentration of LDL fraction and chylomicrons in blood serum (11). Acceleration of the systemic metabolism in the early lactation period takes place at the expense of weakening regulatory mechanisms (18), which leads to disturbances in the organism's lipid metabolism; in particular in reestrification and release of triglycerides from liver cells into the blood. The disturbance of the balance between

supply of free fatty acids to hepatocytes and their release only in the form of triglycerides contribute to development of alterations within the liver, which, especially in polygastric animals, has a poorly efficient system of triglyceride removal and undergoes fatty steatosis (4, 7, 16). In this study, a higher concentration of TG was observed in the lactating cows in winter, which confirms the fact that organism fat reserves are being released in this physiological state for milk production purposes. Moreover we observed a higher concentration of HDL and phospholipids in these animals in comparison to the concentration in dry cows, in both periods.

During pregnancy, a regular decrease in the content of total cholesterol is observed, with its lowest value being found in the periparturient period. During lactation its blood level is elevated, while it decreases at the end of this period (1, 19).

Cholesterol concentration is largely affected by diet. The importance of an amount of fat which contains saturated and unsaturated fatty acids is crucial here (8). Therefore, the maintenance season and the method of feeding affected considerably a higher concentration of this sterol in the examined cows during summer feeding. Most likely green fodder had an elevating effect (17). A variation of cholesterol concentration in the blood serum affects all lipoproteins, since insoluble cholesterol is not found in serum in a free form but is contained in soluble lipoproteins (11). In bovine blood serum, HDL-cholesterols are relatively the highest, and they constitute a major lipoprotein fraction, the high level of which fluctuates depending on organism physiological status. The composition of these lipoproteins is only slightly modified by the feeding system. On the other hand, LDL-cholesterols constitute not more than 10% of the lipoprotein fraction (12) in cattle.

Progesterone plays an important role in maintaining pregnancy (2), and the progesterone level is significantly elevated in blood serum during pregnancy, which is confirmed by the authors' study; i.e. progesterone concentration in the dry cows (pregnancy month 9) was higher and differed statistically significantly in relation to that in the lactating cows in winter (tab. 1). The high progesterone concentration in the blood serum of dry cows was probably induced by their advance stage of pregnancy during which the placenta secret this hormone more intensively to maintain it. Lipid metabolism disturbances in cows in the periparturient period may affect post-parturition progesterone secretion (5). It was proved that reduction of the level of cholesterol related to lipoproteins leads to a decrease in blood progesterone concentration (1). The transport of lipoproteins with blood as a substrate for progesterone synthesis is subject to considerable adrenergic regulation (13).

References

1. Ahmed W. M.: Overview on some factors negatively affecting ovarian activity in large farm species. *Global Vet.* 2007, 1, 53-66.
2. Arndt W. J., Holle A. J., Bauer M. L., Kirsch J. D., Schimek D. E., Odde K. G., Vonnahme K. A.: Effect of post-insemination progesterone supplementation of pregnancy rate cows. *Can. J. Vet. Res.* 2009, 73, 271-274.
3. Barłowska J., Litwińczuk Z., Król J., Kędzierska-Matysek M.: Fatty acid profile and minerals content in milk from cows of various breeds over spring-summer feeding period. *Pol. J. Food Nutr. Sci.* 2006, 56, 13-16.
4. Bobe G., Young J. W., Beitz D. C.: Invited Review: Pathology, Etiology, Prevention, and Treatment of Fatty Liver in Dairy Cows. *J. Dairy Sci.* 2004, 87, 3105-3124.
5. Bronicki M., Dembiński Z.: Wpływ zaburzenia gospodarki lipidowej u krów na poporodową sekrecję progesteronu. *Mat. X Kongresu PTNW, Wrocław 1996*, s. 555.
6. Daley C. A., Abbott A., Doyle P. S., Nader G. A., Larson S.: A review of fatty acid profiles and antioxidant content in grass-fed and grain-fed beef. *Nutrition J.* 2010, 9, 10.
7. Grum D. E., Drackley J. K., Younker R. S., LaCount D. W., Veenhuizen J.: Nutrition during the dry period and hepatic lipid metabolism of periparturient dairy cows. *J. Dairy Sci.* 1996, 79, 1850-1864.
8. Hawkins D. E., Niswender K. D., Oss G. M., Moeller C. L., Odde K. G., Sawyer H. R., Niswender G. D.: An increase in serum lipids increases luteal lipid content and alters the disappearance rate of progesterone in cows. *J. Anim. Sci.* 1995, 73, 541-545.
9. Kalaitzakis E., Roubies N., Panousis N., Pourliotis K., Kaldrymidou E., Karatzias H.: Clinicopathologic evaluation of hepatic lipidosis in periparturient dairy cattle. *J. Vet. Intern. Med.* 2007, 21, 835-845.
10. Maciejewski J., Zięba J.: Genetyka i ogólna hodowla zwierząt. PZWL, Warszawa 1972.
11. Michajlik A., Bartnikowska E.: Lipidy i lipoproteiny osocza. PZWL, Warszawa 1999.
12. Mohebbi-Fani M., Nazifi S., Shekarforoush S. S., Rahimi M.: Effect of monensin on serum lipoproteins, triglycerides, cholesterol and total lipids of periparturient dairy cows. *Vet. Res. Commun.* 2006, 30, 7-17.
13. Niswender G. D., Juengel J. L., Silva P. J., Rollyson M. K., McIntush E. W.: Mechanisms controlling the function and life span of the corpus luteum. *Physiol. Rev.* 2000, 80, 1-29.
14. Orowicz W., Brzezińska M.: Poszukiwania zależności pomiędzy zawartością magnezu, lipidów i β -karotenu we krwi krów lakujących. *Biul. Magnezol. PTMag.* 1999, 4, 143-148.
15. Orowicz W., Brzezińska M.: Zawartość magnezu i wapnia we krwi oraz ich wpływ na poziom wybranych związków lipidowych cieląt w okresie intensywnego wzrostu. *Biul. Magnezol. PTMag.* 1996, 7, 44-47.
16. Pechová A., Illek J., Halouzka R.: Diagnosis and control of the development of hepatic steatosis in dairy cows in the periparturient period. *Acta Vet. Brno* 1997, 66, 235-243.
17. Pushpakumara P. G. A., Gardner N. H., Reynolds C. K., Beaver D. E., Wathes D. C.: Relationship between transition period diet, metabolic parameters and fertility in lactating dairy cows. *Theriogenology* 2003, 60, 1165-1185.
18. Pysera B., Opalka A.: The effect of gestation and lactation of dairy cows on lipid and lipoprotein patterns and composition in serum during winter and summer feeding. *J. Anim. Feed Sci.* 2000, 9, 411-424.
19. Reist M., Erdin D. K., von Euw D., TschümK. M., Leuenberger H., Hammon H. H., Morel C., Philipona C., Zbinden Y., Künzi N., Blum J. W.: Postpartum reproductive function: association with energy, metabolic and endocrine status in high yielding dairy cows. *Theriogenology* 2003, 9, 1707-1723.
20. Sobczyk M.: Statystyka. PWN, Warszawa 1998.
21. Winnicka A.: Wartości referencyjne podstawowych badań laboratoryjnych w weterynarii. Wyd. SGGW, Warszawa 2004.

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