Selenium metabolism in goats – maternal transfer of selenium to newborn kids

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ABSTRACT: The aim of our study was to compare the concentration of selenium (Se) and the activity of glutathione peroxidase (GSH-Px) in the whole blood of goats and their newborn kids. The experiment involved 25 gravid, clinically healthy goats of the white shorthaired breed. On the day of delivery, we took whole blood from the mother and her newborn kid before the kid drank the first colostrum. In mothers, the measured average concentration of Se in whole blood was 149.60 ± 45.01 μg/l, the average concentration of Se in kids was 87.91 ± 29.66 μg/l. Average activity of GSH-Px in the blood of mothers was 938.46 ± 341.09 μkat/l, and in the blood of kids 658.20 ± 339.13 μkat/l. Regression and correlation analysis produced regression line formulas and correlation coefficients that revealed a close, statistically significant relation ($P < 0.01$) between the concentration of Se in the blood of mothers and their kids and the activity of GSH-Px in mothers and their kids. The relation between the concentration of Se in the blood (μg/l) of mothers and kids was $y = 0.484x + 15.55$; $r = 0.73$, the relation between the activity of GSH-Px in blood (μkat/l) of mothers and their kids was $y = 0.809x - 101.27$; $r = 0.80$. The concentration of Se and activity of GSH-Px was lower in newborn kids than in their mothers, reaching approximately 60–70% of the mother's levels. The relation between the concentration of Se and activity of GSH-Px in the blood of goats was $y = 4.23x + 276.31$; $r = 0.64$ ($P < 0.01$) and the relation between the concentration of Se and the activity of GSH-Px in the blood of kids was $y = 6.556x + 64.70$; $r = 0.83$ ($P < 0.01$). It follows that a Se concentration of 100 μg/l corresponds to a GSH-Px activity of 699.51 μkat/l in the blood of mothers and 720.34 μkat/l in the blood of kids. The results show the need to provide for a sufficient Se saturation of goats with a view to preventing Se deficiency in kids and that the Se concentration in the blood of newborn kids is physiologically about 40% lower in comparison with the Se concentration in the blood of their mothers. This should be taken into account when interpreting the results and assessing the reference values of Se concentration in the blood of kids.

Keywords: mother-young; ruminants; trace element; glutathione peroxidase

Selenium is known primarily for its anti-oxidative activity, and together with other antioxidants such as vitamins E, C, β-carotene, zinc and copper it ensures low concentrations of reactive oxygen forms in tissues. Biological functions of selenium are mediated through its presence in selenoproteins. The most widespread selenoproteins include thioredoxin reductase, glutathione peroxidase, deiodinase of thyroid gland hormones, selenoprotein P, selenoprotein W and other selenoproteins (Papp et al., 2007). The best known clinical form of selenium deficiency in animals is nutritional muscular dystrophy. Goat kids are deemed to be more susceptible to this disease than calves or lambs (Underwood and Suttle, 1999).

To assess selenium status researchers use either direct determination of selenium concentration in whole blood or in organs, or indirect determination of the glutathione peroxidase activity (Pavlata et al., 2000, 2001).

In the Czech Republic, the selenium deficiency incidence in animals is high. It has been described

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in cattle (Pavlata et al., 2002, 2005a; Podhorsky et al., 2007) and horses (Ludvikova et al., 2005), but information concerning selenium supplementation in small ruminants is scarce.

In newborn animals and during milk suckling, the saturation of an organism with selenium depends on the saturation of the mother, as selenium permeates placental and mammary barriers. Placental transfer is more effective than the transmission of selenium to the calf through milk (Enjalbert et al., 1999).

Our paper focuses on the relationship between goats and their kids in terms of selenium levels. Levels of microelements in newborns ruminants and their mothers have not yet been studied extensively and thus available information is limited. Most publications on this topic monitor the levels of selenium in cattle (Koller et al., 1984; Kincaid and Hodgson, 1989; Pavlata et al., 2003), or sheep (Langlands et al., 1991). For this reason we monitored the levels of selenium and activity of glutathione peroxidase in goats and their kids.

MATERIAL AND METHODS

We monitored 25 clinically healthy gravid goats of the shorthaired breed with various levels of selenium supplementation. The goats were kept at the Ruminant Clinic of our faculty, fed twice a day with pellets (containing 0.4–0.9 mg Se per kilogram of feed) to an amount of 600 g per animal and day, and with meadow hay. They had free access to drinking water and salt lick. On the day of delivery, we acquired heparinized blood by *vena jugularis* puncture from mothers and their kids. We took the blood from the kids immediately after delivery, before they drank their first colostrum. In cases of twins or triplets we analyzed mixed samples from all kids. The blood was stored frozen at –20°C until processing. Before selenium level determination, the blood samples were mineralized in a closed system using the microwave digestion technique in the presence of HNO_3 and H_2O_2 using Milestone Ethos TC unit by Milestone (Italy). After vaporization and conversion of the mineralizate into water solution, 20% HCl is added. In such a solution, selenium content is determined in AAS Solaar M6 unit by Unicam (Great Britain) using the hydride technique of atomic absorption spectrophotometry (Pechova et al., 2005).

The activity of glutathione peroxidase was determined by the UV-method of Paglia and Valentine (1967) in a Cobas Mira unit (Roche, Switzerland) using the test supplied by Randox (Great Britain) Ransel GPX Cat. No. RS 506.

To formularise the activity of glutathione peroxidase per gram of hemoglobin in each blood sample, we determined the level of hemoglobin using Randox's Haemoglobin test (Great Britain).

Basic statistical parameters of results (means, standard deviation) and the regression and correlation analysis of results were computed using Microsoft Excel XP.

RESULTS AND DISCUSSION

Average values, standard deviations, minimum and maximum used values are listed in Table 1.

The average concentration of selenium in the whole blood of mothers was 149.60 ± 45.01 μg/l, while the average concentration of selenium in kids was 87.91 ± 29.66 μg/l, meaning that the average value of selenium in the whole blood of kids is about 40% lower than the concentration of se-

Table 1. Selenium (Se) concentration and glutathione peroxidase (GSH-Px) activity in the whole blood of goats and their kids (*n* = 25)

	Mean ± S.D.	Minimum	Maximum
Se – goats (μg/l)	149.60 ± 45.01	66.69	235.88
Se – kids (μg/l)	87.91 ± 29.66	35.13	166.34
GSH-Px – goats (μkat/l)	938.46 ± 341.09	375.10	1 806.0
GSH-Px – kids (μkat/l)	658.20 ± 339.13	238.10	1 846.0
GSH-Px – goats (μkat/g Hb)	7.75 ± 3.01	3.30	15.94
GSH-Px – kids (μkat/g Hb)	5.96 ± 3.18	2.0	16.29

lenium in the whole blood of their mothers. The average activity of glutathione peroxidase in the blood of mothers was 938.46 ± 341.09 µkat/l, and in the blood of kids 658.20 ± 339.13 µkat/l. We used regression and correlation analysis to acquire regression line formulas and correlation coefficients proving close, statistically significant relationships between the concentration of selenium in the blood of mothers and their kids and between the activity of glutathione peroxidase in mothers and their kids. The relationship between the concentration of selenium in the blood of mothers and kids was $y = 0.484x + 15.55$; $r = 0.73$ ($P < 0.01$) (Figure 1), while the relationship between the activity of glutathione peroxidase in the whole blood of mothers and their kids was $y = 0.809x–101.27$; $r = 0.80$ ($P < 0.01$) (Figure 2).

The activity of glutathione peroxidase per gram of hemoglobin was 7.75 ± 3.01 µkat/g in the blood of mothers and 5.96 ± 3.18 µkat/g in the blood of kids. Regression and correlation analysis generated the regression line formula $y = 0.851x–0.534$ and correlation coefficient $r = 0.81$, proving a close relation between the activity of glutathione peroxidase converted per gram of hemoglobin in the blood of mothers and their kids (Figure 3). Figure 4 and 5 show a close dependence between the activity of glutathione peroxidase in µkat units per liter of whole blood and µkat per gram of hemoglobin in whole blood. The correlation coefficient for this dependence is $r = 0.93$ ($P < 0.01$) in mothers (Figure 4) and $r = 0.95$ ($P < 0.01$) in kids (Figure 5).

The concentration of selenium and activity of glutathione peroxidase was lower in newborn

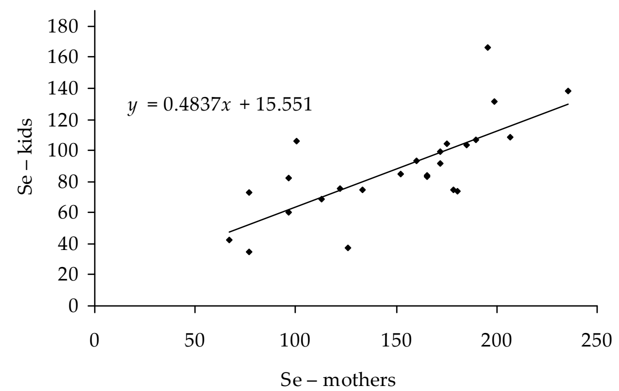

Figure 1. The correlation between the concentration of selenium in the whole blood (µg/l) of goats and their kids (n = 25)

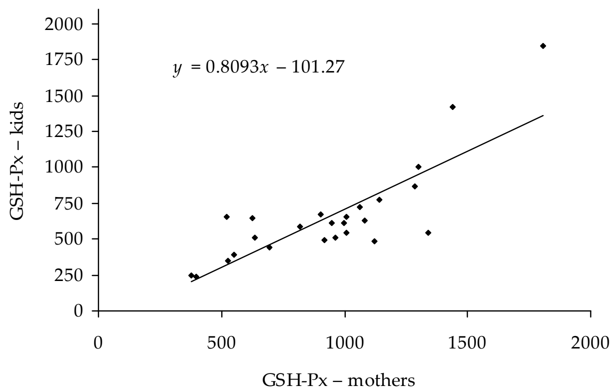

Figure 2. The correlation between the activity of glutathione peroxidase (µkat/l) in the whole blood of goats and their kids (n = 25)

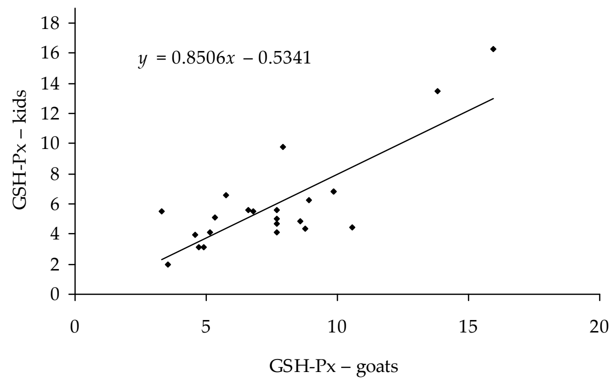

Figure 3. The correlation between the activity of glutathione peroxidase in the blood of goats and their kids in µkat/g of hemoglobin

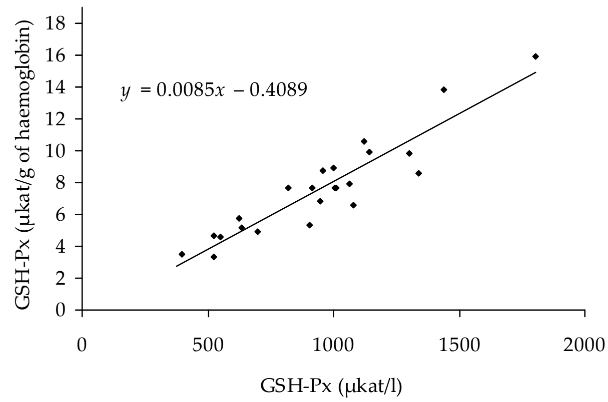

Figure 4. The correlation between the activity of glutathione peroxidase expressed in µkat/l of whole blood and µkat/g of hemoglobin in goats

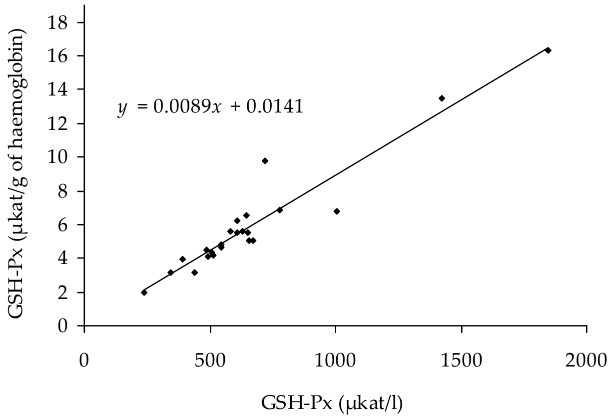

Figure 5. The correlation between the activity of glutathione peroxidase expressed in µkat/l of whole blood and µkat/g of hemoglobin in kids

kids than in their mothers, reaching approximately 60–70% of the mothers' levels. This is in contrast to results which have been acquired in cattle. Pavlata et al. (2003) found similar levels of selenium in the blood of cows and their calves. Kincaid and Hodgson (1989) also found, in cows with access to selenium-containing lick, that their calves had approximately identical levels of selenium in whole blood as their mothers on the day of delivery. Koller et al. (1984) arrived at similar results by supplementing sodium selenite to cows and monitoring selenium levels in their calves. However, they found that the calves of selenium-deficient cows have higher levels of selenium in their blood compared to mothers, which indicates that the fetus is able to accumulate selenium at the expense of the mother. This was corroborated by Rowntree at al. (2004). Calves of selenium-deficient mothers of the Hereford breed had higher concentrations of selenium in their blood on the day of delivery than their mothers. All the cited authors agree that the supplementation of selenium to mothers before delivery increases the levels of selenium in their offspring. It is interesting that Langlands et al. (1991) found that the concentration of selenium in the blood of newborn lambs is lower than in mothers, a phenomenon which is even more marked in twins. These results are in contrast to results from cattle, but similar to the results from our study, although we did not establish lower selenium levels compared to mothers when litters were multiple. To make the results more precise we would need more mothers with triplets.

We also monitored the correlation between the level of selenium and the activity of glutathione peroxidase in the blood of mothers and kids. Regression and correlation analysis produced regression line formulas and correlation coefficients. The relationship between the concentration of selenium and activity of glutathione peroxidase in the blood of adult goats is $y = 4.232x + 276.31$; $r = 0.64$ ($P < 0.01$) (Figure 6), while the relationship between

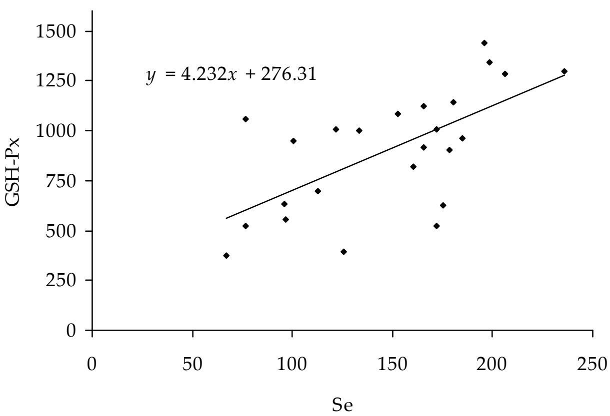

Figure 6. The correlation between the concentration of selenium (µg/l) and the activity of glutathione peroxidase (µkat/l) in the whole blood of goats

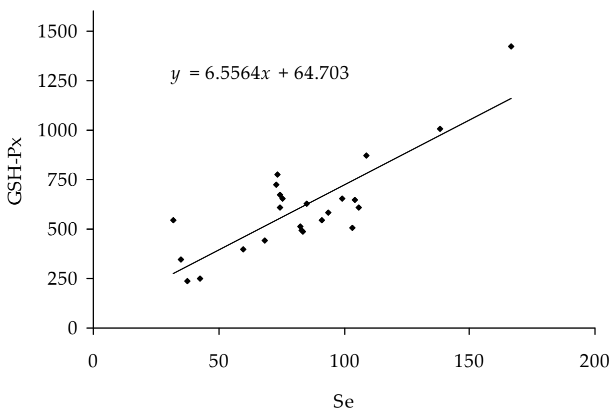

Figure 7. The correlation between the concentration of selenium (µg/l) and the activity of glutathione peroxidase (µkat/l) in the whole blood of kids

the concentration of selenium and activity of glutathione peroxidase in the blood of newborn kids is $y = 6.5564x + 64.703$; $r = 0.83$ ($P < 0.01$) (Figure 7). It follows that a selenium concentration of 100 µg/l corresponds to a glutathione peroxidase activity of of 699.51 µkat/l in the blood of mothers and 720.34 µkat/l in the blood of newborn kids. The graphs reveal that the relationship between both parameters is very close in the blood of mothers as well as in the blood of kids, and it has a character of linear dependence. Pavlata et al. (2005b) monitored the relationship between the concentration of selenium and the activity of glutathione peroxidase in the blood of one month-old kids and arrived at a regression line formula $y = 6.3804x–114.93$, i.e., a selenium concentration of 100 µg/l corresponds to a glutathione peroxidase activity of 523.11 µkat/l in whole blood. It is apparent that the activity of glutathione peroxidase in the blood of goats and of kids depends on the amount of selenium in the blood and we may use it, like in cattle and in horses, for indirect assessment of selenium status (Pavlata et al., 2000; Ludvikova et al., 2005). Since selenium is incorporated by erythrocyte glutathione peroxidase during erythropoesis, the glutathione peroxidase enzyme is considered to be a suitable indicator of biologically active selenium and thus an indicator of long-term supplementation of organism with selenium, while the direct determination of the selenium content in the blood reveals the short-term variation in the levels of this microelement (Gerloff, 1992).

The data presented here highlight the need to sufficiently saturate goats with Se so as to prevent Se deficiency in kids and show that the Se concentration in the blood of newborn kids is physiologically about 40% lower in comparison with the Se concentration in the blood of their mothers. This should be taken into account when interpreting results and assigning reference values of Se concentration in the blood of kids.

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