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Dynamics of changes in iron concentration and total iron binding capacity in blood plasma of goat kids during their first month of life (Short Communication)

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Abstract

The experiment was carried out on 14 kids of Polish Improved White breed during the first 30 days of life. The aim of this study was to show changes in the concentration of blood plasma iron and total iron binding capacity (TIBC) during the neonatal period. The statistically confirmed differences ($P \geq 0.01$) in blood serum iron concentration was show in the kids between 5th (20.57 µmol/l) and 14th (9.97 µmol/l) day of life, and between 3rd and 4th week with the peak in 23rd day (27.50 µmol/l). We have also shown statisticly confirmed increase in TIBC ($P \geq 0.01$) between 1st and 4th day of life (+20.13 µmol/l), and between 14th and 23rd day of life (+15.59 µmol/l). Statistically confirmed decrease of TIBC was observed between 6th (52.30 µmol/l) and 14th (31.78 µmol/l) day of life. Conclusion: The studies have revealed dynamic changes in the concentration and total binding capacity of blood plasma iron concentration during the first month of postnatal life. The pattern of such changes does not depend on the gender or litter size. It was observed a significant decrease in the concentration of this trace element in blood plasma toward the end of the second week, which may indicate a relative iron deficiency, particularly in twin-born kids.

Keywords: goat, goat kid, iron, iron binding capacity, blood plasma, neonatal period

Zusammenfassung

Veränderung der Eisenkonzentration im Blutplasma bei Ziegenkitzen sowie die totale Eisenbindungskapazität im ersten Lebensmonat (Kurzmitteilung)

Untersucht wurden 14 Kitze der Rasse Polnische Edelziege im ersten Lebensmonat. Der Schwerpunkt der Untersuchungen wurde auf die Darstellung der Unterschiede der Eisenwerte und der Eisenbindungskapazität (TIBC) im Blutplasma in der ersten, neonatalen Phase, gelegt. Signifikante Unterschiede ($P \geq 0{,}01$) von Eisenwerten im Blutplasma konnten sowohl zwischen dem 5. (20,57 µmol/l) und 14. (9,97 µmol/l) Lebenstag als auch zwischen der 3. und 4. Lebenswoche – mit dem Höchstwert am 23. Lebenstag – beobachtet werden. Es konnte auch eine Erhöhung der TIBC ($P \geq 0{,}01$) zwischen dem 1. und 4. Lebenstag (+20,13 µmol/l) sowie dem 14. und 23. Lebenstag (+15,59 µmol/l) festgestellt werden. Bedeutende Senkung der TIBC konnte zwischen dem 6. (52,30 µmol/l) und dem 14. (31,78 µmol/l) Lebenstag beobachtet werden. Die Untersuchungen haben bestätigt, dass in der ersten postnatalen Phase des Lebens ein dynamischer Wandel der Eisenwerte und der Eisenbindungskapazität im Blutplasma der Kitze beobachtet werden kann. Die Veränderungstendenz ist sowohl vom Geschlecht als auch von der Wurfgröße unabhängig. Es konnte eine Senkung der Eisenwerte am Ende der 2. Lebenswoche der Kitze beobachten, was auf einen bedingten Eisenmangel, besonders bei Zwillingen, hinweisen kann.

Schlüsselwörter: Ziege, Zicklein, Eisen, Eisenbindungskapazität, Blutplasma, neonatale Phase

Introduction

The supply of sufficient amounts of microelements and their efficient absorption are necessary to maintain a number of metabolic processes that support the growth, development, and sound functioning of the organism. Their deficiencies may have negative effect on the animals' health and, in consequence, jeopardise the profitability of the farm (GURDOGAN *et al.* 2006). Iron ions, as coenzymes of oxidases, catalases, peroxidases, cytochromes, reductases etc., take part in a number of significant cell processes, including the synthesis of DNA and RNA, oxygen transport, cellular cycle regulation, differentiation, and proliferation (WESSLING-RESNICK 1999). Transferrin exists in an either iron-bound or iron-free form (MAY *et al.* 1995). Iron-bound transferrin adheres to membrane receptors of the cells. The transport of iron into the cell takes place in the process of endocytosis. In the endosome, iron unbinds from transferrin and passes to the cytoplasm. Cellular iron may be used or stored in the form of ferritin and haemosiderin (TOURET *et al.* 2003). NICOLAS *et al.* (2001) have demonstrated that hepcidin, produced by the liver, is the chief factor controlling the iron homeostasis. Hepcidin is responsible for iron absorption in the small intestine (inhibiting the absorption of iron by enterocytes) and the processes of iron metabolism in the reticuloendothelial system (LIPINSKI and STARZYNSKI 2004, ROMANOWSKI *et al.* 2006). Iron requirement in livestock animals depends on the genetic age, growth rate, and metabolism rate (OSTERHOFF 1995, WOJDAK-MAKSYMIEC 2002, ANTUNOVIC *et al.* 2004, STEINHARDT and THIELSCHER 2004). It should be stressed that young animals and pregnant females are particularly susceptible to iron deficiencies (TAPIERO *et al.* 2001). Milk is relatively poor in iron (GAUCHERON 2000). Iron in milk is bound to lactoferrin, the protein that chelates the element, which helps in its intestinal absorption (ARTYM and ZIMECKI 2005). Iron concentration in goat's milk, according to KONDYLI *et al.* (2007), varies around the average of 0.06 mg/100 g. Such amount of iron may not be sufficient against the needs of goat kids during their intensive growth. These issues made us investigate into the dynamics of iron levels and total iron binding capacity in blood plasma of goat kids during the first month of their life, in relation to gender and litter size.

Material and methods

The study was performed on 14 White Improved goat kids (female n=9, male n=5, single born n=6, twin born n=8) born between January and April. Kids were after one pure breed father, and different pure breed mothers. The animals were housed with their dams in pens, and fed naturally with colostrum and milk. They also had water and solid feeds *ad libitum*. The material consisted of plasma centrifuged from full circular blood. Blood samples, drawn from the external jugular vein, were collected in the morning, every day from the 1st day until the 8th day of life, and then at 10th, 12th, 14th, 17th, 20th, 23rd, and 30th days of the observations. The plasma was then measured for iron concentration and total iron binding capacity (TIBC). Iron concentration was determined by colorimetry with bathophenanthroline. Transferrin-bound iron was released using sodium-dodecyl sulphate (SDS) and reduced to Fe^{2+} using hydroxylamine. The study, pattern, null, and reagent samples were incubated at 37°C for 20 min. The absorbance was read with reagent sample at the wave length λ=535 nm. Iron concentrations in the plasma were read from the calibration curve. TIBC was measured colorimetrically. Transferrin in blood plasma was saturated with iron ions, with its excess removed with ions of magnesium. The absorbance of the specimens was read at λ=535 nm. The results were analysed jointly for all the animals, as well as in groups according to gender (males, females) and litter size (single-birth kids, twins). Means and standard deviations were calculated. In order to test significances of differences, the data were analysed statistically using one-way ANOVA with replicated measurements and the Duncan range test (Statistica 6.0).

Results and discussion

The mean blood plasma iron concentration in the kids during the first month of life ranged between 9.97 and 27.50 µmol/l (Figure 1). In the first five days, the level of this element remained stable. In the present study was observed a statistically significant ($P \leq 0.01$) decrease in the concentration between day 5th (20.57 µmol/l) and 14th (9.97 µmol/l) days, whereas in the 3rd and 4th week of life, the concentration of iron significantly ($P \leq 0.01$) increased. It should be noted that iron level measured during the 4th week was significantly ($P \leq 0.01$) higher compared to the mean of the first 3 weeks of life.

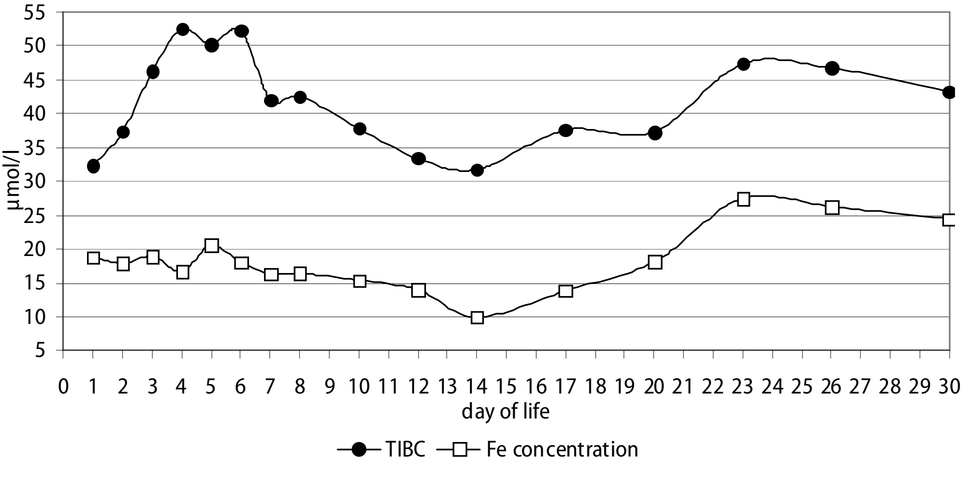

Figure 1
Iron concentration (µmol/l) and Total Iron Binding Capacity (TIBC, µmol/l) in blood plasma of goat kids during the first month of life (*n*=14)

Eisenwerte und Eisenbindungskapazität (TIBC) im Blutplasma von Kitzen im ersten Lebensmonat (n=14)

Plasma iron levels varied during the studied period, both in males and females, with a similar pattern of changes in both sexes. The differences, however, were non-significant at $P \leq 0.05$. In the present study was not found any significant differences in plasma iron concentration changes between the groups of single-birth and twin-birth kids. During the first week, it was found a significant ($P \leq 0.01$) increase in total iron binding capacity. The difference between the 1st and the 6th day after birth reached 20.13 µmol/l. It is worth noting that no such dynamic increase in plasma iron concentration was observed during this period. From 6th day of life, TIBC significantly decreased ($P \leq 0.01$), reaching its minimum at 14th day (31.78 µmol/l). As from the third week, TIBC increased up to a steady level ranging between 43.31 and 47.37 µmol/l in the 4th week. Between weeks 2 and 4 the pattern of changes in both TIBC and plasma iron concentrations were similar. Changes in TIBC did not depend on the gender of the kids. An effect of litter size on TIBC has not been confirmed.

Despite the fact that the kids were provided with iron through colostrum and milk feeding, the mean blood plasma iron concentrations during the first month of their postnatal life did not increase. This may imply a high level of consumption of iron by the organism (in the process of haemopoiesis), on the one hand, or its less efficient absorption, on the other. Increased TIBC confirms these suggestions and reveals that the amount of iron in the organism during kids' first days of postnatal life may not be sufficient to meet their requirements. The reduced level of iron in blood plasma observed during the second week supports the hypothesis about a very high demand for iron resulting from the intensive growth and development. The results indicate that between the second and the third week, a relative deficiency of iron may occur in goats. Increased concentration of blood plasma iron observed towards the end of the first month of life is probably related to a better absorption (lower rate of intestinal epithelium rebuilding) and a more efficient iron management (better hepatointestinal circulation). Converging patterns of changes in plasma iron concentration and TIBC between weeks 2 and 4 seem to support these hypotheses. The results demonstrate that gender of the neonate does not influence plasma iron concentration. The higher iron levels in the females that were observed during the first 2 days *post partum* may have been a result of the neonatal behaviour. What seems more important, however, is that TIBC was higher in the females than in the males over the entire period of studies (the first month of life), despite the fact that this parameter was similar in both groups during the first day after birth. This issue requires a further in-depth analysis. Litter size did not affect significantly either plasma iron or TIBC. The increased level of iron observed during the first week in the single-birth kids indirectly indicates a sufficient supply of iron to the organism from the dam‹s milk. Lower and more stable iron levels in the twin-birth kids seems to support the hypothesis about both a high demand for iron by the growing organism and about possible latent deficiencies occurring during the first two weeks of postnatal life. TIBC in the twins, higher during the first 2 weeks, but also in the 3rd and 4th week of life, also supports this opinion. Reduced plasma iron concentrations during the postnatal period have been observed in other livestock species ANTUNOVIC *et al.* (2005), ATYABI *et al.* (2006), ILIC *et al.* (2006), and RICKENER *et al.* (2004). BOSTEDT *et al.* (1990) have demonstrated that plasma iron concentration directly after birth in calves averages 27.7 µmol/l and decreases statistically significantly during the first hours of life until the second week. Also KUME and TANABE (1996) have reported that blood iron levels in healthy calves decrease from the first day until 10 days of age. Also FRIETSCH *et al.* (1991) and HARVEY *et al.* (1987) state that the first 14 days after birth is a critical period in a foal's life in terms of iron requirements. The authors have also demonstrated that TIBC in foals increases slightly during the first four weeks. They have also reported that blood plasma iron concentration in foals is independent from the gender. A low plasma iron concentration in piglets and its decrease with age have been observed by some authors, including ILIC *et al.* (2006). TIBC in these animals was low after birth, and increased afterwards along with a decrease in iron concentration in blood. The studies have revealed dynamic changes in the concentration and total binding capacity of blood plasma iron during the first month of goat kids‹ postnatal life. The pattern of such changes does not depend on the gender or litter size. It was observed a significant decrease in the concentration of this element in blood plasma towards the end of the second week, which may indicate a relative iron deficiency, particularly in twin-born kids.

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