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Blood metabolic profile and acid-base balance of dairy goats and their kids during lactation

Zvonko Antunović[1]*, Marcela Šperanda[1], Josip Novoselec[1], Mislav Đidara[1], Boro Mioč[2], Željka Klir[1], and Danijela Samac[1]

[1]*Department of Animal Science, Faculty of Agriculture in Osijek, University of J. J. Strossmayer, Osijek, Croatia*

[2]*Department of Animal Science and Technology, Faculty of Agriculture, University of Zagreb, Zagreb, Croatia*

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ABSTRACT

The aim of the present research was to determine the blood metabolic profile and acid-base balance of dairy goats and of their kids during lactation. Analyses were made of 15 Alpine goats and their suckling kids, in a traditional production system. The goats' blood was collected from the 20th to the 140th day of lactation every 30th day. Kids´ blood was collected on the 20th and 50th days of life. From the blood samples the values of pH, partial pressure of carbon dioxide (pCO_2), partial pressure of oxygen (pO_2), total pressure of carbon dioxide (tCO_2) and bicarbonate (HCO_3^-) were determined. Afterwards, the blood samples collected from the goats and kids were centrifuged, and from the plasma obtained the concentrations of calcium, phosphorus-inorganic, potassium, sodium, iron, chloride, urea, glucose, total proteins, albumin, creatinine, cholesterol, HDL-cholesterol, LDL-cholesterol, trygliceryds, alkaline phosphatase (ALP), creatine kinase (CK) and γ-glutamyl transferase (GGT) were assessed. Also, the strong ion difference (SID), anion gap (AG) and z-values were determined from the blood of the goats and kids. The results were obtained by MEANS procedure, and differences between the groups were determined using ANOVA repeated measures. A significant decrease in glucose, tryglicerides, Na and Fe concentrations was determined, as well as the AG and SID content in the blood, and increases in cholesterol, HDL-cholesterol, LDL-cholesterol, total protein, albumin, globulin and P-inorganic in the blood of goats during lactation. The concentrations of Cl, creatinine, and enzymatic activity (CK, GGT and ALP) in the blood of goats during lactation did not differ significantly. The results of the blood metabolic profile and acid-base balance indicate the need for better control of goats and kids´ rations in traditional production systems.

Key words: metabolic profile, acid-base balance, lactation, goats, kids

*Corresponding author:

Zvonko Antunović, Professor, Department of Animal Science, Faculty of Agriculture in Osijek, J. J. Strossmayer University, K. P. Svačića 1d, 31000 Osijek, Croatia, Phone: +385 31 554 899; E-mail: zantunovic@pfos.hr

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Introduction

In small ruminants, pregnancy and lactation, as well as the neonatal period are phases which may modify the metabolism of dams and offspring, respectively (PICCIONE et al., 2012; PICCIONE et al., 2011b; ZUMBO et al., 2011). The specific changes taking place during pregnancy and lactation are very important in clinical practice because all metabolic functions vary during these physiological phases in order to satisfy the demands of the foetus, placenta and uterus, and also to cope with milk production. The values of haematological parameters are influenced by several factors, such as breed, age, malnutrition and season (PICCIONE et al., 2011a). Advanced lactation of goats increases the need for nutrients for milk synthesis, and so physical condition and nutrition have to be adequate (AVONDO et al., 2009). Biochemical parameters, primarily metabolites, enzymes, proteins, and indicators of acid-base balance of the blood indicate possible metabolic disorders, and disorders caused by inadequate nutrition (ANTUNOVIĆ et al., 2002; RIOS et al., 2006; CELI et al., 2008a and 2008b; SAMARDŽIJA et al., 2013). High levels of non-esterifed fatty acids and glucose concentration are indicators of lipid metabolization and fatty acid oxidation (WATHES et al., 2009). If an animal is unable to consume enough feed to meet mainatenance requirements, it uses body reserves, resulting in increases in serum NEFA and urea, due to adipose and protein catabolism (CALDEIRA et al., 2007). Cholesterol is a precursor of the steroid hormones, and varies during the oestrus cycle, gestation and lactation (WILLIAM, 2004). Mineral concentrations and their circulation represent homeostatic mechanisms that are in a close relationship with their neurohumoral regulation (KRAJNIČAKOVA et al., 2003). However, if concentrations of Ca, P, K as well as liver enzymes (GGT, AST, CK, LDH) are below or above reference values in goats this indicates health problems (INVARTSEM and ANDERSEN, 2000; MAHGOUB et al., 2008). In recent years, the determination of the acid-base balance of the blood has involved more parameters. Following all of these is calculation of the anion gap (AG), strong ion difference (SID), z values, and determination of organic acids (lactate, keto acids) and inorganic anions (sulphates, phosphates, etc.). According to research by CASTILLO et al. (1998 and 2000) it is best to identify and combine as many of these indicators and calculations as possible.

The aim of the present research was to determine the blood metabolic profile and acid-base balance of dairy goats during lactation, as well as that of their kids during suckling in a traditional production system.

Materials and methods

Analyses of blood metabolic profile and acid-base balance were made for the same 15 primiparous Alpine goats and their kids in a traditional production system during the lactation period. The traditional production system is based on feeding goats during the

winter in the stable with high quality hay and grain mixture, and during the summer while grazing on natural pastures, with the addition of a grain mixture. The goats were selected from a herd of 50 animals. The selected goats were of an average age of four years and in their 3rd lactation, mated with the same father (buck), from a litter of twins, all healthy and in good physical condition.

The study was conducted during the winter feeding season. The goats were fed with 1 kg/day of grain mixture (wheat-30%, rye-30%, corn-30%, wheat bran-5% and soybean grits-5%), with 13% CP and 7.1 NEL MJ, and with meadow hay (11% CP and 4.7 NEL MJ), salt licks and water *ad libitum*. The kids were suckling goats from birth until the 50th day of life, and were fed the same grain mixture, meadow hay and salt licks *ad libitum*.

The present study began in 2012 when the goats were gravid and continued into 2013 when kidding occurred, while sampling was carried out from February until June 2013. The family goat farm was located in Gat (latitude 45°42' 25.362" N, longitude 18°19' 36.3556" E) about 40 km west of Osijek. The monthly mean temperature for this area from February to June 2013 was 11.2 °C (range from -6 to 35.2 °C), mean monthly values for relative humidity were 85% to 68%, and the monthly temperature-humidity index (THI) was 53.61 for this period of time and area. The THI values were calculated using the equation by KIBLER (1964). The natural photoperiod in this region varied from 9:45/14:15 in February to 15:38/8:22 light/dark ratio in June 2013.

Milk samples were collected manually at 7.00 a.m. before blood collection. To avoid suckling, goat kids were separated from the goats the day before sampling at 7.00 p.m. After that, determination of fat, proteins and lactose in the milk was carried out using the infrared spectrometric method (HRN EN ISO 9622:2001) by a MilkoScan FT 6000, located within the Comby system. Urea milk concentration was established using the color spectrophotometric method. Analysis of the goats' milk was carried out at the Central Laboratory for Milk Control in Križevci, Croatia. All samples of goat milk used in the analysis and processing of the data conformed to the requirements of the Regulation on the quality of fresh raw milk (2000).

From each animal, blood samples were collected from the jugular vein (10 mL) into Venoject® sterile vacuum tubes (Sterile Terumo Europe, Leuven, Belgium) containing Li-heparin as anticoagulants. In particular, from each goat blood sampling was performed every 30 days from the 20th to the 140th day of the lactation period, whereas, from each kid blood sampling was performed on the 20th and 50th days of life. From the blood samples, pH, partial pressure of carbon dioxide (pCO_2), partial pressure of oxygen (pO_2), total carbon dioxide (tCO_2) and electrolites (Na^+, K^+, Cl^- i HCO_3^- - bicarbonate) were determined by automtic analyzer, Rapid Lab 348, that works on the basis of ion-selective electrodes. After that, the blood samples were centrifuged at 3000 revolutions/min for 10 min, and the plasma samples obtained were placed into an Olympus AU640. From the

plasma samples the concentrations of calcium, phosphorus-inorganic, potassium, sodium, iron, chloride, urea, glucose, total proteins, albumin, creatinine, cholesterol, HDL-cholesterol, LDL-cholesterol, tryglicerides, alkaline phosphatase (ALP), creatine kinase (CK) and γ-glutamyl transferase (GGT) were assessed. Globulin content was calculated as the difference between total protein and albumin. The strong ion difference (SID) was estimated by the formula: $[(Na^+ + K^+) - Cl^-]$ according to STEWART (1983), the *z* value was estimated by the formula: (SID/Na) according to WHITEHAIR et al. (1995), and the anion gap (AG) by the formula: $[(Na^+ + K^+) - (Cl^- + HCO_3^-)]$ according to KANEKO et al. (2008). The blood analyses were performed at the laboratory for the Feeding and Physiology of Animals at the Faculty of Agriculture in Osijek, Croatia.

The results from the goats and their kids showing concentrations of biochemical parameters, electrolytes, enzymes activities and indicators of acid-base balance, as well as the milk composition, were obtained using the MEANS procedure, and differences were determined with repeated ANOVA measures. Differences were considered as significant at the level of 0.05 or less. All data were analysed with the statistical software SAS 9.3®.

Results

Analysing Tables 1 and 3, it is evident that glucose, tryglicerides, Na and Fe concentrations in the blood decreased significantly. In contrast, increases in cholesterol, HDL-cholesterol, LDL-cholesterol, total protein, albumin, globulin and P-inorganic in the blood of goats during lactation were determined.

A decrease in glucose concentrations was also observed as lactation progressed, and it was significant on the 20th day compared to the 140th day of lactation. Cholesterol concentrations increased significantly on the 50th day of lactation, and decreased in subsequent measurements. A similar trend was noted for HDL-cholesterol, and LDL-cholesterol, that increased significantly on the 50th day of lactation, and then significantly decreased during lactation. Concentrations of Na significantly decreased during lactation. NEFA concentrations were the the highest on the 110th day of lactation, and significantly decreased on the 140th day of lactation.

A significant increase was observed in the concentrations of total protein, albumin and globulin during lactation. Concentrations of total protein in the blood of goats were significantly higher on the 110th and 140th days of lactation, and lower on the 80th day of lactation. Also, a decreased concentration of urea was observed in the blood on the 50th day of lactation, and later its slow recovery was determined as lactation progressed, with the highest values on the 110th day of lactation. Milk urea concentration increased as lactation progressed and was significantly lower on the 20th, 50th and 80th days of lactation compared to the 110th and 140th days of lactation (Table 2).

Table 1. Biochemical parameters and enzymes activities in blood of goats during lactation

Parameters	Day of lactation (mean ± SD)				
	20th	50th	80th	110th	140th
Glucose mmol/L	3.22 ± 0.43^{a}	3.20 ± 0.21^{a}	3.08 ± 0.20^{a}	3.04 ± 0.40^{a}	2.79 ± 0.28^{b}
Cholesterol mmol/L	2.03 ± 0.39^{aA}	3.10 ± 1.04^{a}	2.55 ± 0.66^{b}	2.79 ± 0.49^{bB}	2.69 ± 0.52^{b}
HDL-cholesterol mmol/L	1.05 ± 0.33^{aA}	1.76 ± 0.47^{a}	1.51 ± 0.32^{b}	1.62 ± 0.23^{B}	1.51 ± 0.27^{B}
LDL-cholesterol mmol/L	0.77 ± 0.29^{aA}	1.25 ± 0.59^{a}	0.99 ± 0.33^{b}	1.09 ± 0.28^{B}	1.05 ± 0.33
Triglycerides, mmol/L	0.19 ± 0.08	0.20 ± 0.05	0.17 ± 0.05	0.17 ± 0.05	0.18 ± 0.03
NEFA, mmol/L	0.14 ± 0.08	0.13 ± 0.07	0.14 ± 0.08	0.21 ± 0.18^{a}	0.11 ± 0.04^{b}
Urea, mmol/L	2.63 ± 1.04^{aA}	1.84 ± 0.51^{bA}	2.25 ± 0.83^{A}	3.82 ± 1.30^{B}	2.62 ± 0.66^{AD}
Total protein, g/L	74.29 ± 7.58	74.94 ± 3.90^{A}	70.78 ± 4.76^{B}	78.94 ± 4.16^{C}	77.60 ± 5.28^{AC}
Albumin, g/L	29.81 ± 2.71^{a}	30.35 ± 2.22^{A}	28.07 ± 2.70^{B}	29.43 ± 3.50	28.13 ± 1.69^{bB}
Globulin, g/L	51.29 ± 7.58	51.94 ± 3.90^{A}	47.78 ± 4.76^{B}	55.94 ± 4.16^{C}	54.60 ± 5.28^{CA}
Creatinin, µmol/L	63.03 ± 7.15	63.63 ± 6.73^{A}	61.74 ± 4.54	63.71 ± 4.67	65.51 ± 8.26
Ca, mmol/L	2.23 ± 0.26	2.30 ± 0.26	2.20 ± 0.26^{A}	2.39 ± 0.23^{B}	2.31 ± 0.13
P-inorganic, mmol/L	1.85 ± 0.64^{ac}	2.28 ± 0.40^{Bc}	2.08 ± 0.34^{C}	2.32 ± 0.53^{ab}	2.15 ± 0.47
K, mmol/L	3.87 ± 0.48^{A}	4.70 ± 0.49^{Ba}	4.16 ± 0.48^{bAB}	3.91 ± 0.69^{A}	3.53 ± 0.43^{CA}
Na, mmol/L	147.82 ± 4.30^{a}	152.38 ± 5.35^{bA}	144.93 ± 2.26^{bB}	144.40 ± 3.91^{b}	135.43 ± 1.35^{BC}
Cl, mmol/L	101.94 ± 8.13	107.70 ± 5.49	108.41 ± 2.99	106.33 ± 2.86	109.02 ± 2.09
Fe, µmol/L	27.11 ± 6.83^{A}	26.06 ± 6.24^{AC}	20.03 ± 4.72^{BbC}	21.64 ± 4.49^{BCb}	19.63 ± 4.23^{B}
CK, U/L	136.56 ± 52.42	162.69 ± 65.18	142.15 ± 36.77	179.34 ± 61.14	118.59 ± 29.07
GGT, U/L	40.84 ± 8.96	43.99 ± 10.80	40.28 ± 6.41	42.93 ± 5.47	44.60 ± 6.06
ALP, U/L	213.10 ± 181.33	241.02 ± 209.04	232.83 ± 217.49	239.67 ± 183.12	251.42 ± 201.23

SD - standard deviation; A, B, C - means with different superscript letters differ significantly: P<0.01; a, b - means with different superscript letters differ significantly: P<0.05

Plasma concentrations of some minerals (Table 1) were significantly different during lactation. A significant increase in the concentration of P-inorganic was determined during lactation. The concentration of K was significantly higher on the 50th day of lactation, and later reached the highest values on the 50th and 80th days of lactation, and decreased again significantly at the end of lactation (140th day). Plasma Ca levels continued to increase during lactation, except on the 80th day when they decreased compared with the 110th day

of lactation. A significant decrease in the Fe content, AG and SID was also found in the blood of goats during lactation (Table 3). The activity of CK decreased on the 140th day of lactation, and GGT activity on the 80th day of lactation.

Table 2. Chemical composition of goat milk during lactation

Parameters	Day of lactation (mean ± SD)				
	20th	50th	80th	110th	140th
Fat, %	3.42 ± 0.46	3.52 ± 0.58	3.31 ± 0.31	3.24 ± 0.48	3.35 ± 0.36
Proteins, %	3.76 ± 1.13	4.01 ± 0.91	3.88 ± 1.00	3.80 ± 0.92	3.52 ± 0.81
Lactose, %	4.35 ± 0.25	4.35 ± 0.18	4.41 ± 0.21	4.28 ± 0.28	4.31 ± 0.22
Urea, mg/dL	24.73^{A} ± 7.48	25.17^{A} ± 8.40	28.64^{a} ± 8.13	32.66^{Bb} ± 6.12	33.13^{Bb} ± 6.10

SD - standard deviation; A, B - means with different superscript letters differ significantly: P<0.01; a, b - means with different superscript letters differ significantly: P<0.05

Table 3. Parameters of blood acid-base balance in goats during lactation

Parameters	Day of lactation (mean ± SD)				
	20th	50th	80th	110th	140th
pH	7.38 ± 0.05	7.37 ± 0.05	7.38 ± 0.05	7.39 ± 0.04	7.39 ± 0.05
pCO_2, kPa	6.45 ± 1.14	6.85^{A} ± 0.65	6.24 ± 1.09	6.34 ± 0.53	6.1^{B} ± 0.57
pO_2, kPa	5.39^{a} ± 2.09	4.28^{b} ± 1.01	5.3^{Aa} ± 0.97	4.99^{A} ± 1.46	3.85^{Bb} ± 0.35
HCO_3^-, mmol/L	25.94 ± 2.94	26.89 ± 2.40	25.57 ± 2.45	26.53 ± 2.21	25.26 ± 2.55
BE, mmol/L	2.66 ± 3.71	3.78 ± 2.70	2.31 ± 3.14	3.33 ± 2.52	2.32 ± 2.74
Lactates, mmol/L	2.79 ± 1.08	2.38 ± 0.33	2.25 ± 0.83	3.82 ± 1.30	2.62 ± 0.66
AG	23.81 ± 11.13^{A}	22.50 ± 10.11^{A}	15.11 ± 6.44^{B}	15.45 ± 7.43^{B}	14.68 ± 9.10^{B}
SID	49.75 ± 11.09^{aA}	49.39 ± 9.68^{aA}	40.68 ± 5.01^{bA}	41.98 ± 6.09^{bA}	29.94 ± 2.65
z-value	0.33^{Aa} ± 0.07	0.33^{Aa} ± 0.06	0.27^{Ab} ± 0.03	0.28^{Ab} ± 0.03	0.28^{B} ± 0.04

SD - standard deviation; A, B - means with different superscript letters differ significantly: P<0.01; a, b - means with different superscript letters differ significantly: P < 0.05

By studying the energy status in the blood of kids during the suckling period, significant changes in LDL-cholesterol were observed, as it increased with the increasing the age of the kids. At the same time, the concentrations of total protein, globulin, Ca, Na, CI increased significantly (Table 4), but SID and albumin concentrations decreased with increasing age (Table 5). In the present research, significant increases in LDL cholesterol, lactate, total protein, glucose, Ca, Na, Cl, and SID, and a decrease in AG were determined as the age of the kids increased.

Table 4. Biochemical parameters and enzymes activities in blood of suckling kids

Parameters	Age of kids (mean ± SD)	
	20th	50th
Glucose, mmol/L	5.08 ± 0.49	5.08 ± 1.19
Cholesterol, mmol/L	2.36 ± 0.66	2.79 ± 0.50
HDL-cholesterol, mmol/L	1.25 ± 0.28	1.27 ± 0.19
LDL-cholesterol, mmol/L	0.96^{a} ± 0.38	1.37^{b} ± 0.36
Triglycerides, mmol/L	0.34 ± 0.20	0.33 ± 0.07
NEFA, mmol/L	0.08 ± 0.10	0.04 ± 0.09
Urea, mmol/L	3.26 ± 1.07	3.68 ± 1.12
Total protein, g/L	50.68^{A} ± 3.38	58.49^{B} ± 5.00
Albumin, g/L	27.83^{a} ± 1.84	25.06^{b} ± 3.38
Globulin, g/L	46.68^{A} ± 3.38	54.49^{B} ± 5.00
Creatinine, µmol/L	51.43 ± 6.58	52.07 ± 5.35
Ca, mmol/L	1.96^{A} ± 0.66	2.36 ± 0.72
P-inorganic, mmol/L	3.33 ± 0.31	3.19 ± 0.37
K, mmol/L	4.91 ± 0.44	5.03 ± 0.43
Na, mmol/L	141.80^{A} ± 1.25	152.80^{B} ± 2.09
Cl, mmol/L	105.70^{A} ± 1.79	114.00^{B} ± 2.45
Fe, µmol/L	26.47 ± 11.37	29.26 ± 10.45
CK, U/L	194.50 ± 88.25	246.20 ± 145.17
GGT, U/L	34.39 ± 7.98	41.75 ± 23.50
ALP, U/L	396.41 ± 180.81	385.64 ± 235.83

SD - standard deviation; A, B - means with different superscript letters differ significantly: P<0.01; a, b - means with different superscript letters differ significantly: P<0.05

Table 5. Parameters of blood acid-base balance of suckling kids

Parameters	Age of kids (mean ± SD)	
	20th day	50th day
pH	7.36 ± 0.03	7.36 ± 0.03
pCO_2, kPa	7.42 ± 0.48	7.60 ± 0.60
pO_2, kPa	4.27 ± 0.58	3.83 ± 0.43
HCO_3^-, mmol/L	28.05 ± 2.38	28.24 ± 2.12
BE, mmol/L	5.44 ± 2.88	6.01 ± 2.70
Lactates, mmol/L	2.65 ± 1.18	2.81 ± 1.05
AG, mmol/L	12.96 ± 2.72	12.39 ± 2.11
SID, mmol/L	41.01^{a} ± 2.60	43.83^{b} ± 1.58
z-value	0.29 ± 0.02	0.29 ± 0.01

SD - standard deviation

Discussion

Advanced lactation had a significant influence on the blood metabolic profile and acid-base balance of the goats. Transition from advanced lactation led to significant stress for the animals, and affected the expression of their productivity. Concentrations of glucose, NEFA and cholesterol in the blood of goats are good indicators of their energy supply. In the present research no significant differences were determined when comparing these parameters with the reference values for goats (KANEKO et al., 2008).

FERNANDEZ et al. (2006) concluded that plasma concentration of NEFA is capable in itself of indicating the energy status of goats. A plasma NEFA concentration of 0.2-0.21 mmol/L has been suggested for lactating goats at zero energy balance (DUNSHEA and BELL, 1989). In our research plasma, NEFA concentrations were below this level, suggesting that the goats experienced an adequate energy balance. PICCIONE et al. (2012) determined an increase in cows´ plasma NEFA concentrations and their correlation with lower glucose consumption for maximize synthesis of milk. This stimulated a marked mobilization from adipose tissue, as confirmed by the increase in NEFA plasma levels (WHEELOCK et al., 2010).

Compared with the reference values for urea (2.9-10.9 mmol/L) according to McDOUGAL et al. (1991), lower values were determined in the present research (1.84-2.7 mmol/L), that may be related to the lower content of protein in the goats´ diet. In fact, KOHN et al. (2005) stated that urea concentration may can be considered a good indicator of the amount of nitrogen consumed in the feed. Decreased concentrations of urea in the plasma during lactation, except on the 110th day of lactation, might be ascribed to an enchanced level of urea recycling into the digestive tract (ODDY et al., 1983) and the lower content of protein in the diet. In this research, no significant differences in the composition of milk were determined, except in the concentration of urea that increased as lactation progressed. Considering the lower content of protein in the diet, a lower deficit in urea content was determined in the milk. This is possibly due to the fact that urea recycling in goats is more efficient than in sheep. In addition, since high-energy diets reduce the necessity for goats to use aminoacids as an energy source, less ammonia is produced from amino acid catabolism (PULINA et al., 2008). The similar chemical composition of Alpine goat milk was observed in conventional production by PAVLIČEK et al. (2006) and in an organic production system by ANTUNOVIĆ et al. (2009).

In our research, concentrations of total protein in the plasma increased during lactation. Similar results for levels of total proteins in goats during lactation were determined by KRAJNIČAKOVA et al. (2003).

In our investigation, plasma Ca levels were similar, apart from a significance different between the 110th and 80th days of lactation, when they were at the lower limit of the reference values (KANEKO et al., 2008). It is likely that this could be connected with

the increased demand for Ca from mammary glands during lactation (CELI et al., 2008b). KRAJNIČAKOVA et al. (2003) suggest that the decrease in Ca is connected with the transfer to goats' milk at the time of lactation. In the investigation by SAMARDŽIJA et al. (2011) of crossbred German Fawn-improved goats during puerperium, it was determined that they suffered from moderate hypocalcemia. The reduction in plasma concentrations of Na during lactation is most likely due to loss of this element in milk (AHMED et al., 2000). A significant decrease in Fe concentration in the blood of Baladi goats during lactation was observed by AZAB and ABDEL MAKSUD (1999).

No significant differences in the content of BE were determined during lactation. It is generally accepted that milk production, with the physiological characteristics of female goats, makes particularly heavy metabolic demands on ruminants because not only energy requirements but also glucose needs are increased (HERDT, 1988). Also, in a general sense, metabolic activity modifies the acid-base balance although it is difficult to estimate the degree of this contribution to the metabolic component of the acid-base balance (CASTILLO et al., 2000). Decreased blood content of AG and SID was determined in the blood of goats during lactation. The anion gap is an indicator used to investigate the presence of unmeasured anions. The anion gap may also significantly differ with changes to pCO_2 and HCO_3 (FENCL and LEITH, 1993; CASTILLO et al., 1998). The value of the anion gap is a limited explanation of the acid-base balance. HAMZAOUI et al. (2010) determined similar values in the blood of dairy goats for HCO_3 (25.71 mmol/L), pCO_2 (26.9 mm Hg) and lower content of AG (12.5 mmol/L).

Concentrations of glucose and total protein in the blood of kids were consistent with the consumptions of high concentrations of lactose and other gluconeogenic energy substrates via milk (RAUPRICH et al., 2000). Similar plasma levels of total protein, a higher content of albumin and lower content of globulin in the blood of kids was observed by CELI et al. (2008b). Deficits in dietary proteins in goats did not alter the metabolic profile parameters and acid-base balance of kids´ blood, which indicates the adaptability of goats. This is because goats have lower protein requirements (KRONBERG and MALECHECK, 1997) due to greater N recycling and thus greater efficiency in N utillization (TISSERAND, 2003). Also, it is well known that goats are resistent to certain metabolic diseases (BRUSS, 1996).

Conclusion

The results of the present study determined a significant decrease in glucose, tryglicerides, Na and Fe concentrations, as well as the content of AG and SID in the blood. In contrast, increases in cholesterol, HDL-cholesterol, LDL-cholesterol, total protein, albumin, globulin and P-inorganic in the blood of goats during lactation were determined. The results showed that dietary protein deficit in goats influenced the protein metabolic

parameters in the blood, in particular in decreasing blood and milk urea concentrations. Results of the blood metabolic profile and acid-base balance indicate the need for better control of goat and kid rations in traditionaly production systems.

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SAŽETAK

Cilj ovog istraživanja bio je utvrditi metabolički profil i acidobaznu ravnotežu krvi mliječnih koza u laktaciji, kao i njihove jaradi. Pokus je proveden na 15 koza pasmine francuska alpina i njihove sisajuće jaradi u tradicionalnom sustavu uzgoja. Uzorkovanje krvi koza provedeno je od 20. do 140. dana laktacije, svakih 30 dana. Uzorkovanje krvi jaradi provedeno je u dobi od 20 i 50 dana. U krvi su utvrđene vrijednosti pH, parcijalni tlak ugljikova dioksida (pCO_2), parcijalni tlak kisika (pO_2), ukupni tlak ugljikova dioksida (tCO_2) i sadržaj bikarbonata (HCO_3). U plazmi dobivenoj centrifugiranjem uzoraka krvi koza i jaradi utvrđene su koncentracije kalcija, fosfora-anorganskog, kalija, natrija, željeza, klora, ureje, glukoze, ukupnih proteina, albumina, kreatinina, kolesterola, HDL-kolesterola, LDL-kolesterola, triglicerida, alkalne fosfataze (ALP), kreatin kinaze (CK) i γ-glutamil transferaze (GGT). U krvi koza i jaradi utvrđena je razlika jakih iona (SID), anionski procjep (AG) te z-vrijednost. Rezultati su analizirani MEANS procedurom, a razlike između skupina utvrđene su procedurom ANOVA-repeated measures. U krvi koza u laktaciji utvrđeno je značajno smanjenje koncentracije glukoze, triglicerida, Na i Fe, kao i sadržaj AG i SID te povećanje kolesterola, HDL-kolesterola, LDL-kolesterola, ukupnih proteina, albumina, globulina i P-anorganski. U krvi koza u laktaciji nisu utvrđene značajne razlike koncentracije Cl, kreatinina i aktivnosti enzima (kao što su CK, GGT i ALP). Rezultati metaboličkog profila i acidobazne ravnoteže ukazuju na potrebu praćenja kvalitete obroka koza i jaradi u tradicionalnom sustavu proizvodnje.

Ključne riječi: metabolički profil, acidobazna ravnoteža, laktacija, koze, jarad