Energy metabolism indicators and body condition in peripartal period of Alpine goats

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SUMMARY

The investigation was performed on two groups of primiparous and multiparous healthy dewormed Alpine dairy goats (25 each) during peripartal period. Blood samples were collected (jugular venipuncture) 10-15 days before and 10-15 and 30 days after the parturition into BD SST-II Advance (3.5 mL) and BD NaF 3.0 mg Na_2EDTA 6.0 mg (2 mL) vacutainers, cooled and centrifuged (1500 r/min, 15 minutes and ≤1300 r/min, 10 minutes, respectively). Glucose, non-esterified fatty acids (NEFA) and β-hydroxybutyrate (BHBA) concentrations in blood sera were determined using A15 automatic spectrophotometric analyzer (*Biosystem, Spain*). Simultaneously, body condition scoring (BCS) was performed by Villaquiran et al. (2007) method. The obtained data were analyzed by IBM SPSS statistics 21.

The glucose concentration inclined to increase in both groups. Differences between glucose levels were significant ($P<0.05$) 15 days before and 15 days after, as well as 15 and 30 days after the parturition, and very significant ($P<0.01$) 15 days before and 30 days after the parturition.

The BHBA blood levels significantly differed 15 days before and 30 days after and 15 and 30 days after the parturition ($P<0.05$). BHBA concentration peaked at week 2 postpartum, following the increase of NEFA, providing the substrate for BHBA synthesis. NEFA levels significantly ($P<0.05$) differed 15 days before and 15 days after the parturition. Goats' BCS ranged from 2 to 4 and significantly depended on glucose ($r=0.392$; $P<0.05$) and BHBA ($r=0.317$; $P<0.05$) level 15 days before parturition. BCS 30 days postpartum very significantly depended on the glucose level ($r=0.450$; $P<0.01$), significantly higher than the concentration of BHBA ($r=0.351$; $P<0.05$) and NEFA concentration ($r=-0.304$; $P<0.05$). BCS 15 days before parturition did not depend on the NEFA concentration. Fifteen days after the parturition BCS did not statistically depend on the observed indicators.

Obtained data suggest that knowledge of BCS and energy indicators levels may be very useful in research and practice in order to appreciate energy metabolism of pregnant and lactating dairy ruminants, particularly dairy goats. These data are poorly documented for goats, but they can reveal early pathological metabolic changes in transiting female goat organism, enabling successful prophylactic, as well as, therapeutic intervention.

KEY WORDS

Body condition, energy metabolism, goat, parity, peripartal period.

INTRODUCTION

Pregnancy imposes a substantial cost to the animal, because total requirements for nutrients at the end of pregnancy are about 75% greater than in a no pregnant animal of the same weight[1]. During the transition period (3 weeks before to 3 weeks after parturition) pregnant ruminants must adapt their metabolism to the new and much higher demands for parturition and lactogenesis[1,2,3], and to a different diet in order to meet their new requirements[4], which results in a negative energy balance[5]. It has been demonstrated that nutritional management in the early dry period is important for maintaining the health and productivity of transition cows[2]. After parturition, the demands for glucose, amino acids and fatty acids due to milk production, are 2-5 times higher than pre-partum requirement in ruminants[3,6,7,8]. This is characterized by fat mobilization and elevation of circulating concentrations of non-esterified fatty acids (NEFA)[9], which in most cases is paralleled by an increased production of β-hydroxybutyrate (BHBA) and other ketone bodies[10]. However, when females enter into this period of important metabolic challenges due to imbalance between demands and supply of nutrients without receiving proper care, the possibilities of developing metabolic and/or nutritional disorders become higher, as verified by Souto *et al.*[11].

Glucose is the primary source of energy for the body's cells and the only energy source for the brain and nervous system. A continuous supply must be available and a more or less constant level of glucose must be maintained in the blood. After feeding, the majority of circulating glucose comes from the diet; during fasting, gluconeogenesis and glycogenolysis maintain glucose concentrations. Very small amount of glu-

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cose could be found in the diet as glucose, but as more complex carbohydrates that are broken down to monosaccharides through the digestive process[12].

These metabolic changes and adaptations modify the concentration of blood indicators that are related to the development of the metabolic profile of female. Thus, blood biochemical parameters are the most important indicator used in the determination of the energy, protein, enzymatic, hormonal and mineral profiles, as well as assessing nutritional status, milk production and animal health[13].

Routine scoring of the body condition of dairy animals can help detect potential problems that might cause a decrease in milk production. Body fat reserve in dairy goats bears importance in terms of milk production, fertility, feed consumption and general health of the animal. Sejian *et al.*[14] suggested a positive correlation between BCS at mating and reproductive performance. According to Soares *et al.*[15], higher concentrations of BHBA were observed at the beginning of lactation ($P<0.001$) in relation to parturition and the end of pregnancy. Higher concentrations of BHBA during early lactation were also reported by Sadjadian *et al.*[16] in the healthy dairy goats. Observed high BHBA concentration at parturition with a gradual decrease up to the 8th week of lactation in Alpine goats with different degrees of body condition score related this finding to the use of this metabolite by the mammary gland for the milk fat synthesis. Previous studies reported different BHBA evolution in ewes and dairy cow that showed the highest concentrations before the parturition and *post-partum* respectively[17].

Soares *et al.*[15] found that there was a gradual increase of NEFA concentrations at the end of gestation, reaching a peak at parturition (0.5 ± 0.38 mmol/L; $P<0.001$), and then a subsequently gradual decrease of its concentration during lactation, confirming that the increase of NEFA concentration in *pre-partum* as well as its peak at parturition is due to the high energy demand in the final third of gestation, rapid growth of foetuses and the mammary gland development, confirmed by Barbosa *et al.*[18].

According to Magistrelli and Rosi[19], increase of glycaemia was observed at parturition ($P=0.0079$), during late pregnancy and early lactation in Saanen goats in the peri-partum period. Blood parameters and milk composition alterations are crucial to predict the energy balance status of buffaloes and therefore other ruminants in order to improve their management and feed intake during the transition period[3]. Transition period is an important metabolic challenge to high-yielding dairy cows. Data on these indicators are very useful in order to prevent the outset of nutritional imbalance that typically occurs in high production dairy cows[7]. On the other hand, biochemical attributes during different metabolism statuses generally have not been reporting routinely in goats[13,16]. In light of the presented data, the objective of this study was to evaluate the adaptive changes of the energy biochemical profile of healthy dairy goats of different parities during the peripartal period and its relationship to goats' body condition.

MATERIALS AND METHODS

Investigation took place at a commercial farm in Veliki Gaj (45°17'05"N 21°10'13"E, 80 m a.s.l.) in South Banat District of Serbia. When the study began, there were 115 healthy dairy goats, 54 primiparous goats, 146 kids and 5 bucks on the farm. The study was conducted on 50 clinically healthy, Alpine breed goats, divided in two groups of 25 each, regarding parity (25 primiparous and 25 multiparous) in two pens, in the period from January until March. At kidding, 5 primiparous goats had twins, while other 20 of them gave birth to a single kid. In the group of 25 multiparous goats, one triplet of kids was born, as well as 21 pair of twins and 3 single newborn kids. All procedures with animals were performed according to our institutional guidelines for animal research and principles of the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other (Official Daily N.358/1-358/6, 18, December 1986). According to the health scheme, the goats were dewormed twice a year, based on the results of the parasitological examination of the faeces, 90 days had passed since the last deworming.

The goats were fed two times a day with alfalfa hay *ad libitum* and 1.5 kg of concentrate (16% of crude protein and 1438.42 kcal/kg Dry Matter min.) during milking. Thirty days after kidding, the average daily milk yield in the groups of primiparous and multiparous goats were 2.4 kg and 4.2 kg, respectively.

Blood samples were collected by jugular venipuncture from all observed goats between 9:00 and 11:00 a.m., after morning feeding, 10-15 days before and 10-15 and 30 days after the delivery. Samples were collected into appropriate vacutainers BD SST-II Advance (3.5 mL) and BD NaF 3.0 mg Na_2EDTA 6.0 mg (2 mL) kept in a cool place and then vacutainers were centrifuged at 1500 r/min during 15 minutes and ≤1300 r/min for 10 minutes, respectively, in order to be prepared for further procedures. Analyses of glucose, non-esterified fatty acids (NEFA) and β-hydroxybutyrate (BHBA) concentrations were performed using A15 automatic analyzer (spectrophotometric - Random Access Analyzer, working set 340 - 900 nm, *Biosystem Spain*). Body condition scoring (BCS) was carried out using method of Villaquiran *et al.*[20], where palpation and observation of three anatomical regions (lumbar region, breastbone and chest) were used. The score was expressed numerically in the scale from 1 to 5. Body condition was evaluated at the same time when blood samples for analysis were taken.

Descriptive statistics, t-test and coefficient of correlation were used for statistical analysis. In addition, statistical significance of differences of all examined parameters were determined by means of the one way ANOVA, followed by the Tukey HSD test. Data were expressed as means ± standard error. Significance level was set at $P \leq 0.05$. Statistical analysis was performed using the SPSS Statistics 21 Software, CA, USA.

RESULTS

The mean values, variability and maximum and minimum values of the concentration of glucose BHBA and NEFA in the blood serum of tested goats and BCS, are shown in Table 1.

Mean values of glucose in the goat's blood of the during the trial ranged from 2.72 mmol/L 15 days before the parturition to 3.61 mmol/L 30 days after the parturition in the primiparous goats, while in the multiparous these values ranged from 3.44 mmol/L 15 days before parturition up to 3.76 mmol/L 30 days after parturition. For primiparous goats, the glucose concentration values ranged from 2 to 5.2 mmol/L,

Table 1 - Concentration of glucose, BHBA and NEFA in goat blood and body condition score.

Parity		$\bar{\chi}$				Sd				Xmax-Xmin				Cv (%)			
		Glucose (mmol/L)	BHBA (mmol/L)	NEFA (mmol/L)	BCS (1-5)	Glucose	BHBA	NEFA	BCS	Glucose (mmol/L)	BHBA (mmol/L)	NEFA (mmol/L)	BCS (1-5)	Glucose	BHBA	NEFA	BCS
PRIMI	- 15 d	2.72	0.28	0.12	3.08	0.28	0.09	0.09	0.37	3.4 - 2.3	0.5 - 0.1	0.3 - 0	4 - 2.5	10.29	33.54	70.92	12.11
	+ 15 d	3.09	0.25	0.27	2.90	0.61	0.12	0.17	0.32	4.3 - 2.0	0.5 - 0.1	0.6 - 0	4 - 2.5	19.71	47.40	63.47	11.13
	+ 30 d	3.61	0.31	0.28	2.84	0.69	0.14	0.26	0.43	5.2 - 2.5	0.7 - 0.1	1.4 - 0	3.5 - 2	19.24	46.79	93.01	15.01
	Σ	3.14	0.28	0.22	2.94	0.66	0.12	0.20	0.38	5.2 - 2.0	0.7 - 0.1	1.4 - 0	4 - 2	16.41	42.58	75.80	12.75
MULTI	- 15 d	3.44	0.31	0.17	3.50	0.60	0.06	0.22	0.43	5.1 - 2.1	0.4 - 0.2	0.49 - 0	4 - 2.5	17.57	20.79	129.43	12.37
	+ 15 d	3.61	0.47	0.23	2.92	0.44	0.17	0.25	0.40	4.8 - 3.2	1.0 - 0.2	0.9 - 0	3.5 - 2	11.88	36.96	110.75	13.70
	+ 30 d	3.76	0.58	0.08	3.12	0.46	0.26	0.10	0.36	5.44 - 3.2	1.4 - 0.3	0.46 - 0	3.5 - 2.5	12.16	46.01	126.63	11.59
	Σ	3.63	0.45	0.16	3.18	0.52	0.21	0.21	0.46	5.44 - 2.1	1.4 - 0.2	0.9 - 0	4 - 2	13.87	34.59	122.27	12.55
Total	- 15 d	3.08	0.29	0.15	3.29	0.59	0.08	0.17	0.45	5.1 - 2.1	0.5 - 0.1	0.49 - 0	4 - 2.5	19.12	27.54	114.09	13.76
	+ 15 d	3.39	0.36	0.25	2.91	0.61	0.18	0.21	0.36	4.8 - 2.0	1.0 - 0.1	0.9 - 0	4 - 2	17.94	51.12	86.31	12.37
	+ 30 d	3.69	0.44	0.18	2.98	0.59	0.25	0.22	0.42	5.44 - 2.5	1.4 - 0.1	1.4 - 0	3.5 - 2	15.93	56.74	121.50	13.96
	Σ	3.39	0.36	0.19	3.06	0.64	0.19	0.20	0.44	5.44 - 2.0	1.4 - 0 1	1.4 - 0	4 - 2	17.66	45.13	107.30	13.36

PRIMI - primiparous goats, **MULTI** - multiparous goats, Σ - total, **- 15 d** - 15 days before parturition, **+ 15 d** - 15 days after parturition, **+ 30 d** - 30 days after parturition.

and in multiparuos, 2.1 to 5.44 mmol/L. The variability of the glucose concentration was not high and ranged from 10.29% 15 days before to 19.71% 15 days after the parturition in primiparous, while in the multiparous it ranged from 11.88% 15 days to 17.57% 15 days before the parturition.

Mean BHBA concentration in goat's blood during the trial ranged from 0.25 mmol/L 15 days after parturition to 0.31 mmol/L 30 days after parturition in primiparous goats, while in multiparous these values ranged from 0.31 mmol/L 15 days before parturition up to 0.58 mmol/L 30 days after the parturition. The BHBA concentrations in the primiparous goats ranged from 0.1-0.7 mmol/L, and in the multiparous 0.2-1.4 mmol/L. The variability of the BHBA concentration ranged from 33.54% 15 days before to 47.40% 15 days after the parturition in the primiparous, while in multiparous ranged from 20.79% 15 days before to 46.01% 30 days after the parturition.

Mean NEFA levels in goat's blood during the trial ranged from 0.12 mmol/L 15 days before the parturition to 0.28 mmol/L 30 days after the parturition in the primiparous goats, while in multiparous these values ranged from 0.08 mmol/L 30 days after parturition up to 0.23 mmol/L 15 days after parturition. For primiparous goats, NEFA concentration values ranged from 0 to 1.4 mmol/L, and in multiparous 0-0.9 mmol/L. The variability of the NEFA concentration was high and ranged from 63.47% 15 days before to 93.01% 30 days after the parturition in the primiparous, while the multiparous ranged from 110.75% 15 days after to 129.43% 15 days before the parturition.

The mean values of BCS in the examined periods ranged from 2.84 30 days after parturition to 3.08 15 days before parturition in primiparous goats, while in multiparous these values ranged from 2.92 15 days after parturition to 3.50 15 days before parturition. In primiparous goats, BCS ranged from 2 to 4, which was the case with multiparous, too. The variability was lowest in primiparous 15 days after the parturition (11.13%) and the highest 30 days after the parturition (15.01%), also in primiparous goats.

Between two groups of goats (primiparous and multiparous), very significant differences in glucose levels were found 15 days before and 15 days after parturition, in the level of BHBA 15 and 30 days after the parturition, as well as in the NEFA level 30 days after parturition (Table 2).

In other cases, the differences were not significant. In addition, a very significant difference in the BCS 15 days before the parturition and a significant difference 30 days after the parturition were found. No significant differences were found 15 days after the parturition.

Factors parity and the time of sampling have very significantly influenced the glucose and BHBA levels and BCS, and significantly on NEFA level. The influence of the interaction of these two factors (parity x time of sampling) on glucose level and BCS was significant, while on BHBA and NEFA levels was very significant (Table 3).

According Table 4, the results of the Tukey HSD test indicated that the glucose level established 15 days before the parturition significantly differed from the level established 15 days after the parturition and very significantly from the level of 30 days after the parturition. The level of glucose 15 days after the parturition significantly differed from the level established thirty days after the parturition. The levels of BHBA in the blood significantly differed 15

Table 2 - Primiparous and multiparous goats glucose, BHBA, NEFA and BCS levels differences.

Term of measurement	Glucose		BHBA		NEFA		BCS	
	t-test	p	t-test	p	t-test	p	t-test	p
15 days before	-5.357**	0.000	-1.422^{ns}	0.162	-0.984^{ns}	0.333	-3.674**	0.001
15 days after	-4.051**	0.000	-5.203**	0.000	0.657^{ns}	0.514	-0.195^{ns}	0.847
30 days after	-0.933^{ns}	0.356	-4.442**	0.000	3.517**	0.001	-2.504*	0.016

^{ns} - p>0.05, * - p<0.05, ** - p<0.01

Table 3 - Parity and time of sampling significance regarding glucose, BHBA, NEFA and BCS.

Indicator	Glucose		BHBA		NEFA		BCS	
Values	F	p	F	p	F	p	F	p
Parity	32.105**	0.000	45.563**	0.000	3.943*	0.049	14.347**	0.000
Time of sampling	16.243**	0.000	11.391**	0.000	3.483*	0.033	13.583**	0.000
Interaction	3.886*	0.023	7.864**	0.001	5.003**	0.008	3.421*	0.035

* - p<0.05, ** - p<0.01

Table 4 - Tukey HSD test results for glucose, BHBA and NEFA levels and BCS.

Indicator	Glucose	BHBA	NEFA	BCS
Term of sampling	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$
15 days before	3.08 ± 0.08^{c}	0.29 ± 0.01^{b}	0.15 ± 0.02^{b}	3.29 ± 0.06^{a}
15 days after	3.39 ± 0.09^{b}	0.36 ± 0.02^{b}	0.25 ± 0.03^{a}	2.91 ± 0.05^{b}
30 days after	3.69 ± 0.08^{a}	0.44 ± 0.03^{a}	0.18 ± 0.03^{ab}	2.98 ± 0.06^{b}

Means followed by different letters differ significantly at P<0.05.

days before and 30 days after the parturition, and a significant difference was found between the levels 15 and 30 days after the parturition. Fifteen days before and 15 days after the parturition the differences were not significant. The levels of NEFA in the blood of examined goats significantly differed 15 days before and 15 days after the parturition. In other cases, the differences were not significant.

BCS significantly differed 15 days before the parturition compared to 15 days after and 30 days after the parturition. The differences were not significant 15 days after and 30 days after the parturition.

The correlation between concentrations of glucose, BHBA, NEFA and BCS is also calculated. BCS 15 days before parturition statistically very significantly depended on the glucose concentration (r = 0.392; P<0.01), and statistically significant depended on the BHBA concentration (r = 0.317; P<0.05) and did not depend on the NEFA concentration. Fifteen days after the parturition BCS did not statistically depend on the observed indicators. Thirty days after the parturition BCS statistically very significantly depended on the concentration of glucose (r = 0.450; P<0.01), and statistically significant depended on the concentration of BHBA (r = 0.351; P<0.05) and on the NEFA concentration (r = -0.304; P<0.05). Fifteen days after parturition BHBA and NEFA concentrations very significantly depended on the glucose concentration (r = 0.485 and r = -0.387; P<0.01, respectively). Thirty days after parturition BHBA and NEFA concentrations very significantly depended on the glucose concentration (r = 0.369 and r = -0.383; P<0.01, respectively) and NEFA concentration very significantly depended on the BHBA concentration (r = -0.434; P<0.01).

DISCUSSION

An increase of glucose concentration at parturition is due to the high concentration of glucocorticoid hormones such as cortisol, which promotes an increase in hepatic glycogenolysis and gluconeogenesis from glucose precursors[16,19]. The result obtained is consistent with the results of Radin *et al.*[21], who found significantly higher glucose concentrations in foetuses and lower parities compared to older animals two and four weeks after parturition (P<0.01). The same authors report lowering blood glucose levels in older animals, unlike primiparous goats. Evolution of glucose concentration during late pregnancy and early lactation was similar observed by other studies in Saanen goats in the peri-partum period[19]. Certain studies have reported a decrease in glycaemia in the first weeks of lactation, especially in high producing dairy goats, related to high demand for milk lactose synthesis[16,19]. Other studies also reported similar glycemia in sheep[22] and in dairy cows[17]. Moreover, a recent study has reported that the regulation of glucose homeostasis changes at different physiological stages. Also, an additional elevation of BHBA beyond the metabolic adaptation after parturition might change glucose concentration in early-lactation dairy cows[17]. Slightly different results were obtained by Soares *et al.*[15], who found that the glucose level was the highest during the kidding and then decreased (P<0.05). Antunović *et al.*[13] recorded a significant drop in the level of glucose in the observed period, and later as lactation progresses.

The BHBA concentration tended to increase in our study. Synthesized from fatty acids during energy deficiency, BHBA composes the main part of the ketone bodies[23]. If the concentrations of the ketone bodies in body fluids exceed a certain level, the adaptability of metabolism is exceeded and whole-body homeostasis cannot be maintained[24]. The low level of serum BHBA recorded at all stages of lactating cows suggested that they have adapted for the state of negative energy balance[25].

BHBA concentration increased after parturition and peaked at week 2 postpartum, following the increase of NEFA; this suggests that NEFA provides the substrate for BHBA synthesis. This increase in BHBA concentration reveals incomplete oxidation of NEFA in the tricarboxylic acid cycle during negative energy balance[26]. Obtained results were in accordance with the results of Sadjadian *et al.*[16] indicated that the changes in BHBA concentrations were between 134 and 375 μmol/L, with a low number of does with BHBA concentrations above 1,000 μmol/L. This increase of the BHBA concentration in early lactation is due to the high energy requirement in organisms such as cattle with a high milk yield[27]. However, despite this increased concentration of BHBA observed in this study, mean values of this variable were within the reference interval for the species (≤0.8 mmol/L, according Rook[28]).

NEFA concentrations grew in primiparous goats as in multiparous decreased. For primiparous goats, NEFA concentration values ranged from 0 to 1.4 mmol/L, and in multiparous 0-0.9 mmol/L. The variability of the NEFA concentration was high, especially in the case of multiparous goats. Similarly, Soares *et al.*[15] found that the NEFA level was the highest during kidding and subsequently declined ($P<0.05$).

During early lactation ruminants can mobilize considerable amounts of body fat to maintain milk production[29,30]. Authors proved the link between NEFA values and the energy balance in goats. This study predicts a value of 217 μmol/L of NEFA at zero Energy Balance.

Similar to obtained results in this study, NEB (Negative Energy Balance) occurs in dairy Saanen goats during the periparturition period. NEFA concentration reflected a NEB better than BHBA in dairy Saanen goats. In addition, Sadjadian *et al.*[16] found out that the number of does with abnormal NEFA concentrations (≥0.6 mmol/L) was high.

The magnitude of the metabolic challenge during the peripartum period due to the higher energetic demand causes a greater release of NEFA into the bloodstream due to the lipolysis rate that overlaps with the lipogenesis. Part of this metabolite is used as a source of energy by peripheral tissues and another part is metabolized in the liver, being completely oxidized for energy production or partially oxidized to produce ketone bodies or esterified and stored as triglycerides[18]. The NEFA concentrations obtained during this study have not exceeded values considered normal for the species, being to those reported by other authors in clinically healthy goats[31,32]. These results have demonstrated the ability of adaptive mechanisms in order to adjust to the demand situation without developing metabolic disorders in different species of ruminants[16,18,19,22]. According to Eşki *et al.*[26], during the postpartum period, blood NEFA concentration reflects the rate of lipolysis or lipomobilization; that is, NEFA levels model the balance between lipolysis and the reesterification of the fatty acids[23]. Hence, evaluation of plasma NEFA concentrations during the periparturient period should provide insight into the time course of fatty liver development[32]. Blood NEFA concentrations consistently increased 2 weeks prepartum until 2 weeks postpartum and reached a peak at 2 weeks postpartum and then steadily decreased, reflecting the mobilization of body fat[26]. Pirmohammadi *et al.*[33] reported that the plasma NEFA concentrations are useful indicators to monitor the energy status of goats in the last month of gestation.

Animal body condition is considered to be an indicator of body fat reserves, which reflect the production performance of the herd[34]. Under farm conditions BCS is an important tool to assess the adequacy of feeding programmes[35]. When overall body condition starts to decrease in the goats, it is a sign that managerial intervention such as supplemental feeding, deworming or pasture rotation is needed. Conversely, when overall body condition starts to increase in the herd, it is a sign that the producer should reduce supplemental feeding[36]. Goats need to be maintained at a moderate amount of body condition. Therefore, BCS is a useful tool to manage feeding of the herd[37]. The study of Cavestany *et al.*[38] describes this effect of parity (multiparous versus primiparous) and body condition score (BCS) at calving (<3 or 3 or more on scale 1-5), body weight (BW) and metabolic profiles in Holstein cows grazing on improved pastures, confirming that primiparous cows had lower BCS during the early postpartum (PP) period and produced less milk than multiparous. In primiparous cows NEFA concentrations were higher during the early postpartum period; BHBA levels were similar in both categories during this period. Primiparous cows showed a more unbalanced metabolic profile than multiparous cows, reflecting that they are recovering from the loss of BCS after calving with less success. This is supported by research of Pambu[36], who found out that BCS has an effect on blood glucose. Fifteen days after parturition BHBA and NEFA concentrations very significantly depended on the glucose concentration ($r = 0.485$ and $r = -0.387$; $P<0.01$, respectively). According to Sadjadian et al.[16], it appears to be related to high energy demands for lactation, especially in high milk-producing breeds of goats. The mobilization of body reserves entailed a gluconeogenesis mechanism which boosted blood glucose concentrations. According this author, does with BCS 3 were significantly different in blood glucose concentrations from does with BCS 2.

CONCLUSION

According presented and analyzed data, the concentration of glucose had a tendency to increase in both groups of goats. The glucose level established 15 days before the parturition significantly differed from the level established 15 days after the parturition and very significantly from the level of 30 days after the parturition. The level of glucose 15 days after the parturition significantly differed from the level established thirty days after the parturition.

The BHBA concentration tended to increase and the blood levels significantly differed 15 days before and 30 days after the parturition, and a significant difference was found between the levels 15 and 30 days after the parturition. Fifteen days before and 15 days after the parturition, the differences were not significant.

BHBA concentration increased after parturition and peaked at week 2 postpartum, following the increase of NEFA, which suggests that NEFA provides the substrate for BHBA synthesis. The variability of the NEFA concentration was high, especially in the case of multiparous goats.

For primiparous goats, physical fitness estimates ranged from 2 to 4, which was the case with multiparous goats. The variability was lowest in primiparous 15 days after the parturition (11.13%) and the highest 30 days after the parturition (15.01%), also in primiparous goats. In most cases, the BCS has decreased, which is probably a consequence of using body reserves for lactation needs.

Fifteen days prior to parturition BCS was significantly dependent on the glucose concentration ($r = 0.392$; $P<0.05$), as well as on the concentration of BHBA ($r = 0.317$; $P<0.05$) and did not depend on the NEFA concentration. BCS 15 days after the parturition did not statistically depend on the observed indicators. BCS was statistically very significantly dependent on the concentration of glucose ($r = 0.450$; $P<0.01$), significantly higher than the concentration of BHBA ($r = 0.351$; $P<0.05$) and NEFA concentration ($r = -0.304$; $P<0.05$). The mobilization of body reserves entailed a gluconeogenesis mechanism which boosted blood glucose concentrations.
Obtained data suggest that knowledge of BCS and energy indicators levels may be very useful in research and practice in order to appreciate energy metabolism of pregnant and lactating dairy ruminants, particularly dairy goats. These data are poorly documented for goats, but they can reveal early pathological metabolic changes in transiting female goat organism, enabling successful therapeutic intervention.

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