Iranian Journal of Applied Animal Science

Influence of Body Condition on Milk Production and Metabolic Profile in Assaf Sheep

Research Article

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Received on: 23 Nov 2022
Revised on: 11 Jan 2023
Accepted on: 25 Feb 2023
Online Published on: Sep 2023

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Online version is available on: www.ijas.ir

ABSTRACT

The aim of the study was to monitor the relationship between body condition score (BCS) and body weight (BW) on milk productivity and metabolic profile in sheep of the Assaf breed during the first months of lactation. The experiment was conducted from January 2020 to April 2020 with 378 ewes aged 3 and 4 years (second and third lactation). The influence of BCS and BW on milk yield and dry matter (DM) and metabolizable energy (ME) intake was established. Animals with BCS < 3 had significantly higher average daily millk (ADM) consumed more DM and ME (P<0.01) and had a higher negative energy efficiensy (-17.53%), compared to animals with BCS above 4.1. The sheep weighing 71 to 75 kg have a higher ADM, compared to animals weighing less than 71 kg and more than 76 kg, but also had a higher negative energy efficiency (-20.35%), despite the fact that they consumed significantly more DM and ME (P<0.01). It was found that the expenditure of ME for lactation was higher, the higher the milk yield of the animals (R^2=0.9734). When combining the ME requirement for maintenance (ME_m), Mcal and the ME requirement for gain (ME_g), when ADG was positive the total ME_{red}, Mcal, was highly related with the milk yield of the animals (R^2=0.6519). The direct effect of milk yield on average daily gain shows a high correlation between the milk yield and average daily gain (R^2=0.8747), which had an impact on body energy loss/gain, with the correlation between mean daily milk yield and body energy los/gain ($BE_{L/g}$) being significant (R^2=0.6309).

KEY WORDS body condition score, body weight, lactation, metabolic energy, milk.

INTRODUCTION

Milk production in sheep depends on the genetics and nutritional plane of feeding, which is associated with the physiological status and body condition. The NRC (2007) suggests the most critical period where physiological condition impacts production occurs during the last weeks of pregnancy. When feeding is optimum, some of the nutrients are deposited in the body as fat and that if needed, can be mobilized (Rauw, 2008). A large part of these reserves are concentrated in the abdominal cavity as glycogen in the liver and intra-abdominal fat. In the study of Cimen *et al.* (2007) it was stated that The cholesterol in plasma was positively correlated with urea in the milk, milk yield and negatively with milk fat. According Aliyu *et al.* (2022) the blood parameters must be monitored and controlled to ensure stability and adequate health and nutritional status of sheep. The indicators that characterize metabolic processes during lactation are body condition score (BCS) and body weight (BW) and are important performance indicators in sheep management (Semakula, 2021). According to Hu *et al.* (1990) these two indicators are often used as indicators for proper feeding of sheep. BCS is a recommended method for evaluating management in dairy farming (Gillund *et al.*

2001), which proves whether the ration meets the needs of the animals. Body condition score in sheep is a widely used measure of the degree of body fatness (Vieira *et al.* 2015) and it show the degree of fat and muscle in lumbar region and (Kenyon *et al.* 2014).

According to Jilek *et al.* (2008) the milk production correlates with BCS is and effective method to evaluate the nutritional management of dairy cows. In both cows and sheep at the beginning of lactation, the lack of energy and protein reserves in the body, according to Domecq *et al.* (1997), is the reason for the decrease in milk yield.

Subcutaneous muscle reserves along the backbone can be determined through BCS which is used as the main tool for checking body reserves to correct nutrition and increase productivity. Slozhenkina *et al.* (2020) found that BCS is an effective tool in establishing energy intake for other ruminants such as cows.

It has been reported that BCS has a direct impact on reproduction (Yılmaz *et al.* 2011), colostrum and millk yield (Jalilian and Moeini, 2013), fertility (Corner-Thomas *et al.* 2015), birth weight of lambs (Simeonov *et al.* 2015) and health status.

According to Todorov (2008) the disadvantage of this method is that it is more representative of the past and does not determine whether a current deficiency or excess exists. Body weight in sheep is a combination of body size and physical condition, which according to Ducker and Boyd (1977) is a poor indicator of the body condition of animals. At the end of pregnancy, body weight is directly dependent on the number of offspring and their weight, which according to Sanson *et al.* (1993) is not a good indicator of the metabolic status of the animals.

It indicates that detailed knowledge of the metabolic status of sheep at the end of pregnancy and during lactation will help to improve nutrition and optimize efficiency on the farm.

The aim of the study was to monitor the relationship between body condition score (BCS) and body weight (BW) on milk productivity and metabolic profile in sheep of the Assaf breed during the first months of lactation.

MATERIALS AND METHODS

The experiment was conducted from 07 January 2020 (fourth day after birth) to 28 April 2020 (116 days from birth) with 378 sheep of the Assaf breed at 3 and 4 years (second and third lactation) of age kept with average body wight 72.25 kg and body condition score 3.21. The experiment was conducted on a private stock farm in the town of Vratsa (43.2102˚ N and 23.5529˚ E) Bulgaria.

Management

Ewes were synchronized using Syncro-part 30 mg tampons. Insertion of the tampons was vaginal when the animals were in anestrus (one SINCROPART® 30 mg tampon containing 30 mg of flugestone acetate was inserted) and removed on day 12. Immediately after removal of the tampons, each animal was injected intramuscularly with Folligan 1000 IU to induce and synchronize ovulation. On the second day (48 hours) after administration of Folligan, the sheep were artificially inseminated twice. The ewes gave birth during a period of 6 days and the lambs were isolated with the ewes until 24 hours after birth, when the ewes began to produce milk at which time the lambs were weaned from the ewe. During the experiment 548 lambs were born from 378 ewes giving a fertility of 1.38.

Body condition was determined by twotrained personnel following the description of Todorov *et al.* (1994). Body condition score and body weight were determined in the morning (from 7 to 10 a.m.), after milking and before feeding of ewes. During the experiment both indicators were determined every 14 days. In the beginning (3 days after birth) and at the end experiment (112 days after birth) ewe body weight was determined after 12 hours of water deprivation and 24 hours of food deprivation. Both indicators (BCS and BW) were determined evry 28 days.

Nutrition

During the experiment the animals were divided into three groups according to their BCS after which all animals received the same ration regardless of their body condition and weight for 112 days (Table 1). The animals were fed *ad libitum* to achive 5% refusals. The ration was formulated for sheep with an average body weight of 70 kg and an average daily milk production of 3 kg following the norms by Todorov *et al.* (2007). Throughout the experimental throughout the experimental period period, the specified amount of feed for each group of animals was distributed twice a day (at 8:00 a.m. and at 6:00 p.m.). Strict mixing of the individual components in the ration was performed using a mixer. The purpose of mixing was to obtain a total mixed ration (TMR). The order of placing the individual feeds in the mixer was: barley straw, alfalfa hay, maize silage and mixture of maize grain, protein, minerals and vitamins (pre-prepared in the feed kitchen mixing for 5 min). The total mixing time of these feeds in the mixer was about 40 min until a TMR was obtained. During the experiment during the experiment the animals had free access to clean and cool drinking water. The chemical content of feeds (Table 1) was determined by the standard methods AOAC (2007).

For this purpose, samples were taken from the total ration every tenth day of the experiment.

Table 1 Composition of the total mixed ration fed to lactating sheep of the Assaf breed

Ingredient	Amount, %
Maize silage	47.4
Maize grain	16.8
Alfalfa hay	15.6
Sunflower meal, 31% CP	7.8
Soybean meal, 46% CP	7.6
Barley straw	3.0
Sodium bicarbonate	1.2
Sodium chloride	0.5
Vitamins and minerals1	0.1
Nutrient Analyses	
Dry matter (DM), kg	2.73
Energy in the ration (Mcal/kg DM)	4.268
Crude protein (CP), g	501.73
Crude protein, g/kg DM	18.38
Digestible protein in the intestine (DPI)	280.61
Balance of the protein in the rumen (BPR)	99.14
Neutral detergent fibre (NDF)	750.83
Acid detergent fibre (ADF)	550.54
Calcium (Ca)	17.3
Phosphorus (P)	11.2

[1] Contains in 1 kg: vitamine A: 4 500000 IU; vitamine D_3: 550000IU; vitamine E (α-tocopherol): 300000 IU; vitamine B_{12}: 10 000 mg/kg; vitamine B_1: 1000 mg/kg (tiamin); Biotin: 100 mg/kg; Sulfate: 37 500 mg/kg; Cu: 40 000 mg/kg; Mg: 40000 mg/kg; I: 2000 mg/kg; Co: 500 mg/kg; Se: 100 mg/kg; Mn: 2500 mg/kg; Etoxyquin: 50 mg/kg; Butylhydroxytoluene (BHT): 150 mg/kg and Propil galat: 50 mg/kg.

The energy efficiency of ewes to make milk was determined through reverse factorial energy calculations using literature values for coefficients of milk and feedstuffs (NRC, 2007).

1. ME_m, Mcal/d= UME_m + VO
2. ME_g, Mcal/d= NE_g/0.6
3. ME_L, Mcal/d= $ME_{L\text{-}d}$ + $ME_{l\text{-}t}$
4. ME_{red}, Mcal/d= ME_m + ME_g + $ME_{L\text{-}d}$

Where:
ME_m: ME requirement for maintenance, Mcal/d.
UME_m: unadjusted metabolizable energy requirement for maintenance, Mcal/d.
VO: visceral organ tissue energy use, Mcal/d.
ME_g: ME requirement for gain, Mcal/d.
NE_g: NE reqyirement for gain, Mcal/d.
ME_L: total ME for lactation, Mcal/d.
$ME_{L\text{-}d}$: dietary ME for lactation, Mcal/d.
$ME_{L\text{-}t}$: mobilized tissue energy used for lactation, Mcal/d.
ME_{red}: total ME requirement, Mcal/d.
ME_m: ME requirement for maintenance, Mcal/d.
ME_g: ME requirement for gain, Mcal/d.
$ME_{L\text{-}d}$: dietary ME for lactation, Mcal/d.

Milk energy (direct measure) and feed energy content (direct measure), were combined with published coefficients to back-calculate daily ME, Mcal and digestible energy (DE). Measures of BCS and BW were used to calculate body energy loss/gain and DM and ME intake.

Milk productivity and milk composition

Milking was done in the milking room (2×24) and individual milk yield was determined by the sum of morning and evening milkings. The composition of the milk was determined (fat. protein. lactose and dry matter) at the beginning, in the middle and the end of the experiment and averaged. This included individual milk samples from the morning and evening milking. The samples were placed in a refrigerator and analyzed the next day. The fat, protein, lactose and dry matter were determined using a Milko-Skan 104 (A/S Foss Electric, Denmark).

Blood collection schedule and assays for β-hydroxybutyrate (BHBA) non-esterified fatty acids (NEFA) and glucose (GL)

At the beginning and the end of the experiment blood samples were collected from 120 ewes (60 ewes to different BCS and 60 ewes to different BW) which were averaged to determine BHBA, NEFA and GL. The indicated number of animals were recorded so that at the end of the experiment, blood samples were taken from them agai. Blood samples were taken in the morning after milking and before feeding to determine BHBA and NEFA. The blood glucose content was determined on samples taken before feeding (0 hours), and at 3 and 6 hours after feeding and the values obtained were averaged.

The blood was taken from the jugular vein using a 21 g needle and a sterilized vacuum tube (5 mL) with heparin. The plasma concentration of BHBA was determined using the Xpress-I (Nova Biomedical. UK). The NEFA in the blood plasma was determined using the NEFA ELISA Kit (Changhay Crystal Day Biotech Co., LTD., China) and ELISA Reader Sunrise (Tecan. Switzerland). Blood glucose concentrations were determined by a Biolabo Diagnostics (France) test using an automated biochemical analyzer "Mindray BS-120" – China.

Animal health during the experiment

During the experiment the animals were in good health and all veterinary medical measures were followed: Ewes were vaccinated against Agalaxia with Agalax-S (2 mL/animals/subcutaneously) and revaccinated after 4 weeks. Ewes were dewormed with Ivermectin (5 mL/animals/subcutaneously) 2.5 months before the birth of the lambs. Ewes were vaccinated with Coglavax against

Enterotoxemia (2 mL/animals/subcutaneously) 45 days before the birth of the lambs.

Statistical analysis

The average estimated least square means for each animals and the effect of body condition (BCS and BW) were determined by General Linear Model (GLM).

The mathematical model was:

$$Y_{ijk}= \mu + a_i + b_j + e_{ijk}$$

Where:

Y_{ijk}: effects as follows; i (BCS) j (BW); k (milk).

μ: overall mean.

a_i: effect of BCS and BW groups.

b_j: effect of milk.

e_{ijk}: random error term.

The one way analysis of variance and analysis of the correlations between the factors BCS and BW and their impact on productivity and blood counts were defined by Pearson's, using the software program Statistica for Windows (Statistica, 2006). Differences between the groups was determined by t-test at $P < 0.01$.

RESULTS AND DISCUSSION

It was found that the average daily milk (ADM) of the Assaf sheep was 2.065 kg for the 112 days of experimental period (Table 2).

Our results show the relationship on BCS and BW on milk productivity in the sheep (Table 2). The influence of the two indicators was established (BCS and BW), on the milk yield and DM and ME intake. The animals with BCS < 3 had significantly higher ADM, took more DM and ME ($P<0.01$) but nevertheless had a high negative energy efficiency (-17.53%), compared with animals with BCS above 4.1 (Table 2).

According to the BW indicator, sheep weighing 71 to 75 kg had a higher milk yield, compared with animals weighing less than 71 kg and more than 76 kg, but they also had a high negative energy efficiency (-20.35%), compared with the other two groups (Table 2). This was largely the result that they consumed more DM and ME ($P<0.01$).

As expected the expenditure of metabolic energy for lactation (ME_L, Mcal/kg DM) was higher, the higher the milk yield of the animals (Figure 1a; R^2=0.9734). When combining the metabolic energy requirement for maintenance (ME_m, Mcal) and the metabolic energy requirement for gain, when ADG is positive (ME_g, Mcal) the total ME requirement (ME_{red}, Mcal) is highly related with the milk yield of the animals (R^2=0.6519, Figure 1b).

The relationship of milk yield and average daily gain is described in Figure 2a, where a high correlation between the two factors is found (R^2=0.8747, Figure 2a). Similary, the body energy loss/gain, was highly correlated with mean daily milk yield (R^2=0.6309, Figure 2b).

The influence of some factors on milk yield in ewes in Table 3 shows that the factors BCS, BW, IDM and IME have a reliable influence on milk yield of animals ($P<0.01$). The R^2 indicator shows a high correlation between the factors indicated in Table 3 and the milk yield of an animal, considering a high correlation.

Both BCS and BW were negatively related with ADM however, the relationship was weak because of the extremely high and low BCS of the animals (Table 4). Both BHBA and NEFA provided strong relations with milk production.

In was found that sheep with BCS < 3 has significantly higher content of BHBA (0.821 mmol/L) compared with the other animals and the content of BHBA was lowest in the sheep with BCS > 4.1 (0.522 mmol/L, Table 5). The content of NEFA was highest in the animals with BCS over 4.1 ($P<0.01$, Table 5).

The animals weighing < 70 kg had a significantly higher BHBA content (0.794 mmol/L), animals with weighing more than 71 kg had a high content of NEFA in their blood (0.853 mol/L), and animals weighing from 71 to 75 kg had a higher blood GL content (42.792 mg/dL, Table 5).

Maintenance energy is that energy which is required to sustain the life of the animals. This energy must be supplied through the feed and meet the requirements for maintaining life without having productivity (milk or gain). In our study, higher productivity sheep (BCS<3 and BW from 71 to 75 kg) had significantly higher ME_m consumption compared to the other animals. The ME_m consumption was the lowest in animals with BCS > 4.0 and BW > 76 kg.

High-producing animals are usually in a state of negative energy balance during the first months of lactation, as described by Bekuma and Galmessa (2019) for cows. At the peak of lactation, energy requirements exceed energy supply, resulting in a negative energy balance, which mobilizes body reserves and animals lose weight (Geetesh Mishra *et al*. 2021), which is in support of our study (Figure 2a). Animals with a BCS < 3 and BW from 71 to 75 kg had negative EE (-17.53% and -20.35%) and higher milk yield compared to other animals (2.539 and 2.588 kg/ADM, Table 2 and Fig. 2b). The reason for this is that in high milk animals, the energy required production exceeds what animals can consume through the ration (Reist *et al*. 2002). The mobilization of body energy reserves at the beginning of lactation allows the animal to fill the gap between energy intake, and energy requirements (Schroder and Staufenbiel, 2006).

Table 2 Analysis of the milk yield and the necessary energy in ewes from sheep of the Assaf breed based on BCS and BW

Indicators	ADM (kg)	IDM (kg)	IME_r (Mcal/kg DM)	ME_m (Mcal)	ME_g (Mcal)	ME_L (Mcal)	$BE_{L/g}$ (Mcal)	EE (%)
All ewes (n=378)	2.065	2.654	4.028	1.396	-0.040	3.365	-0.428	- 7.98
SEM	0.038	0.012	0.019	0.041	0.035	0.057	0.051	-
Body condition score								
< 3 (n=222)	2.539^c	2.788^c	4.241^c	1.753^c	-0.456^a	4.048^c	-0.804^a	- 17.53
3.1 to 4 (n=70)	1.732^b	2.698^b	4.079^b	1.491^b	0.182^b	2.907^b	-0.420^b	- 6.77
> 4.1 (n=86)	1.112^a	2.475^a	3.764^a	0.397^a	0.853^c	1.973^a	0.533^c	15.66
Body weight, kg								
< 70 (n=48)	1.550^b	2.669^b	4.071^b	1.175^b	0.442^b	2.610^b	-0.225^b	- 2.52
71 to 75 (n=237)	2.588^c	2.817^c	4.237^c	1.878^c	-0.482^a	4.087^c	-0.926^a	- 20.35
> 76 (n=93)	1.075^a	2.477^a	3.777^a	0.283^a	0.835^c	1.914^a	0.736^c	20.70

ADM: average daily milk; IDM: intake dry matter; IME_r: intake metabolic energy from ration; ME_m: metabolic energy requirement for maintenance; ME_g: metabolic energy requirement for gain when ADG is positive; ME_L: dietary metabolic energy for lactation; $BE_{L/g}$: body energy loss/gain and EE: energy efficiency.
n: number of animals.
The means within the same column with at least one common letter, do not have significant difference (P>0.01).
SEM: standard error of the means.

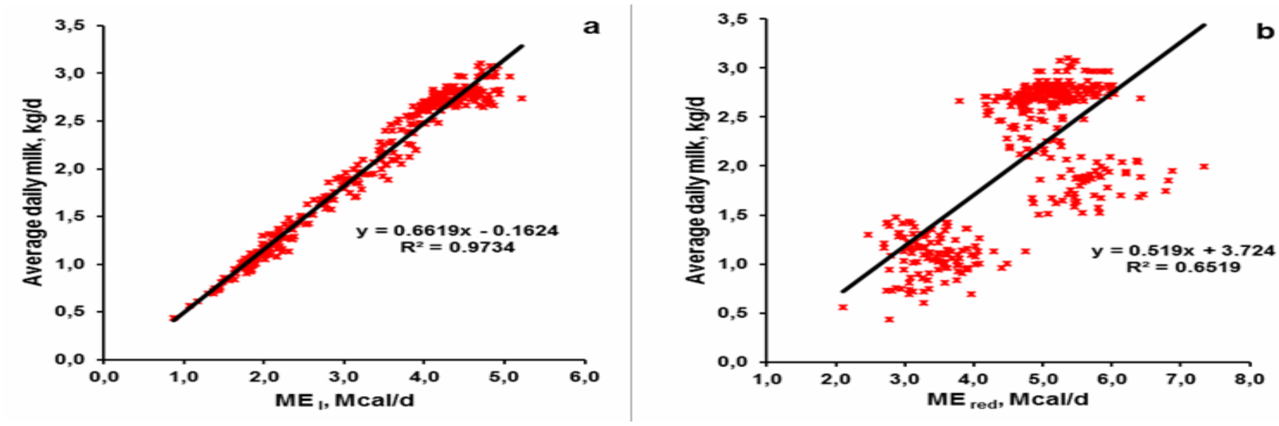

Figure 1 Influence of dietary metabolic energy for lactation (ME_L, Mcal) and total ME requirement (ME_{red}, Mcal) on averadge daily milk (ADM) in sheep of tha Assaf breed

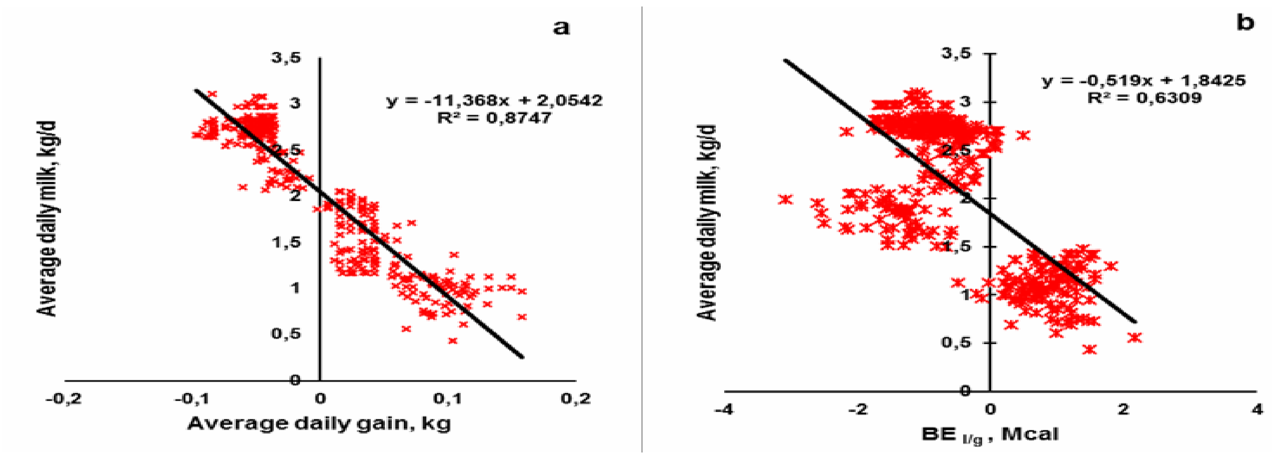

Figure 2 Influence of average daily milk yield on average daily gain and body energy loss/gain ($BE_{L/g}$ Mcal)

BCS is a subjective, visual, and physical estimate of the amount of metabolizable energy that is stored as fat and muscle. According to Andrew *et al.* (1994) BW alone is a poor indicator, due to the fact that body energy reserves can vary by up to 40%. In early lactation, tissue energy is mobilized even though feed intake increases, but body tissue loss may be masked by rumen filling, whereby changes in BW may not be reflected (NRC, 2001).

Our results show the influence of BCS and BW in Assaf sheep on milk production.

Table 3 Analysis of some relationships for milk yield in Assaf sheep

Factors	SS	df	MS	F	P	R^2
BCS	173.011	59	2.932	26.604	**	0.832
BW	178.947	153	1.170	8.998	**	0.860
IDM	31.810	272	0.117	0.751	**	0.937
IME	168.299	123	1.368	8.740	**	0.809

BCS: body condition score; BW: body weight; IDM: intake dry matter; IME: intake metabolic energy; *SS*: sum of squares; df: degree of freedom; MS: mean square; F: fisher criterion; P: degree of significantly and R^2: R squared.
** (P<0.01).

Table 4 The phenotypic correlations (r) between milk yield (ML), composition of the milk, blood counts and body condition of the ewes

Factors	ADM	Fat	Protein	Lactose	DM	BHBA	NEFA	GL
BCS	-0.363^*	0.455^*	0.363^*	0.256^*	0.509^*	-0.781^*	0.941^*	-0.142^{ns}
BW	-0.340^*	0.393^*	0.241^*	0.255^*	0.420^*	-0.891^*	0.908^*	0.293^*

ADM: averagy daily milk; DM: dry matter; BHBA: β-hydroxybutyrate; NEFA: non-esterified fatty acids; GL: glucose; BCS: body condition score and BW: body weight.
* (P<0.01).

Table 5 Blood counts[1] based on body weight and body condition

Indicators	BHBA (mmol/L)	NEFA (mmol/L)	GL (mg/dL)
Average (n=120)	0.664	0.592	41.56
SEM	0.013	0.019	0.144
Body condition score (BCS)			
< 3 (n=20)	0.821^d	0.818^c	39.409^a
3.1 to 4 (n=20)	0.616^c	0.583^b	42.769^b
> 4.1 (n=20)	0.522^a	0.373^a	41.199^{ab}
Body weight (BW), kg			
< 70 (n=20)	0.794^c	0.853^c	40.995^b
71 to 75 (n=20)	0.654^b	0.555^b	39.708^a
> 76 (n=20)	0.581^a	0.390^a	42.792^c

BHBA: β-hydroxybutyrate; NEFA: non-esterified fatty acids; GL: glucose (the results were averaged from 0, 3, 6 hours after the morning meal).
n: number of animals.
The means within the same column with at least one common letter, do not have significant difference (P>0.01).

It was found that sheep with BCS > 4.1 were fairly lower average daily milk yield (P<0.01, Table 2). High levels of BCS are appropriate at the end of pregnancy (the last month before birth), which will be a prerequisite for higher milk yield (Robinson, 1990) and better growth and development of suckling lambs (Mathias-Davies *et al.* 2013). NRC (1989) indicates that when the feeding of the animals is based on the requirements (for average milk yield by 3.5 kg/animal/day), the minimum loss of body weight will be about 20 g/day, regardless of the body condition of the animals. In this case, feeding sheep in the last month of pregnancy must comply with the norms for nutrition (NRC, 2007), otherwise overfeeding may be a prerequisite for increased dystocia, reduced vitality of lambs and low milk yield, which is found in our study in sheep with BCS over 4.1 and body weight under 71 and over 76 kg (Table 2).

In our study, high daily milk yield was observed throughout the experimental period in sheep with a BCS < 3.0 compared to other groups of animals. According to Cannas (2002) one third of sheep's milk yield is achieved by mobilizing body fat and protein stores in the body. When sheep are higher BCS at the beginning of lactation they lose body mass and tend to produce more milk than those who had low BCS (Gibb and Treacher, 1982).

In support of this is the study of Greenwood *et al.* (2010), which stated that improper nutrition during pregnancy reduces the energy reserves in the body of sheep, which affects the development of the fetus and the mammary gland, which according to Tygesen *et al.* (2008) is a prerequisite for low milk yield. However, this was not observed in our study, where animals that have low BCS or BW had significantly higher milk productivity (Table 2). This indicates that BCS could be used as an indicator to determine thethe milk yield of animals (Mushtaq *et al.* 2012) and should not be ignored by farmers.

Energy balance and performance of the body condition of the animals can be evaluated by the concentration of BHBA and GL in the blood (Pichler *et al.* 2014). In the study of Piirsalu *et al.* (2018) they found that levels of GL were not directly influenced by the level of nutrition in sheep and were not more accurate than their body condition. In our study, there was a clear relationship between BCS and blood metabolites (Table 5). In this case, the information we can get by tracking the relationship between metabolic parameters and the BCS of animals will give us important information regarding the metabolic status of the sheep, which would help to correct feeding (Jalilian and Moeini, 2013). According to Sun *et al.* (2007) metabolism of glucose is carried out not only in the liver but also in adipose tissue, which is correlated with the level of crude protein in the ration.

The research of Caldeira *et al.* (2007) has shown that animals with low BCS (about 2) have a decreased plasma concentration of GL which corresponds with our results (Table 5) where animals with BCS < 3 had significantly lower GL. The reason is that pregnant and lactating sheep redirect most of their GL and amino acid stores to the fetal-placental unit and the mammary gland, which according to Chilliard (1999) in such a transfer the animals have high energy needs.

Cincovic *et al.* (2012) found that the negative energy balance at the beginning of lactation caused a lower concentration of GL and a higher concentration of NEFA and BHBA in cows, which was caused by the mobilization of adipose tissue. This difference was also observed in our study, where animals with higher milk yield had lower GL content and higher NEFE and BHBA content (P<0.01, Table 5). According to Ingvartsen *et al.* (2000), animals are subjected to metabolic challenges, as a result of which tissue sensitivity to insulin is reduced and hepatic gluconeogenesis is increased (Reynolds *et al.* 2003). When there is mobilization of body fat for productivity, plasma NEFA is increased to support energy needs (Locher *et al.* 2015).

The reason for the differences in body condition of the sheep in our study was the number of offspring (a large percentage of animals with body condition < 3 gave birth to 2 lambs each) in combination with low temperatures in December. The combination of these two factors is a metabolic challenge to sheep in late pregnancy and early lactation. The reason is the low energy intake by the animals during the period when they have high requirements, which causes a reduction of gluconeogenesis and leads to hypoglycemia. According to Harmeyer and Schulunbhon (2006) when the glucose is reduced, the levels of lipolysis increase, as does the release of fats, triglycerides and NEFA, which increases the likelihood of developing metabolic diseases. To achieve energy balance, and to prevent the development of metabolic diseases Smith and Sherman (1994) found that the body condition of sheep should be between 3.0 and 3.5 in the last third of pregnancy; 3.5 at birth and between 2.0 and 2.5 at weaning of lambs.

When the feeding of sheep is limited in the last weeks of pregnancy Cal-Pereyra *et al.* (2015) observed NEFA levels of 1.28 mmol/L with restricted feeding, while in sheep whose diet was not restricted. NEFA values were close to 0.18 mmol/L. In this case, the restricted diet leads to reduced glucose levels.

The highest glucose levels are observed in the first days after the birth, which according to Schmitta *et al.* (2018) are due to the action of cortisol, the level of which increases five days before birth. Thus, it affects the action of the glucose carrier (GLUT4) in the peripheral tissue and stimulates hepatic gluconeogenesis (Ingvartsen and Andersen, 2000).

CONCLUSION

The reliable influence of the two indicators was established (BCS and BW), on the milk yield and DM and ME intake of Assaf sheep. It is recommended that the optimal BCS in Assaf sheep during the first months of lactation should vary from 3.1 to 4, which corresponds to the average BW of the breed from 71 to 75 kg. It was found that the expenditure of ME for lactation (ME_L, Mcal/kg DM) is higher, the higher the milk yield of the animals. Blood concentrations of BHBA, NEFN and GL are directly dependent on BW and body condition of the animals.

ACKNOWLEDGEMENT

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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