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MILK YIELD, COMPOSITION, NUTRITIVE AND TECHNOLOGICAL VALUES FROM EWES FED DRIED DISTILLERS' WHEAT GRAINS WITH SOLUBLES (DDGSw)

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Abstract: The aims of this study were to evaluate the effects of lactating dairy ewes diets supplementing with different vegetable protein sources (sunflower meal (*SFM*) vs. dried distillers' wheat grains with solubles (*DDGSw*)) at the pick of lactation (27 – 72 lactating day). The experiment was carried out with sixteen lactating dairy ewes, Bulgarian Dairy Synthetic Population (BDSP) in 60-d feeding trial (7-d preparatory + 45-d experimental + 8-d closing periods). Animals were allotted randomly (by age, lactation, milk yield, % milk fat, % milk protein) into two dietary treatments: 1./ a SFM- based control diet (*CD*), and 2./ DDGSw- based experimental diet (*ED*). Diets were iso- nitrogenous, iso- fibrogenous, iso- caloric and equal in protein truly digestible in the small intestines (*PDI*), calcium (*Ca*) and phosphorus (*P*). Compared with the *CD*, supplementation with *DDGSw* decreased ($p<0.001$) the average daily milk yield (5.8 %) and 6.5 % fat-corrected milk (6.8 %). There're no significant differences in milk composition between treatments (*CD* and *ED*): solids non-fat (*SNF*) + 0.8; dry matter (*DM*) + 0.1 %; fat content of milk (*MF*) - 1.1 and milk protein (*MP*) content + 0.4 % per sheep for *ED*, compared with *CD*. *DDGSw*- based diet did not affect nutritive and technological parameters of raw milk: *MP*/*MF* (+ 1.3 %), *MP*/*DM* (- 0.1 %) and *MF*/*DM* (- 1.0 %) ratios. In conclusion, observed data indicates that *DDGSw* at level of 17 % *DM* basis affected ewe milk yielding negatively, without affecting milk composition, nutritive and technological parameters.

Key words*:* Lactating dairy ewes, Dried distillers' wheat grains with solubles (DDGSw), Feed conversion and efficiency, Milk yield, composition, nutritive and technological parameters.

Abbreviations: *DDGSw*-Dried distillers' wheat grains with solubles; *SFM*-sunflower meal; *ED*-experimental diet; *CD*-control diet; *SNF*-solids non fat;

Ca-calcium; *CP*-crude protein; *DM*-dry matter; *MF*-fat content of milk; *MP*-milk protein.

Introduction

The „Green thinking" and the „boom" of biofuel production caused an increase of by-products from this industry available as livestock feeds (*Kozelov and Yossifov, 2013; Lyons, 2007*). Bioethanol in EU, e.g. Bulgaria, is produced mainly from grains – wheat and corn (*Paul et al., 2012; Piron et al., 2009***)**. So, the main byproduct is dried distillers' wheat grains with solubles (*DDGSw*). It contains high concentrations of digestible fibre, so it's an ideal feed for ruminants. Simultaneously, the *DDGSw* is high in protein (40 %) and with optimal levels of fats (3 – 7 %) and fiber (8 – 9 %) with high digestibility (*Aldai et al., 2009; Gibb et al., 2008; Paul et al., 2012; Yossifov, 2012*).

Commonly, *DDGS* have been recognized at low/moderate levels in feedlot rations as substitute for both traditional protein and energy sources (*Yossifov and Kovelov, 2012*). But recent studies indicate that adding *DDGS* to dairy rations improve cow' dry matter intake (*DMI*) (*Zhang et al., 2010*), milk yield (*Anderson at al., 2006; Chibisa et al., 2010*), milk protein and fat (*Schingoethe et al., 1999; Sasikala-Appukuttan et al., 2008*). Nevertheless, there have been relatively few studies reported in which *DDGS* has been fed to sheep. Some suggested that it can be successfully fed to lactating dairy sheep without any effect on animal performance, milk composition and rennet abilities (*Dimova et al., 2009; Yossifov, 2014a*).

So, our experiment was intended to explore the concept of supplementing lactating dairy ewe' diets with *DDGSw*. The objectives of this were to verify if higher (than recommended) *DDGSw* levels affect milk yield at the pick of lactation curve, and if the *ED* affect milk composition and milk nutritive and technological parameters. Such differences, if existing, may be used from animal nutritionists to balance dairy sheep total mixed ration.

Material and methods

Experimental animals and diets. The experiment was conducted at the Experimental Farm of the Institute of Animal Science, Kostinbrod, BG using 60-d feeding trail (7-d preparatory + 45-d experimental + 8-d closing periods). Sixteen lactating dairy ewes of Bulgarian Dairy Synthetic Population (*BDSP*) breed were randomly (by age, lactation, milk production, % milk fats, % milk protein) divided into two diet treatments (n=8): control (*CD*) and experimental diet (*ED*) in order to

evaluate the effects of *DDGSw* supplementation during the pick of lactation (27 – 72 lactating day).

The experimental design is shown in table 1. Daily ration (as *DM* basis) contained 75 % forage (meadow hay + corn silage) and 25 % concentrate mixture. *CD* concentrate mixture consisted of corn (7.72 %), wheat (8.79 %), sunflower meal (*SFM*= 8.26 %) and supplement (0.65 %). Part of the wheat and whole *SFM* of the *CD* were replaced by 16.75 % *DDGSw* in *ED*. Diets were formulated to be iso-caloric, iso-fibrogenous and equal in *PDI*, *Ca* and *P* to meet and exceed all nutrient requirements of lactating dairy ewes (*NRC, 2007*). The supplement provided *Ca* (limestone), ammonium sulphate and vitamin-mineral premix (per kg of diet: *Mg* - 60.0 mg, *Fe* - 1.3 mg, *copper* - 1.0 mg, *I* - 1.6 mg, *Zn* - 60.0 mg, *Co* - 1.0 mg, *Vit. A* – 5000 IU, *Vit. D* - 2000 IU, *Vit. E* -10.0 mg). The diets were fed twice daily – 7.00 AM and 6.00 PM throughout the experimental period. Feed intake was being adjusted daily. Animals were provided free access to fresh water and salt blocks.

Feed sampling and analytical procedures. Feeds were sampled and analysed bimonthly. The feed refusals were collected and weighed daily and analysed twice a month. Samples were analysed for *DM* by drying in a forced-air drying oven at 65 ^{o}C for 48 h. Samples were ground to pass through a 1 -mm screen for further chemical analyses: crude

Table 1. Diet formulation

Item	**SFM- based diet**	**DDGSw- based diet**
		Forage:
Meadow hay	13.32	13.30
Corn silage	61.26	61.17
		Concentrate mixture:
DDGSw	–	16.75
SFM	8.26	–
Wheat	8.79	0.26
Corn	7.72	7.71
		Supplement:
Limestone	0.20	0.40
$(NH_4)_2SO_4$	0.45	0.41
SFM - Sunflower meal; DDGSw - Dried distillers' wheat grains with solubles.		

protein (*CP*) (Kjeldahl N x 6.25), ether extract (*EE*), crude fibres (*CF*), ash, calcium (*Ca*) and phosphorus (*P*) according to *AOAC (2002)*.

Milk sampling and Analysis. Milk yield was recorded twice a day – individually per ewe, during the morning and evening milking. Milk samples were taken and analysed weekly in accordance to the regulations for milk sampling (*country AC method*). Physicochemical characteristics of the raw milk samples were analysed with apparatus EcoMilk (Milkana KAM 98-2A – Bultech Company). The following milk composition parameters were investigated: solids non fats (*SNF*), dry matter (*DM*), milk fats (*MF*) and milk protein (*MP*).

Biostatistical Analyses. The amount of feed offered and refused was recorded daily for each treatment (*CD* and *ED*) of ewe and feed intake and dry matter intake (*DMI*) was calculated (average per sheep). Feed efficiency (*FE*) was calculated as ratio of average daily milk yield to the average *DMI* (M: F). The following indices and ratios for milk samples were calculated: *MP*/*MF*, *MP*/*DM* and *MF*/*DM* to evaluate the nutritive and technological qualities of raw sheep milk. All parameters were analysed using MS Office 2007 and Student t-test. Statistical significance was accepted at $p<0.05$ and $p\geq0.05$ but ≤0.1 was interpreted as indicating a trend towards significance.

Results and discussion

Diet composition. Chemical composition of feedstuffs is presented in **table 2**. *DDGSw* was higher in *DM* (9.6 %), *CP* (0.8 %) and *EE* (315 %) but lower in *CF* (235.3 %), Ash (31.5 %), *Ca* (241.7 %) and *P* (6.7 %) compared with SFM.

Table 2. Chemical composition of diet' ingredients (as % of DM):

	MH	Corn silage	SFM	DDGSw	Wheat	Corn
Dry matter	80.68	39.58	84.62	92.72	86.88	86.29
Crude protein	6.63	6.86	36.55	36.85	11.70	9.28
Ether extract	1.65	2.66	1.37	5.70	2.35	3.42
Crude fibre	30.66	16.74	21.96	6.55	2.62	3.84
Ash	6.34	5.21	7.14	4.89	1.96	1.47
Ca	0.38	0.41	0.41	0.12	0.07	0.06
P	0.09	0.11	1.04	0.97	0.33	0.24
MH- Meadow hay, SFM- Sunflower meal; DDGSw - Dried distillers' wheat grains with solubles.						

DDGSw' content of crude protein (*CP*) in our trial corresponded to that reported by other authors (*Kluth, 2010; Thacker, 2007*), but was lower than that

found by *Vilarino et al. (2007)* and *Dimova et al. (2009)*. Higher values of *CP* were found by *Oryschaк (2010); Slominski et al. (2010)*. Content of fats (*EE*) was twice as much in *DDGSw* as in *SFM*. Similar values were reported by *Kluth et al. (2010)* and *Thacker et al. (2007)*. On the contrary, significantly lower values were found by *Cozannet et al. (2009)*. Other reported higher values (*Cozannet et al., 2009*). The crude fiber (*CF*) values in *DDGSw* was twice lower in *SFM*, which corresponded with *Vilarino et al. (2007)*, but were lower than those found by *Kluth (2010)* and *Oryschaк (2010)*.

The chemical composition of total mixed ratios (*TMRs*) was similar in *DM* (2.1 kg) and ensured iso-caloric (on the average 2.3 *FUM* as net energy), iso-fibrogenous (on the average 0.6 kg *CF*) and equal in *PDI* (on the average 0.19 kg), *Ca* (0.017 kg) and *P* (0.009 kg). Balance of Protein in Rumen (*BPR*) was between - 0.001 and + 0.002 kg for *CD* and *ED*, respectively (table 3).

Intake. Average daily intake (*ADI*), dry matter intake (*DMI*) and consumption of nutrients from *TMRs* are summarized in figure 1. Sheep fed *ED* consumed higher levels of *TMRs* as fed basis (2.2 %), *DM* from forage (3.0 %), *DM* from concentrate mixture (5.4 %) and *DM* from *TMRs* (3.9 %). Thus, our results are in agreement with the reported DDGS-induced increase in feed consumption (as *DMI*). The higher values of average daily intake (*ADI*) of *CP* (33.2 %), Ash (6.4 %), Ca (22.1 %) and P (36.5 %) were found in *ED* compared to *CD*.

Table 3. Chemical composition and nutritive value of DDGSw- and SFM-based diets (g):

	SFM- based diet	**DDGSw- based diet**
		Chemical composition[1]
Dry matter	2134.69	2183.99
Crude protein	391.77	471.24
Ether extract	91.35	115.49
Crude fiber	626.18	590.98
Ash	184.40	186.80
Ca, %	15.71	17.60
P, %	7.87	9.70
		Nutritive value[2,3]
FUM[4]	2.37	2.29
PDI	179.37	195.54
BPR	- 2.19	+ 3.61
BPR/FUM	- 0.92	+ 1.58

[1] As DM basis (except DM); [2] Our own data (our unpublished data); [3] As fed basis; [4] According to Bulgarian feed evaluation system. PDI- Protein truly digestible in small intestines, BPR- Balance of protein in rumen, FUM- Feed units for milk as net energy.

The higher *EE* intake from *ED* (48.7 %) seem to be compensated by the lower consumption of fibres (5.5 %) and did not increase the net energy intake expressed as feed units for milk (2.2 %). Consumption of *PDI* was higher at *ED* (10.0 %) and balance of protein in rumen varied between *CD* (- 1.39) and *ED* (+ 3.23 %).

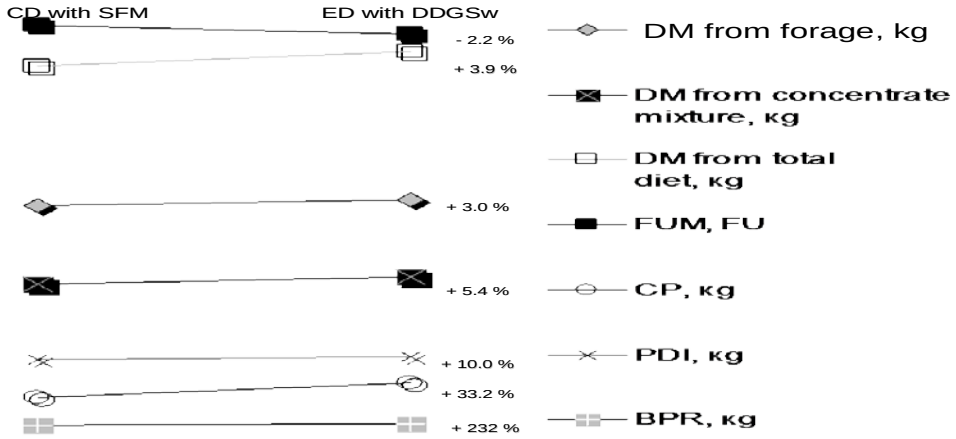

Figure 1. Average daily intake of forage, DM and nutrients

Animal performance. Ewe performance is shown in table 4. The *DDGSw* supplementation to the ewe diets decreased (5.8 %) significantly ($p<0.001$) the average daily milk yield for the studied segment of lactation curve (1.32 L (*CD*) to 1.24 L (*ED*)). The observed distance was higher (6.8 %) when milk yield was corrected to 6.5 % milk fat (*FCM*) as a difference between *ED* and *CD* ($p<0.001$).

Table 4. Yield, composition and technological parameters of sheep milk:

ITEMS / GROUP		SFM- based diet	DDGSw- based diet
			Productivity:
Average daily	Actual	1315.75 ± 196.90[a]	1239.90 ± 164.45[a]
milk yield, ml	6.5 % fat corrected	1437.44 ± 215.11[a]	1339.91 ± 177.71[a]
			Chemical parameters:
Solids non fats		10.93 ± 0.32	11.02 ± 0.24
Dry matter		18.03 ± 0.93	18.05 ± 0.49
Protein		5.65 ± 0.279	5.67 ± 0.199
Fat		7.10 ± 0.801	7.024 ± 0.540
			Ratios:
Protein /Fat		0.80 ± 0.05	0.81 ± 0.08
Protein /Dry matter		0.314 ± 0.005	0.314 ± 0.014
Fat /Dry matter		0.393 ± 0.024	0.389 ± 0.021

[aa] p<0.001.

Milk analyses. Milk composition is presented in figure 2. The differences between investigated milk parameters were not significant among the treatments. So, our data on the sheep milk content correspond to *Boikovski et al. (2006)* and *Djorbineva et al. (2002)*. Also, they're within the limits of dairy sheep and standards for *SBDP* breed (*Hinkovski et al., 1984; Nedelchev et al., 2003*).

Besides, we evaluated milk properties by physicochemical parameters, nutritive and technological ratios and indices in order to get more profound insight on its quality. Percentage of *SNF* and *DM* (fig. 2) among the groups was within the norms (10.93 – 11.02 and 18.03 – 18.05 %) and the differences were not significant (*CD << ED*). Similar values were reported by *Boikovski et al. (2005)*.

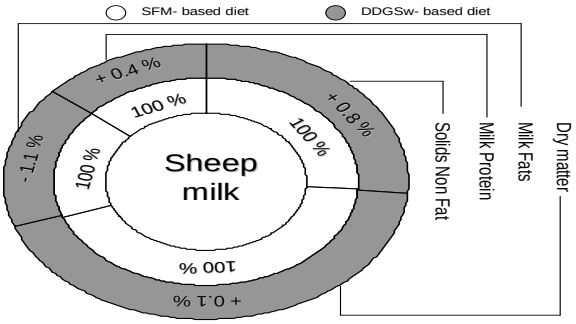

Figure 2. Chemical composition of sheep milk

However, some authors found lower values (*Stancheva, 2003*), while other reported higher (*Djorbineva et al., 2002*). The content of milk fat (fig. 2) showed downward tendency – ED << CD (1.1 %), but results were within the normal range and corresponded with the results found by *Stancheva (2003)*. Some found lower values (*Djorbineva et al., 2002*), and other – higher (*Stancheva et al., 2011*). Milk proteins were actually the same among the groups (5.66 %) and exceeded the values found by other authors (*Boikovski et al., 2005; Stancheva et al., 2011*).

The nutritive and technological parameters of raw sheep milk were characterized by the use of the following ratios (figure 3): *MP/MF, MP/DM and MF/DM*. All values were within the recommended standards (0.80, 0.31 and 0.39). The *MF/DM* and *MP/DM* values were lower at *ED* (1.0 and 0.1 %) than *CD* and corresponded to the values published by *Stancheva (2003)*, but were lower than values found by *Djorbineva et al. (2002)* and *Stancheva et al. (2011)*. The *MP/MF* ratio was higher at *ED* (1.3 %) than *CD* but the values were lower than those found by *Djorbineva et al. (2002)* and *Stancheva et al. (2011)*.

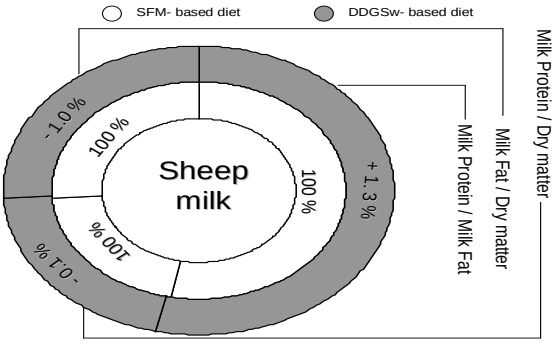

Figure 3. Nutritive and technological quality of sheep milk

Feed efficiency. The nutrients utilization and their biotransformation into milk production is summarized in fig. 4. The conversion of nutrients into 1 L milk production was less effective in animals consuming *DDGSw*- based diet, as compared with *CD*: *TMR* (9.7 %), *DM* (11.5 %), *CP* (14.1 %), *FUM* (4.4 %) and *PDI* (18.0 %). Feed efficiency, as presented by milk/ feed (*M/ F*) ratio, also was decreased (19.3 %) in *DDGSw*- based diet (fig. 4).

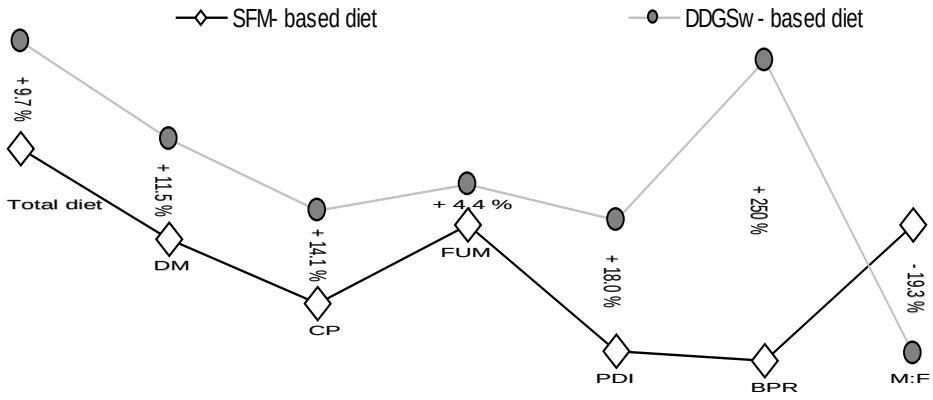

Figure 4. Feed conversion (g.L^{1}milk) and feed efficiency (as M/ F)

The nitrogen, as a limiting factor in high productive dairy animals was used to be established the effect of dietary protein source (*SFM* vs. *DDGSw*) on milk production (figure 5). So, animals fed with *CD* consumed (253 g) lower levels of dietary *CP* (as *N*), compared with *ED* (24.9 %). The percentage of *N* retained in milk rose in order *ED* << *CD* (- 5.4 %). Thus, the percentage of N utilization was higher in *SFM*- based diet (40.8 %) compared with *ED*.

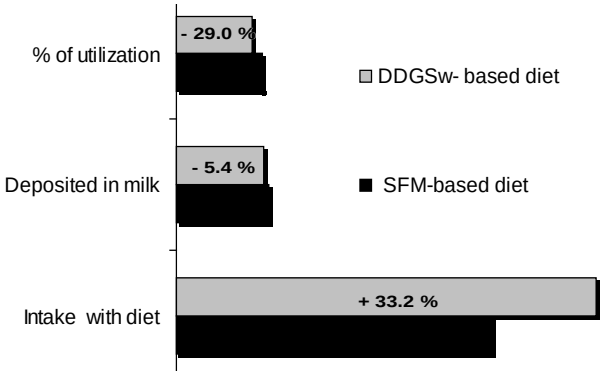

Figure 5. Nitrogen balance

The observed results of the present study indicate that DDGSw supplementation of lactating dairy sheep in early to peak of lactation, as protein source, decreases milk yield but has no effect on its composition, nutritive and technological qualities. Lower to moderate levels of supplementation should be tested (*Dimova et al., 2009*).

Conclusion

The results in our experimental conditions shows that:

- The data on the chemical composition of *DDGSw* were as follows: *DM* – 92.72 %; *CP* – 368.50 g/kg *DM*; *EE* – 57.00 g/kg *DM*; *CF* –65.50 g/kg *DM*; Ash – 48.90 g/kg; *Ca* – 0.12 g/kg *DM* and *P* – 0.97 g/kg *DM*;
- Sheep fed *ED* consumed higher levels of total diet as fed basis (2.2 %), *DM* from forage (3.0 %), *DM* from concentrate mixture (5.4 %) and *DM* from total diet (3.9 %), average daily intake (*ADI*) of *CP* (33.2 %), Ash (6.4 %), *Ca* (22.1 %) and *P* (36.5 %) as compared with *CD*. The higher *EE* intake from *ED* (48.7 %) compensated for the lower consumption of fibres (5.5 %) and didn't increase intake of feed units for milk (2.2 %). Consumption of *PDI* was higher in *ED* (10.0 %) and balance of protein in rumen varied between *CD* (1.39) and *ED* (3.23 %);
- Average daily milk yield for the studied segment of lactation curve was significantly ($p<0.001$) lower in *ED* < *CD* (5.8 %). The differences between treatments were significant and statistically proved as 6.5 % fat-corrected milk – *CD* >> *ED* ($p<0.001$);
- Differences between controlled physicochemical milk composition parameters (solids non fats (*SNF*), dry matter (*DM*), milk fat (*MF*) and

milk protein (*MP*)) and nutritive and technological parameters (*MP*/*MF*, *MP*/*DM*, *MF*/*DM*) were within the recommended range and were not affected by treatments;

- The conversion of nutrient ingredients into 1 L milk production was less effective in animals consuming *DDGSw*- based diet, relative to *CD*: Total diet (9.7 %), *DM* (11.5 %), *CP* (14.1 %), net energy as *FUM* (4.4 %), *PDI* (18.0 %).;
- The feed efficiency, presented as milk/feed (*M/F*) ratio was advantaged by the *SFM*- based diet (19.3 %).

So, we can conclude that higher (than recommended) DDGSw levels (17 and 44 % as fed total ration or concentrate mixture, respectively) in our experimental units affected animal response negatively. Thus, the ED decreased significantly milk yield, but did not affected milk composition, nutritive and technological parameters.

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Prinos, sastav, nutritivne i tehnološke vrednosti mleka ovaca hranjenih sušenom džibrom rastvorljivim materijama (DDGSv)

M. R. Yossifov

Rezime

Cilj ove studije je bio procena efekata korišćenja obroka dopunjenog različitim izvorima biljnih proteina (suncokretova sačma (SFM) vs. sušena džibra pšenice sa rastvorljivim materijama (DDGSw)) u ishrani mlečnih ovaca u vrhuncu laktaciji (27 - 72 dan). Eksperiment je izveden sa šesnaest mlečnih ovaca u laktaciji, bugarske mlečne sintetička populacija (BDSP) u 60-dnevnom hranidbena tretmanu (7-dnevni pripremni period + 45-dnevni ogledni period + 8-dnevni završni period). Životinje su nasumično dodeljene (po starosti, laktaciji, prinosu mleka, % mlečne masti, % proteina u mleku) u dva hranidbena tretmana: 1. Kontrolni tretman na

bazi SFM (CD), i 2. / DDGSw- zasnovan eksperimentalni obrok (ED). Obroci su bili izo-azotni, izo-fibrogenous, izo-kalorijski i jednaki u proteinima svarljivim u tankom crevu (PIO), kalcijumu (Ca) i fosforu (P). U poređenju sa CD-om, suplementacija DDGSw utiče na smanjenje ($p<0.001$) prosečnog dnevnog prinosa mleka (5,8%) i 6,5% mast-korigovanog mleka (6,8%). Tu su i značajne razlike u sastavu mleka između tretmana (CD i ED): nemasne čvrste materije (SNF) + 0,8; suva materijae (DM) + 0,1%; sadržaj mlečne masti (MF) - 1.1 i mlečnog proteina (MP) Sadržaj + 0,4% po ovaci za ED, u poređenju sa CD-om. Ishrana obrokom baziranim na DDGSw nije uticala na nutritivne i tehnološke parametre sirovog mleka: MP/MF (+ 1,3%), MP/DM (- 0,1%) i MF/DM (- 1,0%) odnosi. U zaključku, primetio podaci ukazuju da je DDGSw na nivou 17% suve materije uticao negativno na prinos mleka ovaca, bez uticaja na sastav mleka, nutritivne i tehnološke parametre.

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