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Nutritive value of Saanen goat diets with dried distillers grains with solubles as a replacement for soybean meal

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ABSTRACT - The objective with this study was to evaluate the effect of including dried distillers grains with solubles (DDGS) as a replacement for soybean meal on feed intake, digestibility, and total digestible nutrients (TDN), as well as plasmatic glucose and serum urea concentrations. Fifteen Saanen goats were distributed in a completely randomized design with three treatments and five replicates. Treatments were soybean meal (SBM), SBM+DDGS (12.28% of dry matter [DM]), and DDGS (23.16% of DM), as protein source in diets, common to all corn ground and mineral-vitamin supplement, and corn silage (60% of DM). Response variables were evaluated every 30 d, from 1 to 120 d after parturition. Measurements included body weight, DM intake, DM and nutrient digestibility, and blood samples. Indigestible neutral detergent fiber was used to estimate fecal excretion. There was a difference in neutral detergent fiber intake from 1 to 30 d after parturition. In the four phases of lactation evaluated, there were treatment effects on DM, organic matter, ether extract, and total carbohydrate digestibility, as well as on TDN concentration. Neutral detergent fiber digestibility was affected by treatments, except from d 61 to 90. There was no treatment effect on non-fibrous carbohydrate digestibility, regardless of period. Therefore, SBM+DDGS (12.28% of DM), as protein source on diets may be used in Saanen goat diets from 1 to 120 d of lactation without negative effects on feed intake, digestibility, and plasma glucose and urea concentrations.

Keywords: dairy goats, DDGS, digestibility, ethanol byproduct, feed efficiency, TDN

Introduction

The dairy goat industry has socioeconomic importance, with good productive performance, due to management conditions and nutrition, providing increasing production with high dairy potential, which requires specific feeding once it has higher nutrient requirements (Novais et al., 2015; Souza et al., 2016). According to Gonçalves et al. (2008), among the dairy breeds, Saanen is the most used, as it is a dairy breed with low adaptation to harsh environments and greater susceptibility to diseases.

Feed nutritive value is a major factor affecting the productivity of dairy herds; therefore, it is important to characterize the feed contained in a diet. Thus, it has been observed that concentrate feeds are more adequate protein sources to maintain productivity during lactation period (Roque, 2014; Cabral et al., 2015).

Soybean meal (SBM) is the most used protein source for lactating dairy goats; however, in comparison to other sources, it is usually expensive, independent of the season of the year. Therefore, producers have searched for new sources to supply the nutrient requirements of their animals (Santos et al., 2014; Maciel, 2017). According to Valadares Filho et al. (2015), average crude protein (CP) and neutral detergent fiber (NDF) concentrations in soybean meal are 49.28 and 15.82%, respectively. Thus, byproducts have been used in animal diets for their high nutritive value and low cost, as soybean meal is usually more expensive (Ferreira and Urbano, 2013).

The use of dried distillers grains with solubles (DDGS) may be an alternative in animal diets (Khullar et al., 2009), aiming to reduce costs and increase productivity. It is obtained from the ethanol production process, from corn, through the grinding process. After ethanol production, in which corn is converted to alcohol through dry grinding, which is made through the conventional and fractionation methods, occurs the drying at high temperatures and the products is then called DDGS (Alves et al., 2012; Milanez et al., 2014; Silva et al., 2016).

Dried distillers grains with solubles have high CP (30.9%) and NDF concentration (ranging from 33.1 to 43.9%), with variable nutrient composition as its quality depends upon the characteristics of the ethanol production process and corn processing conditions (Ayadi et al., 2012), allowing for their use in animal diets.

Nevertheless, to formulate an adequate diet, it is important to know the nutritive value characteristics of the ingredients, such as chemical composition, nutrient digestibility, and dry matter (DM) intake (Berchielli et al., 2006).

Therefore, the objective of this study was to evaluate the effect of replacing SBM with DDGS in Saanen goat diets, from parturition to 120 d of lactation, on feed intake, digestibility of DM and nutrients, total digestible nutrient, and concentrations of plasmatic glucose and serum urea.

Material and Methods

The experimental procedures were approved by the institutional Ethics and Animal Use Committee (number 29/18). The experiment was conducted in the Iguatemi district, Maringá, PR, Brazil (23°25' S; 51°57’ W, 550 m above sea level).

Fifteen lactating Saanen goats, with 55 kg of live weight, were distributed in three treatments and five replicates, in a completely randomized design. Treatments were the replacement levels of dietary soybean meal with DDGS: SBM, SBM+DDGS (12.28% of DM), and DDGS (23.16% of DM), as protein source on diets. Animals received corn silage (60% of DM) as roughage and composed concentrate feed, besides the protein source, by ground corn and mineral-vitamin supplement (Tables 1 and 2).

Animals were allocated in each treatment according to body weight and milk production. The DDGS was acquired from a corn alcohol industry located in São José do Rio Claro, MT, Brazil.

The beginning of adaptation to diets started 10 d before the expected parturition date, and the experimental period was divided in four phases (1 to 30 d; 31 to 60 d; 61 to 90 d; and 91 to 120 d of lactation). Goats were subjected to four periods of feed, refusals, feces, and blood sample collections. The ration was formulated to meet the nutrient requirements of Saanen goats weighing 60 kg of body weight with daily milk production of 3.0 kg, according to the NRC (2007).

Animals were maintained in individual pens equipped with wooden floors and troughs for feed, mineral, and water, where they remained confined with 30-min access to a solarium after the morning and afternoon milking. Goats were milked twice a day at 8:00 and 16:00 h, for daily control of milk production. The animals were weighed after parturition and every 15 d for a 120-d period, between the first and the second milking. The total mixed ration (concentrate and roughage) was offered twice a day (8:30 and 16:30 h) to allow 10% of refusals to ensure the *ad libitum* intake. The DM intake was determined through the difference between offered and refused feed.

Samples from offered and refused feed were collected in each period, according to the parturition date, and were homogenized to generate a single composed sample per period. Feces samples were collected in each period, in three consecutive days, for analysis of DM and nutrient digestibility. Around 30 g of feces were collected from the rectum at the following times: day 1, at 8 and 14 h; day 2, at 10 and 16 h; and day 3, at 12 and 18h. Subsequently, samples were composed to generate one sample per animal per period.

Fecal excretion was estimated by using indigestible NDF (iNDF) as an internal marker (Cochran et al., 1986). Feed and feces samples were sealed in non-woven textile and incubated for 144h in rumen-cannulated goats. Subsequently, samples were analyzed for NDF concentration according to Van Soest et al. (1991).

Feed, refusals, and feces samples were stored in a freezer, subsequently pre-dried in forced-air oven at 55 °C for 72h and processed in a Willey mill to pass through a 1-mm screen.

Table 1 - Chemical composition of the ingredients

Nutrient (g/kg)	Feed			
	Corn silage	Ground corn	Soybean meal	DDGS[1]
		1-30 days		
Dry matter (g/kg)	327.20	923.70	929.60	916.80
Organic matter	956.60	986.30	937.10	972.00
Ashes	44.00	13.70	62.90	28.00
Crude protein	68.70	93.40	540.00	370.10
Ether extract	31.10	32.70	18.80	34.00
NDF	511.60	147.50	174.10	478.70
iNDF	165.00	18.90	9.50	76.60
Total carbohydrates[1]	856.20	860.20	378.30	567.90
		31-60 days		
Dry matter (g/kg)	320.00	923.20	937.10	916.10
Organic matter	963.60	987.00	938.80	970.30
Ashes	36.40	13.00	61.20	29.70
Crude protein	68.20	93.50	550.00	370.50
Ether extract	20.50	32.70	18.80	34.00
NDF	529.70	155.00	182.50	469.80
iNDF	157.80	19.70	9.30	75.40
Total carbohydrates[1]	874.90	860.80	370.00	565.80
		61-90 days		
Dry matter (g/kg)	335.10	924.20	942.10	917.60
Organic matter	953.00	985.70	937.90	973.80
Ashes	47.00	14.30	62.10	26.20
Crude protein	69.10	93.40	542.10	369.60
Ether extract	28.60	35.00	20.10	34.90
NDF	512.90	146.10	165.60	470.20
iNDF	162.20	20.30	9.00	74.30
Total carbohydrates[1]	855.30	857.30	375.70	569.30
		91-120 days		
Dry matter (g/kg)	302.40	924.20	942.10	902.20
Organic matter	955.50	985.70	938.90	974.30
Ashes	44.50	14.30	61.10	25.70
Crude protein	67.20	93.40	549.70	355.40
Ether extract	23.20	26.70	19.70	36.10
NDF	517.20	153.30	160.40	478.70
iNDF	169.70	19.50	9.60	77.10
Total carbohydrates[1]	865.10	865.60	369.50	582.80

DDGS - dried distillers grains with solubles; NDF - neutral detergent fiber; iNDF - indigestible neutral detergent fiber; TC - total carbohydrates; DM - dry matter; CP - crude protein; EE - ether extract.
[1] Estimated according to Sniffen et al. (1992): TC (g/kg of DM) = 1000 − (CP + EE + ash).

Samples were analyzed for DM, ashes, CP, and ether extract (EE) concentration according to AOAC (1990), being the organic matter (OM) estimated as the difference between DM and ashes. Neutral detergent fiber concentration was determined according to Van Soest et al. (1991).

Concentrations of total carbohydrates (TC), non-fibrous carbohydrates (NFC), and total digestible nutrients (TDN) were estimated according to the equations described by Sniffen et al. (1992).

Table 2 - Ingredient and chemical composition of diets

Item	Treatment[1]		
	SBM	SBM+DDGS	DDGS
Ingredient (g/kg)			
Corn silage	600.00	600.00	600.00
Ground corn	230.00	190.80	148.00
Soybean meal	149.60	66.00	
DDGS		122.80	231.60
Mineral-vitamin supplement[2]	20.40	20.40	20.40
		1-30 days	
Dry matter (DM; g/kg)	547.80	547.20	545.40
Organic matter (g/kg DM)	961.00	963.40	965.10
Ash (g/kg DM)	39.00	36.60	34.90
Crude protein (g/kg DM)	143.50	140.10	140.80
Ether extract (g/kg DM)	29.00	30.30	31.40
Neutral detergent fiber (g/kg DM)	366.90	405.40	439.70
Indigestible neutral detergent fiber (g/kg DM)	104.80	112.60	119.50
Total carbohydrates (g/kg DM)	788.50	793.00	792.90
		31-60 days	
Dry matter (g/kg)	544.50	542.50	540.80
Organic matter (g/kg DM)	966.00	968.00	969.40
Ash (g/kg DM)	34.00	32.00	30.60
Crude protein (g/kg DM)	144.70	140.60	140.70
Ether extract (g/kg DM)	22.60	24.00	25.00
Neutral detergent fiber (g/kg DM)	380.80	417.10	449.60
Indigestible neutral detergent fiber (g/kg DM)	100.60	108.30	115.10
Total carbohydrates (g/kg DM)	798.70	803.40	803.70
		61-90 days	
Dry matter (g/kg)	554.60	552.30	550.40
Organic matter (g/kg DM)	959.00	961.80	963.60
Ash (g/kg DM)	41.00	38.20	36.40
Crude protein (g/kg DM)	144.00	140.50	140.90
Ether extract (g/kg DM)	28.30	29.50	30.40
Neutral detergent fiber (g/kg DM)	366.10	404.30	438.30
Indigestible neutral detergent fiber (g/kg DM)	103.30	110.90	117.50
Total carbohydrates (g/kg DM)	786.70	791.80	792.30
		91-120 days	
Dry matter (g/kg)	534.90	530.70	527.20
Organic matter (g/kg DM)	960.90	963.40	965.20
Ash (g/kg DM)	39.10	36.60	34.80
Crude protein (g/kg DM)	144.00	130.10	136.50
Ether extract (g/kg DM)	23.00	24.70	26.20
Neutral detergent fiber (g/kg DM)	369.60	408.90	443.90
Indigestible neutral detergent fiber (g/kg DM)	107.70	115.60	122.60
Total carbohydrates (g/kg DM)	793.90	808.60	802.50

[1] SBM: soybean meal; SBM+DDGS: soybean meal + dried distillers grains with solubles (12.28% of DM); DDGS: 23.16% of DM.
[2] Mineral-vitamin supplement composition (per kg of product): Ca, 190.0 g; P, 80.0 g; K, 54.0 g; Mg, 5.0 g; Na, 114 g; S, 20.0 g; Fe, 4120 mg; Cu, 400 mg; Mn, 600 mg; Zn, 3000 mg; Co, 60 mg; I, 75 mg; Se, 18 mg; vitamin A, 20,000 IU; vitamin D3, 2500 IU; vitamina E, 350 IU.

Urea and blood glucose concentrations were obtained by collections performed 4 h after the morning feeding, in 10-mL test tubes by puncture of the jugular vein. Serum was obtained by centrifuging the blood at 3500 rpm for 15 min, stored in Eppendorf tubes, and frozen. Serum urea and glucose were determined using a Gold Analisa Diagnostica® commercial kit (Urea-PP and Glucose-PP) and read on the Bioplus 2000 spectrophotometer.

The data were analyzed by variance analysis and the means were compared by Tukey's test at 5% probability, using the statistical software SAS (Statistical Analysis System, version 9.0), through the model:

$$Yij = m + ti + \varepsilon ij,$$

in which i = treatments, j = replicates, and ε = error associated to the Yij observation.

Results

There were no treatment effects (P>0.05) from parturition to 120 d for the intakes of DM, OM, CP, EE, TC, and NFC (Table 3), even with the inclusion of 23.16% of DDGS (Table 2).

At the beginning of the lactation (from d 1 to 30), NDF intake was different between SBM+DDGS and DDGS, as the total replacement of SBM with DDGS increased NDF intake.

From parturition to d 30 of lactation (Table 4), there were treatment effects (P<0.05) for the digestibilities of DM, OM, EE, NDF, TC, and TDN. However, there were no treatment effects (P>0.05) on CP and NFC digestibilities.

The treatment SBM+DDGS, which corresponds to 12.28% of the total diet in DM (Table 2), did not affect DM digestibility from parturition to d 120 of lactation; however, when all soybean meal was replaced with DDGS (23.16% of the total diet in DM), there was a decrease in DM digestibility, as well as the digestibilities of most nutrients.

There were treatment effects (P<0.05) for DM, OM, NDF digestibility, and TDN from lactation d 31 to 60; however, there were no treatment effects (P>0.05) for the CP, EE, and NFC digestibility.

From d 61 to 90, there were treatment effects (P<0.05) for DM, OM, EE, TC digestibility, and TDN, whereas similar effects were not observed in CP, NDF, and NFC digestibility (P>0.05). However, from to 91 to 120, there were treatment effects for digestibilities of DM, OM, CP, EE, NDF, TC, and TDN, whereas similar effect was not observed in NFC (P>0.05).

Crude protein digestibility was not affected by treatment (P>0.05) from parturition to lactation d 90. Greater EE digestibility was observed in SBM+DDGS in comparison with DDGS from parturition to d 30, from d 61 to 90, and from d 91 to 120 (P<0.05), although there was no treatment effect (P>0.05) from d 31 to 60.

The SBM treatment had greater NDF digestibility than DDG from parturition to d 60 and from d 91 to 120 (P<0.05).

Increasing dietary DDGS decreased TC digestibility in all lactation phases (P<0.05), although no treatment effect was observed in NFC digestibility (P>0.05). With the increase in the fiber present in DDGS, TC digestibility was affected, although it did not affect NFC digestibility.

Total digestible nutrients were affected by treatments in all the evaluated lactation phases (P<0.05); however, SBM and SBM+DDGS treatments had similar or greater observed values in comparison with estimated TDN (72%), providing good digestibility efficiency in those treatments.

Serum urea and plasma glucose concentrations were not affected by treatments, regardless of the lactation phase (P>0.05; Table 5).

Table 3 - Live weight and intake of Saanen goats from parturition to 120 d of lactation, fed diets with dried distillers grains with solubles (DDGS) as substitute for soybean meal

Item	Treatment[1]			P-value
	SBM	SBM+DDGS	DDGS	
		1-30 days		
Live weight (kg)	51.2±1.97	48.6±1.89	48.8±2.03	0.82
Intake (kg/d)				
Dry matter	1.67±0.45	1.52±0.18	1.66±0.25	0.69
Organic matter	1.57±0.42	1.43±0.17	1.57±0.23	0.67
Crude protein	0.22±0.56	0.21±0.02	0.23±0.03	0.76
Ether extract	0.05±0.01	0.05±0.01	0.05±0.01	0.66
Neutral detergent fiber	0.61±0.16ab	0.59±0.05a	0.78±0.11b	0.03
Total carbohydrates	1.27±0.35	1.15±0.13	1.28±0.20	0.62
Non-fiber carbohydrates	0.66±0.32	0.56±0.16	0.50±0.18	0.66
Total digestible nutrients	1.17±0.31	1.03±0.27	1.01±0.29	0.62
		31-60 days		
Live weight (kg)	52.0±1.93	50.2±1.93	50.7±1.98	0.92
Intake (kg/d)				
Dry matter	1.75±0.34	1.61±0.27	1.52±0.31	0.52
Organic matter	1.65±0.32	1.53±0.25	1.43±0.29	0.49
Crude protein	0.23±0.04	0.22±0.03	0.22±0.05	0.87
Ether extract	0.04±0.01	0.03±0.01	0.03±0.01	0.87
Neutral detergent fiber	0.66±0.14	0.71±0.14	0.73±0.14	0.74
Total carbohydrates	1.34±0.27	1.25±0.20	1.78±0.24	0.53
Non-fiber carbohydrates	0.68±0.22	0.54±0.17	1.06±0.19	0.48
Total digestible nutrients	1.21±0.30	1.07±0.28	0.99±0.32	0.12
		61-90 days		
Live weight (kg)	51.6±1.87	50.1±1.92	52.3±1.90	0.92
Intake (kg/d)				
Dry matter	1.71±0.38	1.67±0.30	1.73±0.25	0.95
Organic matter	1.61±0.35	1.57±0.30	1.64±0.23	0.93
Crude protein	0.22±0.06	0.22±0.05	0.24±0.04	0.86
Ether extract	0.05±0.01	0.05±0.01	0.05±0.01	0.89
Neutral detergent fiber	0.59±0.12	0.64±0.14	0.76±0.15	0.17
Total carbohydrates	1.30±0.28	1.27±0.25	1.34±0.21	0.89
Non-fiber carbohydrates	0.71±0.23	0.63±0.24	0.58±0.20	0.94
Total digestible nutrients	1.19±0.33	1.14±0.28	1.10±0.32	0.90
		91-120 days		
Live weight (kg)	54.1±1.91	53.2±1.89	51.1±1.76	0.86
Intake (kg/d)				
Dry matter	1.89±0.40	1.67±0.22	1.70±0.32	0.52
Organic matter	1.78±0.37	1.57±0.21	1.61±0.31	0.53
Crude protein	0.25±0.05	0.22±0.03	0.23±0.04	0.63
Ether extract	0.04±0.01	0.04±0.01	0.04±0.01	0.94
Neutral detergent fiber	0.68±0.18	0.66±0.08	0.81±0.15	0.23
Total carbohydrates	1.45±0.29	1.27±0.17	1.33±0.24	0.54
Non-fiber carbohydrates	0.77±0.24	0.61±0.17	0.52±0.22	0.29
Total digestible nutrients	1.34±0.27	1.16±0.32	1.11±0.25	0.26

[1] SBM: soybean meal; SBM+DDGS: soybean meal + DDGS (12.28% of DM); DDGS: 23.16% of DM.
Means followed by similar letters on the same row do not differ by Tukey's test (P<0.05).

Table 4 - Dry matter and nutrient digestibility, as well as total digestible nutrients of Saanen goats from parturition to 120 d of lactation fed diets with dried distillers grains with solubles (DDGS) as substitute for soybean meal

Digestibility coefficient %	Treatment[1]			P-value
	SBM	SBM+DDGS	DDGS	
	1-30 days			
Dry matter	68.88±1.89a	66.36±3.19ab	62.25±3.29b	0.0070
Organic matter	72.30±1.36a	68.57±2.13b	64.50±2.22c	<0.0001
Crude protein	68.08±1.83	67.74±2.44	65.11±3.29	0.1613
Ether extract	84.13±2.90ab	85.22±2.93a	79.24±4.58b	0.0375
Neutral detergent fiber	50.63±2.45a	46.26±2.48bc	45.60±2.02c	0.0075
Total carbohydrates	71.93±2.33a	67.47±3.14ab	63.40±3.16b	0.0013
Non-fiber carbohydrates	87.42±2.31	89.91±1.98	89.38±2.02	0.2380
Total digestible nutrients	71.98±1.58a	68.79±2.80ab	65.04±2.81b	0.0018
	31-60 days			
Dry matter	70.02±3.25a	66.09±2.03ab	62.35±2.89b	0.0020
Organic matter	72.35±2.29a	68.55±1.90b	64.21±1.39c	<0.0001
Crude protein	69.77±2.76	66.58±3.49	63.46±6.45	0.1244
Ether extract	77.42±4.68	80.16±2.71	76.73±1.66	0.2173
Neutral detergent fiber	54.09±2.70a	49.46±2.67bc	46.47±2.10c	0.0008
Total carbohydrates	72.59±3.41a	67.76±0.92b	62.17±2.15c	<0.0001
Non-fiber carbohydrates	85.75±2.25	86.47±3.17	85.84±3.05	0.0672
Total digestible nutrients	72.01±3.11a	68.12±0.98b	62.43±1.92c	0.0061
	61-90 days			
Dry matter	71.37±3.49a	68.38±4.14ab	64.22±3.21b	0.0190
Organic matter	73.20±2.46a	70.37±3.46ab	65.92±2.92b	0.0045
Crude protein	68.57±2.63	67.32±2.46	64.44±3.33	0.0842
Ether extract	84.22±3.17ab	86.51±2.69a	80.63±2.16b	0.0095
Neutral detergent fiber	51.12±3.23	49.87±3.47	50.74±4.15	0.7737
Total carbohydrates	72.67±3.50a	69.75±5.93ab	65.42±2.86b	0.0405
Non-fiber carbohydrates	86.74±2.49	85.93±2.84	86.09±2.97	0.0787
Total digestible nutrients	72.39±2.90a	70.43±5.00ab	66.42±2.67b	0.0453
	91-120 days			
Dry matter	72.59±2.89a	71.25±3.01a	63.55±2.55b	0.0002
Organic matter	75.26±2.57a	72.71±1.81a	65.88±3.54b	0.0003
Crude protein	71.56±2.34a	67.78±3.84ab	66.03±2.94b	0.0335
Ether extract	80.59±2.28b	86.53±3.25a	76.38±3.00b	0.0002
Neutral detergent fiber	54.83±3.23a	49.76±3.47ab	45.65±4.15b	0.0044
Total carbohydrates	74.21±3.02a	72.37±2.71a	66.37±2.86b	0.0015
Non-fiber carbohydrates	86.97±3.08	85.53±2.89	84.38±2.67	0.2593
Total digestible nutrients	73.37±2.65a	72.15±1.98a	66.77±2.69b	0.0019

[1] SBM: soybean meal; SBM+DDGS: soybean meal + DDGS (12.28% of DM); DDGS: 23.16% of DM.
Means followed by similar letters on the same row do not differ by Tukey's test (P<0.05).

Discussion

Schingoethe et al. (2006), when including DDGS levels greater than 30% in cow diets, observed a decrease in DM intake. Thus, the experimental conditions, byproduct composition, byproduct form (dry or humid), diet composition, particle size, and animal species may cause DM intake differences (Benchaar et al., 2013), considering that goats have greater ingestive chewing efficiency.

Ramirez-Ramirez et al. (2016) observed greater NDF intake in dairy cows fed treatments with DDGS when compared with a control. Although the NDF concentration increased seven percentage points when all SBM was replaced with DDGS (Table 2), DM intake was not affected in the present study.

Table 5 - Serum urea nitrogen (mg/dL) and glucose (mg/dL) in Saanen goats from parturition to 120 d of lactation fed diets with dried distillers grains with solubles (DDGS) as substitute for soybean meal

Item (mg/dL)	Treatment[1]			P-value
	SBM	SBM+DDGS	DDGS	
		1-30 days		
Urea	33.8±3.27	38.8±3.06	36.0±3.27	0.25
Glucose	49.7±3.45	47.4±3.53	43.2±3.49	0.24
		31-60 days		
Urea	35.7±3.26	36.6±3.71	35.2±3.09	0.76
Glucose	47.4±3.41	46.3±3.97	45.2±2.98	0.91
		61-90 days		
Urea	32.7±3.20	34.8±3.02	35.3±2.87	0.63
Glucose	46.1±3.81	48.3±2.89	44.8±3.01	0.41
		91-120 days		
Urea	31.0±3.28	33.5±3.28	33.4±2.90	0.56
Glucose	48.9±3.09	45.8±3.81	45.5±2.99	0.38

[1] SBM: soybean meal; SBM+DDGS: soybean meal + DDGS (12.28% of DM); DDGS: 23.16% of DM.

Benchaar et al. (2013) clarified that the increase in dietary DDGS may decrease DM digestibility due to the increase of the byproduct in the diet. According to Schingoethe et al. (2006), DDGS is considered a protein source of low ruminal degradability, showing high intestinal digestibility, allowing amino acids to be absorbed in the intestine, increasing animal performance (Siebert and Hunter, 1982).

Foth et al. (2015) observed a decrease in OM digestibility with a DDGS inclusion of 28.8% in diets for Holstein and Jersey lactating cows. Zambom et al. (2005), evaluating nutrient digestibilities in the diets of 20 Saanen goats (59.59±6.97 kg), from 1 to 152 d of lactation, observed decrease in OM digestibility coefficients as NDF increased, reducing the digestive capacity. According to Mertens (1994) and Mertens (1997), the increase in dietary fiber may decrease the utilization efficiency of carbohydrates and other nutrients.

Regarding CP digestibility, the increasing levels of DDGS may linearly reduce the concentration of ammonia-N in the rumen, without affecting its digestibility (Leite, 2018).

According to Macedo Júnior et al. (2007), at the beginning of lactation, low fiber digestibility rate may be observed, which may reduce intake when rumen filling is the limiting factor. According to Valadares Filho et al. (2015), the NDF quantity in the soybean meal is 15.82%, while in the DDGS, according to Tjardes and Wright (2002), it may vary from 39 to 46%. However, in the present study, observed concentrations were 17.65 and 47.43% of soybean and DDGS, respectively. Therefore, with the substitution of SBM with DDGS, an increase in fiber concentration occurs, consequently reducing the digestibilities of other nutrients.

With the increase in the fiber from DDGS, an influence on TC digestibility occurred, without affecting NFC digestibility. Castillo-Lopez et al. (2014) observed that cows fed DDGS levels up to 30% of the diet showed linear decrease in NFC digestibility.

According to D'Angelino et al. (1990), serum urea levels in goats may vary from 31.30 to 39.0 mg/dL. Santos et al (2018) verified variation from 36.12 to 40.08 mg/dL of serum urea in lactating goats that received protein diets. Thus, it is possible that the inclusion of DDGS in Saanen goat diets, from parturition to 120 d of lactation, did not affect the renal function of the animals (Braun et al., 2010).

Therefore, ruminal ammonia production was normal, leading to normal levels of blood urea, through positive correlation between blood urea and rumen ammonia, as well as the use of gluconeogenic precursor amino acids (alanine, glutamine, and glycine) in the liver (Kozloski, 2011).

Araújo and Silva (2008) evaluated 30 goats and observed average glucose level of 48.3 mg/dL. According to Cannas and Pulina (2008), plasma glucose values of lactating goats may vary from 35 to

45 mg/dL. Santos et al. (2018), evaluating eight Anglo-Nubian goats that received a diet with 13.35% CP, observed plasma glucose values ranging from 48.21 to 52.34 mg/dL, and Menezes et al. (2019) evaluating 42 Saanen goats receiving diets with 29% of SBM observed average glucose of 47 mg/dL, which was similar to the values observed in the present study (Table 5).

However, glucose is important for respiratory oxidation, brain metabolic functions, and lactation, being an indicative of homeostasis failures (Wittwer, 2000; Araújo and Silva, 2008). Hence, the substitution of SBM with DDGS meets the plasma urea concentration without altering the levels of blood serum glucose in goats, in the four lactation phases, without effects on homeostasis.

Conclusions

The diet soybean meal plus dried distillers grains with solubles (12.28% of DM), as protein source on diets, may be used for feeding Saanen goats from parturition to 120 d of lactation, without affecting dry matter intake and digestibility, as well as digestibility of most nutrients and the concentrations of serum urea and glucose.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization: V.P. Pontes, C.R. Alcalde and G.T. Santos. Data curation: V.P. Pontes and C.R. Alcalde. Formal analysis: V.P. Pontes, C.R. Alcalde and G.T. Santos. Funding acquisition: V.P. Pontes, C.R. Alcalde and M.A. Zambom. Investigation: V.P. Pontes, C.R. Alcalde and G.T. Santos. Methodology: V.P. Pontes, C.R. Alcalde, F.M.S. Pili, J.B. Altero, V. Duarte, U.H.G. Teixeira and G.T. Santos. Project administration: V.P. Pontes and C.R. Alcalde. Resources: V.P. Pontes, C.R. Alcalde and G.T. Santos. Supervision: V.P. Pontes, C.R. Alcalde, M.A. Zambom and G.T. Santos. Validation: V.P. Pontes, C.R. Alcalde and M.A. Zambom. Visualization: V.P. Pontes, C.R. Alcalde, M.A. Zambom and G.T. Santos. Writing-original draft: V.P. Pontes and C.R. Alcalde. Writing-review & editing: V.P. Pontes, C.R. Alcalde, M.A. Zambom and G.T. Santos.

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