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.

Feeding 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 18 h. 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 144 h 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 72 h and processed in a Willey mill to pass through a 1-mm screen.

Table 1 - Chemical composition of the ingredients

| Nutrient (g/kg)                  | Feed                                      | 1-30 days         | 31-60 days         | 61-90 days         | 91-120 days        |
|----------------------------------|-------------------------------------------|-------------------|--------------------|--------------------|--------------------|
|                                  | Corn silage                               | Ground corn       | Soybean meal       | DDGS1              |                    |
| 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 carbohydrates1              | 856.20                                    | 860.20            | 378.30             | 567.90             |                    |
|                                  |                                          |                   |                    |                    |                    |
|                                  | Corn silage                               | Ground corn       | Soybean meal       | DDGS1              |                    |
| 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 carbohydrates1              | 874.90                                    | 860.80            | 370.00             | 565.80             |                    |
|                                  |                                          |                   |                    |                    |                    |
|                                  | Corn silage                               | Ground corn       | Soybean meal       | DDGS1              |                    |
| 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 carbohydrates1              | 855.30                                    | 857.30            | 375.70             | 569.30             |                    |
|                                  |                                          |                   |                    |                    |                    |
|                                  | Corn silage                               | Ground corn       | Soybean meal       | DDGS1              |                    |
| 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 carbohydrates1              | 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 | 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                 | 2.04      |      | 20.40   | 20.40 |
| 1-30 days                                 |           | 547.80 | 547.20 | 545.40 |
| Dry matter (DM; g/kg)                     |           | 961.00 | 963.40 | 965.10 |
| Organic matter (g/kg DM)                  |           | 39.00  | 36.60  | 34.90 |
| Ash (g/kg DM)                             |           | 143.50 | 140.10 | 140.80 |
| Crude protein (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                                |           | 544.50 | 542.50 | 540.80 |
| Dry matter (g/kg)                         |           | 967.00 | 968.00 | 969.40 |
| Organic matter (g/kg DM)                  |           | 34.00  | 32.00  | 30.60 |
| Ash (g/kg DM)                             |           | 144.70 | 140.60 | 140.70 |
| Crude protein (g/kg DM)                   |           | 22.60  | 24.00  | 25.00 |
| Neutral detergent fiber (g/kg DM)         |           | 381.10 | 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                                |           | 554.60 | 552.30 | 550.40 |
| Dry matter (g/kg)                         |           | 959.00 | 961.80 | 963.60 |
| Organic matter (g/kg DM)                  |           | 41.00  | 38.20  | 36.40 |
| Ash (g/kg DM)                             |           | 144.00 | 140.50 | 140.90 |
| Crude protein (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                               |           | 534.90 | 530.70 | 527.20 |
| Dry matter (g/kg)                         |           | 960.90 | 963.40 | 965.20 |
| Organic matter (g/kg DM)                  |           | 39.10  | 36.60  | 34.80 |
| Ash (g/kg DM)                             |           | 144.00 | 130.10 | 136.50 |
| Crude protein (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; vitamin 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:

\[ Y_{ij} = m + ti + \varepsilon_{ij}, \]

in which \( i \) = treatments, \( j \) = replicates, and \( \varepsilon \) = error associated to the \( Y_{ij} \) 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 | 1-30 days | 31-60 days | 61-90 days | 91-120 days |
|-----------------------------|-----------|-----------|------------|------------|-------------|
| Live weight (kg)            |           |           |            |            |             |
|                             | SBM       | SBM+DDGS  | DDGS       | SBM        | SBM+DDGS    | DDGS        | P-value |
| Live weight (kg)            | 51.2±1.97 | 48.6±1.89 | 48.8±2.03  | 52.0±1.93  | 50.2±1.93   | 50.7±1.98   | 0.82    |
| Intake (kg/d)               |           |           |            |            |             |             |         |
| Dry matter                  |           |           |            |            |             |             |         |
|                             | 1.67±0.45 | 1.52±0.18 | 1.66±0.25  | 1.75±0.34  | 1.61±0.27   | 1.52±0.31   | 0.69    |
| Organic matter              | 1.57±0.42 | 1.43±0.17 | 1.57±0.23  | 1.65±0.32  | 1.53±0.25   | 1.43±0.29   | 0.67    |
| Crude protein               | 0.22±0.56 | 0.21±0.02 | 0.23±0.03  | 0.23±0.04  | 0.22±0.03   | 0.22±0.05   | 0.76    |
| Ether extract               | 0.05±0.01 | 0.05±0.01 | 0.05±0.01  | 0.04±0.01  | 0.03±0.01   | 0.03±0.01   | 0.66    |
| Neutral detergent fiber     | 0.61±0.16ab| 0.59±0.05a| 0.78±0.11b | 0.66±0.32  | 0.56±0.16   | 0.50±0.18   | 0.66    |
| Total carbohydrates         | 1.27±0.35 | 1.15±0.13 | 1.28±0.20  | 1.34±0.27  | 1.25±0.20   | 1.78±0.24   | 0.62    |
| Non-fiber carbohydrates     | 0.66±0.32 | 0.56±0.16 | 0.50±0.18  | 0.68±0.22  | 0.54±0.17   | 1.06±0.19   | 0.48    |
| Total digestible nutrients  | 1.17±0.31 | 1.03±0.27 | 1.01±0.29  | 1.21±0.30  | 1.07±0.28   | 0.99±0.32   | 0.12    |

### 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.

Ramírez-Ramírez 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 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 % | SBM | SBM+DDGS | DDGS | P-value |
|-----------------------------|-----|----------|------|---------|
| 1-30 days                   |     |          |      |         |
| Dry matter                  | 68.88±1.89a | 66.36±3.19ab | 62.25±3.29b | 0.0070  |
| Organic matter              | 73.30±3.66a | 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±1.90c  | 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  | 65.58±3.54b | 0.003  |
| Crude protein               | 71.56±2.34a | 67.78±3.84ab | 66.03±2.94b | 0.0335  |
| Ether extract               | 80.59±2.28ab| 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).
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

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**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 | Treatment 2 | Treatment 3 | 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.
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.

**References**

Alves, J. O.; Zhuo, C.; Levedis, Y. A. and Tenório, J. A. S. 2012. Síntese de nanomateriais de carbono a partir do resíduo de milho (DDGS). Revista Química Nova 35:1534-1537. https://doi.org/10.1590/S0100-40422012000800008

Araújo, D. F. and Silva, I. P. 2008. Valores de amilase, glicose, colesterol e triglicerídeos em soro de cabras de Mossoró, RN. Acta Veterinaria Brasileira 2:97-100.

AOAC - Association of Official Agricultural Chemists. 1990. Official methods of analysis. 15th ed. AOAC International, Arlington, VA.

Ayadi, F. Y.; Rosentratr, K. A.; Muthukumarappan, K. and Brown, M. L. 2012. Twin-screw extrusion processing of distillers dried grains with solubles (DDGS) - based yellow perch (Perca flavescens) feeds. Food and Bioprocess Technology 5:1963-1978. https://doi.org/10.1007/s11947-011-0535-5

Benchaar, C.; Hassanat, F.; Gervais, R.; Chouinard, P. Y.; Petit, H. V. and Massé, D. I. 2013. Effects of increasing amounts of corn dried distillers grains with solubles in dairy cow diets on methane production, ruminal fermentation, digestion, N balance, and milk production. Journal of Dairy Science 96:2413-2427. https://doi.org/10.3168/jds.2012-6037

Berchielli, T. T.; Pires, A. V. and Oliveira, S. G. 2006. Nutrição de ruminantes. 2.ed. Funep, Jaboticabal.

Braun, J. P.; Trumel, C. and Bézillé, P. 2010. Clínica bioquímica em suínos: um levantamento. Small Ruminant Research 92:10-18. https://doi.org/10.1016/j.smallrumres.2010.04.002

Cabral, A. M. D.; Batista, A. M. V.; Carvalho, F. R.; Guimarães, G. A.; Amorim, G. L.; Silva, M. J. M. S.; França, A. A. and Belo Júnior, G. S. 2015. Cana-de-açúcar em substituição ao feno de capim-tifton 85 em rações para cabras Saanen. Arquivo Brasileiro de Medicina Veterinária e Zootecnia 67:198-204. https://doi.org/10.1590/1678-7355

Cannas, A. and Pulina, G. 2008. Dairy goats feeding and nutrition. CAB International, Wallingford, UK.
Castillo-Lopez, A.; Ramirez Ramirez, H. A.; Klopfenstein, T. J.; Hostetler, D.; Karges, K.; Fernando, S. C. and Kononoff, P. J. 2014. Ration formulations containing reduced-fat dried distillers grains with solubles and their effect on lactation performance, rumen fermentation, and intestinal flow of microbial nitrogen in Holstein cows. Journal of Dairy Science 97:1578-1593. https://doi.org/10.3168/jds.2013-6865

Cochran, R. C.; Adams, D. C.; Wallace, J. D. and Galvean, M. L. 1986. Predicting digestibility of different diets with internal marks: evaluation of four potential markers. Journal of Animal Science 63:1476-1483. https://doi.org/10.2527/jas1986.6351476x

D’Angeli, J. L.; Ishizuka, M. M.; Ribeiro, L.; Tucci, T. V. and Birgel, E. H. 1990. Valores padrões de constituintes bioquímicos do soro de caprinos sadios criados no estado de São Paulo. Estudo da influência do fator etário. Brazilian Journal of Veterinary Research and Animal Science 27:91-97. https://doi.org/10.11606/sbn0000-0000.27191-97

Ferreira, M. A. and Urbano, A. S. 2013. Novas tecnologias para alimentação de bovinos leiteiros na seca. Revista Cientista Produção Animal 15:42-52.

Foth, A. J.; Brown-Brandl, T.; Hanford, K. J.; Miller, P. S.; Gomez, G. G. and Kononoff, P. J. 2015. Energy content of reduced-fat dried distillers grains with solubles for lactating dairy cows. Journal of Dairy Science 98:7142-7152. https://doi.org/10.3168/jds.2014-9226

Gonçalves, A. L.; Lana, R. B.; Vieira, R. A. M.; Henrique, D. S.; Mancio, A. B. and Pereira, J. C. 2008. Avaliação de sistemas de produção de caprinos leiteiros na Região Sudeste do Brasil. Revista Brasileira de Zootecnia 37:366-376. https://doi.org/10.1590/S1516-35982008000200025

Khullar, E.; Sall, E. D.; Rausch, K. D.; Tumbleson, M. E. and Singh, V. 2009. Ethanol production from modified and conventional dry-grind processes using different corn types. Cereal Chemistry 86:616-622. https://doi.org/10.1094/CCHEM-06-6-0616

Kozloski, G. V. 2011. Bioquímica dos ruminantes. 3.ed. Editora UFSM, Santa Maria.

Leite, R. G. 2018. Uso de DDGS na suplementação protéica energética em bovinos em pastejo na estação chuvosa. Dissertação (M.Sc.). Universidade Estadual Paulista, Jaboatão.

Macedo Júnior, G. L.; Zanine, A. M.; Borges, L. and Pérez, J. R. O. 2007. Qualidade da fibra para a dieta de ruminantes. Ciência Animal 17:7-17.

Maciel, L. P. A. A. 2017. Diferentes fontes de nitrogênio na alimentação de cabras leiteiras. Tese (D.Sc.). Universidade Federal Rural de Pernambuco, Recife.

Menezes, E. B.; Salles, M. G. F.; Silva, C. M. G.; Fernandes, C. C. L.; Galeati, G.; Araújo, A. A. and Rondina, D. 2019. Milk production in Saanen goats treated with repeated low doses of intermediate-release insulin during early lactation. Ciência Rural 49:e20180340. https://doi.org/10.1590/S1516-359820180340

Mertens, D. R. 1994. Regulation of forage intake. p.450-493. In: Forage quality, evaluation and utilization. Fahey Jr., G. C., ed. American Society of Agronomy, Crop Science Society of America, and Soil Science Society in America, Madison, WI.

Mertens, D. R. 1997. Creating a system for meeting the fiber requirements of dairy cows. Journal of Dairy Science 80:1463-1481. https://doi.org/10.3168/jds.80022-0302(97)76705-2

Milanez, A. Y.; Nyko, D.; Valente, M. S.; Xavier, C. E. O.; Kuly, L. A.; Donle, C. G.; Matsuura, M. I. S. F.; Ramos, N. P.; Morandi, M. A. B.; Bonomi, A.; Capitani, D. H. D.; Chagas, M. F.; Cavalett, O. and Gouveia, V. L. R. 2014. A produção de etanol pela integração do milho-safrinha às usinas de cana-de-açúcar: avaliação ambiental, econômica e sugestões de política. Revista BNDES 41:147-208.

NRC - National Research Council. 2007. Nutrient requirements of goats. 7th ed. National Academy Press, Washington, D.C.

Novais, D. L.; Leite, L. C.; Eiras, C. E.; Leite, M. C. P. and Queiroz, M. A. A. 2015. Desempenho de cabras em lactação alimentadas com dietas de concentrado em base de soja e farelo de soja. Arquivo Brasileiro de Medicina Veterinária e Zootecnia 70:1867-1876. https://doi.org/10.1590/S1678-4162-10022

Schingoethe, D. J.; Kalscheur, K. F. and Garcia, A. D. 2006. Distillers grains for dairy cattle. Extension Extra Dairy Science 4022.
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