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# Desempenho e perfis metabólicos de cordeiros Ile de France confinados e alimentados com grãos de soja in natura

# Performance and metabolic profiles of confined Ile de France lambs fed soybean grains in natura

# Rendimiento productivo y perfiles metabólicos de corderos Ile de France confinados y alimentados con granos de soja in natura

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**Resumo**

A utilização do grão de soja in natura na dieta de ovinos pode ser uma alternativa na nutrição de animais confinados, como fonte de proteína e energia. Avaliar os níveis da inclusão de grão de soja inteiro in natura em dietas de cordeiros sobre o consumo, desempenho, biometria in vivo, perfil metabólico. Foram utilizados 18 cordeiros da raça Ile de France desmamados e confinados em delineamento inteiramente casualizado com seis repetições e três tratamentos: Controle, GS 6,25% e GS 14% de inclusão de grão de soja na dieta (com base na MS). O grupo Controle e GS 6,25% apresentaram maior ganho médio diário (0,296 kg/dia) e ganho de peso total (17,570 kg) em comparação ao GS 14%. Não foram observadas diferenças no consumo de matéria seca, proteína, FDN, FDA expressos em kg/dia e na conversão alimentar entre os tratamentos. A inclusão do grão de soja levou a aumento linear no consumo de extrato etéreo (EE), em kg/dia, em porcentagem do peso vivo. Não houve diferença entre os grupos quanto a concentração dos metabólitos estudados. Quanto a biometria in vivo o tratamento controle e GS 6,25% foram superiores para a conformação e condição corporal. A inclusão do grão de soja inteiro in natura em dietas para cordeiros em confinamento deve ser

feita com cautela, pois pode provocar redução no consumo de matéria seca e no ganho médio diário.

**Palavras-chave:** Alimentação; Análises bioquímicas; Confinamento de ovinos; Lipídios oleaginosa.

**Abstract**

Soybeans in natura can be used in the feed of confined animals as a source of protein and energy. We measured consumption, performance, in vivo biometry, and metabolic profiles lambs fed whole grain soybean in natura. We used Ile de France breed lambs, weaned and confined in a completely randomized design with six repetitions and three treatments: Control, soybean grain (SG) 6.25%, and SG 14% (based on dry matter) in feed. The control and SG 6.25% groups showed higher average daily gain (0.296 kg/day) and total weight gain (17.57 kg) than did the SG 14% group. There were no differences among groups in terms of consumption of dry matter, protein, neutral detergent fiber, acidic detergent fiber, or feed conversion. The inclusion of soybean grain was associated with linear increases in consumption of ethereal extract, and in percentage of live weight. There were no differences among groups in terms of concentrations of studied metabolites. Regarding in vivo biometrics, the control treatment and SG 6.25% groups were superior in terms of conformation and body conditions. Inclusion of soybean whole grain in natura in the feed of confined lambs may be reduced consumption of dry matter and average daily weight gain.

**Keywords:** Biochemical analysis; Feeding; Lipids oleaginous; Sheep confinement.

**Resumen**

La soja in natura se puede utilizar en la alimentación de animales confinados como fuente de proteínas y energía. Fueron mensurados el consumo, rendimiento productivo, biometría in vivo y perfiles metabólicos de corderos alimentados con soja integral in natura. Se utilizaron corderos de raza Ile de France, destetados y confinados en un diseño completamente al azar con seis repeticiones y tres tratamientos: Control, grano de soja (SG) 6.25% y SG 14% (basado en materia seca) en el pienso. Los grupos de control y SG 6.25% mostraron una ganancia diaria promedio (0,296 kg / día) y un aumento de peso total (17,57 kg) más altos que el grupo SG 14%. No hubo diferencias entre los grupos en términos de consumo de materia seca, proteína, fibra en detergente neutro, fibra en detergente ácido y conversión alimentaria. La inclusión de grano de soja se asoció con incrementos lineales en el consumo de extracto etéreo y en porcentaje del peso vivo. No hubo diferencias entre los grupos en términos de

concentraciones de metabolitos estudiados. Con respecto a la biometría in vivo, el tratamiento de control y los grupos de SG 6.25% fueron superiores en términos de conformación y condiciones corporales. La inclusión de granos integrales de soja in natura en la alimentación de corderos confinados puede reducir el consumo de materia seca y la ganancia de peso diaria promedio.

**Palabras clave:** Alimentación; Análisis bioquímico; Confinamiento de ovinos; Lípidos oleaginoso.

## 1. Introduction

Termination of confined sheep in the southeastern and southern regions of Brazil has accelerated with the aim of producing earlier animal carcasses and improved quality meat to the market (Rodrigues et al. 2008). This production system allows increasing the occupancy rate of farms, i.e., greater productivity (Frescura et al. 2005). To feed large and small ruminant animals, soybean grain can be used in natura or processed (deactivated) (Alves et al. 2014); this makes soybean use economically viable, especially when containment systems are adopted (Santos et al. 2014). The oil contained in soybean grain in natura provides more energy than carbohydrates, thereby increasing the use efficiency of the feed consumed, as long as the consumption of dry matter is not affected (Gibb et al. 2005). According to the content and source of fat used, animal performance may be compromised, because long-chain polyunsaturated fatty acids are potentially toxic to ruminal microorganisms, primarily to protozoa and cellulolytic bacteria (Palmquist and Jenkins, 1980); Gibb et al. (2005) reported reduction in microbial activity and consequent decrease in fiber digestion.

To monitor animal performance, it is possible to work with indicators of nutritional imbalances that are important factors for animal health and production (Alves et al., 2003). Of these, it is possible to evaluate metabolic profiles of the animals using biochemical analysis; the results provide information regarding the animal's blood and nutritional parameters. These data provide information regarding whether feed is being offered properly, both in terms of quality and quantity, thereby contributing to determination of the true nutritional requirements of the animals (González, 2000; Barros Brito et al. 2016). In this sense, the protein metabolic profile can be understood as the determination of serum concentrations of total protein, albumin, globulin, hemoglobin, and urea. As indicators of energy metabolism, it is possible to evaluate levels of glucose, ß-hydroxybutyrate, cholesterol, and free fatty acids (González, 1997). Therefore, the objective of the present study was to measure nutrient consumption and

performance of confined Ile de France lambs receiving soybean whole grains in natura in their feed. We also followed the profile of some blood metabolic components related to energy and protein metabolism.

## 2. Materials and Methods

### 2.1. Treatment and handling of animals

The experiment was carried out in the sheep farming section of the La Salle Agriculture School, Xanxerê-SC (latitude 26° 52' 37''S, 52° 24' 15'' W, altitude 800 m). We used 18 weaned Ile de France lambs, with an average age of 60 days, confined throughout the entire evaluation period. The trial was conducted from July to September 2017, when the average weight of each group reached the established slaughter weight at 40 kg of live weight for Ile de France animals, with 60% of the live weight corresponding to the maturity of the mothers.

Immediately after weaning, the animals were divided into three groups of six animals, six for each group, distributed so as to present similar weights. Animals were housed in bays with covered areas (six animals per bay), measuring 4.0 m x 2.5 m with trellis flooring, feeders and drinking fountains.

The animals were weighed at the beginning of the experiment and at intervals of seven days after 14-hour solids fasting. The first seven days were used for installation, management, and feed. At each weighing, the biometric measures and body condition were also evaluated, with sequential adjustment of the diet according to weight gain. The animals were confined with average live weight of 24.3 ± 1.9 kg and were randomly assigned to levels of inclusion of soybean grain (0%, 6.25%, and 14%). The forage used was corn silage, and the concentrate consisted of ground corn, soybean meal, soybean whole grain in natura, and mineral core (Table 1), formulated for daily gain of 250 to 300 g, following the nutritional requirements recommended by the NRC (2007).

**Table 1** – Nutritional composition of the ingredients used in the experimental diets, corn silage (CS), ground corn (GC), soybean meal (SM), soybean grain (SG), sheep core (SC), calcitic limestone (CL), ammonium chloride (AC), and sodium bicarbonate (SB)

| **Chemical composition (% DM)** | **Ingredient** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **CS** | **GC** | **SM** | **SG** | **SC** | **CL** | **AC** | **SB** |
| Dry matter | 29.6 | 89.24 | 90.33 | 91.8 | 100 | 100 | 100 | 100 |
| Mineral Matter | 4.74 | 1.54 | 6.85 | 5.21 | - | - | - | - |
| Crude protein | 8.05 | 8.03 | 43.69 | 39.81 | - | - | - | - |
| Ethereal extract | 3.99 | 3.55 | 1.80 | 22.9 | - | - | - | - |
| NDF | 45.14 | 16.33 | 15.17 | 23.97 | - | - | - | - |
| ADF | 25.80 | 3.57 | 9.69 | 21.3 | - | - | - | - |

NDF = neutral detergent fiber; ADF = acid detergent fiber. Source: Research data (2020).

The feeds were formulated to be isoproteic, comprised of 50% of forage (corn silage) and 50% of concentrate in dry matter (DM), differing with respect to level of inclusion of soybean grains (SG), as follows: 0%, 6.25%, and 14% of feed DM (Table 2); we named the experimental treatments Control, SG 6.25, and SG 14, respectively.

**Table 2** – Proportion of ingredients and chemical composition of the experimental diets (% DM)

| **Ingredients** | **Treatments** | | |
|---|---|---|---|
| | **Control** | **SG 6.25%** | **SG 14%** |
| Corn silage | 50 | 50 | 50 |
| Ground corn | 36 | 35 | 33.5 |
| Soybean meal | 11.5 | 6.25 | - |
| Soybean whole grain | - | 6.25 | 14 |
| Sheep core | 1.5 | 1.5 | 1.5 |
| Calcitic limestone | 0.5 | 0.5 | 0.5 |
| Ammonium chloride | 0.25 | 0.25 | 0.25 |
| Sodium bicarbonate | 0.25 | 0.25 | 0.25 |
| **Nutritional composition (% DM)** | **Control** | **SG 6.25%** | **SG 14%** |
| DM | 57.31 | 57.42 | 57.56 |
| MM | 3.71 | 3.66 | 3.62 |
| CP | 11.94 | 12.05 | 12.29 |
| EE | 3.48 | 4.78 | 6.39 |
| NDF | 30.19 | 30.73 | 31.40 |
| ADF | 15.30 | 16.09 | 17.08 |

DM – dry matter; MM – mineral matter; CP – crude protein; EE – ethereal extract; NDF – neutral detergent fiber; ADF – acid detergent fiber. Source: Research data (2020).

Meals were offered at 8 a.m. and 4 p.m. ad libitum, predicting 10% of leftovers. The average consumption of DM was calculated as the difference between the amount of DM of the offered food and the amount of DM of the declined food. Before the first feeding in the morning, the stable was cleaned and the leftovers were weighed, to adjust the feed aiming at a maximum of 10% of leftovers. Samples of the offered feed and leftovers were collected every 7 days to quantify dry matter (DM), mineral matter (MM), ethereal extract (EE), crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF), as described by AOAC (1995).

### 2.2. Consumption, morphology, and performance measures

The variables evaluated in the lambs were live weight at the beginning of the experiment, live weight during the time periods (seven days), average daily gain (ADG), dry matter consumption (DMC), feed conversion (FC), crude protein (CP) consumption, protein efficiency (PE), NDF and ADF consumption, and ethereal extract (EE) consumption. We also evaluated in vivo morphology at the beginning of the experiment and every 7 days, in terms of the following characteristics (Osório; Osório, 2005): subjective conformation and body condition (1.0 = very poor to 5.0 = excellent); body length (BL), distance of the crosses to the insertion of the glue; anterior height, posterior height, thoracic perimeter (using a measuring tape, passing it behind the crosses and shoulders); and estimation of body compactness (LW/BL).

### 2.3. Metabolic profile analysis

Blood samples were taken from all animals of each group to evaluate the biochemical profiles (energy and protein). The blood samples were collected at the middle and end of the experiment period by puncture of the jugular vein; blood was stored in vials without anticoagulant. Immediately after collection, the samples were centrifuged at 1800 x g for 15 minutes, placed in Eppendorff type tubes and frozen at –20 °C. Biochemical analysis of protein profiles included the determination of total protein, albumin, globulin, and urea. To analyze the energy profile we measured glucose and triglyceride levels. We used spectrophotometric techniques with specific reagent kits (LABTEST®, Brazil) on a visible-light spectrophotometer (FEMTO 700 Plus®).

### 2.4. Statistical analysis

We employed a completely randomized design, with six repetitions per treatment. For the performance characteristics, analysis of variance was carried out according to GLM procedures of the statistical program SAS (1997), considering a significance level of 5%. Metabolic profile variables were analyzed using Proc mixed (SAS). For repeated measures, an auto-regressive first-order covariance structure was used, as well as time as repeated measurements. All comparisons of averages were analyzed using the Tukey test with a significance level of 5%. The results of in vivo measurements were evaluated using analysis

of variance and the averages were compared using the Tukey test at 5% probability.

## 3. Results

There were differences between groups with respect to average daily weight gain (ADWG) with SG 14% presenting significantly lower daily weight gain and total weight gain (Table 3). No significant differences were observed with respect to initial live weight and final live weight (Table 3).

**Table 3** – Productive performance of confined Ile de France lambs fed with diets containing soybean whole grain *in natura*, concerning initial live weight (ILW), final live weight (FLW), total weight gain (TWG), average daily weight gain (ADWG), and total days in confinement (TDC)

| | Diet | | | | |
|---|---|---|---|---|---|
| **Variable** | **Control** | **SG 6.25%** | **SG 14%** | **CV%** | **P-Value** |
| ILW (kg) | 26.667 | 26.128 | 25.820 | 14.10 | 0.9408 |
| FLW (kg) | 44.620 | 43.317 | 39.683 | 11.54 | 0.4407 |
| TWG (kg) | 17.953 [a] | 17.188 [a] | 13.863[b] | 16,33 | 0,0449 |
| ADWG (kg/day) | 0.285[a] | 0.307 [a] | 0.198[b] | 23.62 | 0.0017 |
| TDC | 63.0 | 56.0 | 70.0 | - | - |

Different letters in the same line differ significantly from each other by Tukey test, at a probability of 5%. Source: Research data (2020).

There were no differences among treatments with respect to DMC expressed as kg/day, with an average value of 1.154 kg/day and DMS g/kg L 0.75, with average values of 81.21 g. As for the DMC when expressed in %LW, treatment SG 14% presented the smallest DMC related to %LW ($P<0.05$), with an average value of 3.15% LW and consumed 0.18% LW less of dry matter concerning the control and SG 14% treatments (Table 4). There were no differences among treatments with respect to consumption of CP expressed as kg/day or %LW. Similarly, FC did not significantly differ among treatments. Treatment SG 14% showed the lowest PE among all treatments. Feeds containing soybean grain gave significantly larger intake of ethereal extract (EE), expressed as kg/day and %LW. This may be explained by the elevated levels of this nutrient in feed with greater inclusion of soybean

grain. There were no differences among treatments for NDF consumption, either in terms of kg/day or %LW (Table 4). ADF consumption did not differ among groups in terms of kg/day; however, the SG 6.25% group showed significantly greater ADF consumption in terms of %LW.

**Table 4** – Consumption of nutrients of confined Ile de France lambs fed with diets containing soybean whole grain *in natura*

| | Diet | | | | |
|---|---|---|---|---|---|
| **Variable** | **Control** | **SG 6.25%** | **SG 14%** | **CV%** | **P-Value** |
| Dry matter consumption (kg/day) | 1.198 | 1.221 | 1.043 | 15.49 | 0.0835 |
| Dry matter consumption (% LW) | 3.30[a] | 3.37[a] | 3.15[b] | 3.44 | 0.0012 |
| DMC g/kg LW $^{0.75}$ | 82.11 | 85.33 | 76.19 | 15.49 | 0.3046 |
| Crude protein consumption (kg/day) | 0.150 | 0.154 | 0.139 | 15.20 | 0.3395 |
| Protein efficiency (kg of weight gained/kg of CP) | 1.96[ab] | 2.06[a] | 1.42[b] | 26.14 | 0.0161 |
| Consumption of ethereal extract (kg/day) | 0.043[c] | 0.060[b] | 0.071[a] | 15.16 | < .0001 |
| Food conversion (kg of DM/kg of weight gained) | 4.31 | 4.30 | 5.64 | 35.01 | 0.1602 |
| Consumption of NDF (kg/day) | 0.357 | 0.368 | 0.324 | 15.47 | 0.2061 |
| Consumption of ADF (kg/day) | 0.172 | 0.183 | 0.154 | 16.08 | 0.0959 |
| Consumption of CP% LW | 0.41 | 0.43 | 0.42 | 2.47 | 0.1302 |
| Consumption of EE% LW | 0.12[c] | 0.17[b] | 0.22[a] | 2.84 | < .0001 |
| Consumption of NDF% LW | 0.98 | 1.02 | 0.98 | 3.72 | 0.1210 |
| Consumption of ADF% LW | 0.47[b] | 0.51[a] | 0.47[b] | 5.07 | 0.0067 |

Different letters in the same line differ significantly from each other by Tukey test, at a probability of 5%. CV% = coefficient of variation. Source: Research data (2020).

The concentrations of total protein, albumin, globulin, and urea did not differ significantly among treatments (Table 5). Regarding energy profiles, serum concentrations of glucose and triglycerides were not influenced by the treatments (Table 5).

**Table 5** – Levels of total protein (TP), albumin, globulin, and urea (protein profile) as well as glucose and triglycerides levels of confined lambs using different levels of inclusion of soybean whole grain *in natura* in the diet

| Variable | Diet | | | Probability |
|---|---|---|---|---|
| | Control | SG 6.25% | SG 14% | |
| TP g/dL | 7.14 | 6.40 | 6.17 | 0.2710 |
| Albumin g/dL | 3.62 | 2.98 | 3.53 | 0.0641 |
| Globulin g/dL | 3.52 | 3.42 | 2.63 | 0.2042 |
| Urea mg/dL | 56.68 | 53.07 | 46.08 | 0.3499 |
| Glucose mg/dL | 131.82 | 144.23 | 148.58 | 0.3502 |
| Triglycerides mg/dL | 33.29 | 39.35 | 35.42 | 0.5408 |

Different letters in the same line differ (P <0.05) among themselves by Tukey test. Source: Research data (2020).

There were no significant differences among treatments with respect to anterior height, posterior height, thoracic perimeter, or body compactness (Table 6). body length in the Control treatment was significantly greater than in the SG 14% group; however, there was no significant difference for treatment SG 6.25%. With respect to conformation and body condition, the SG 14% group presented significantly worse data than did treatment SG 6.25%; however, the control group showed no significant differences from the others regarding these parameters.

## 4. Discussion

We observed a reduction in the average daily weight gain of lambs who consumed greater concentrations of soybean grains in their feed. This phenomenon might be explained by the greater amount of soybean grain that raised the amount of ethereal extract in the diet. Furthermore, high levels of non-esterified unsaturated fatty acids may have interfered in the digestive process by coating the ruminal contents, preventing the adhesion of bacteria and fibrolytic enzyme activity, thereby promoting a toxic effect on the bacteria, damaging performance (Kozloski, 2002; Teixeira and Borges, 2005).

**Table 6** – Average of *in vivo* biometric measures of Ile de France lambs fed with soybean whole grain *in natura*

| Characteristics | Diets | | | CV (%) | P-Value |
|---|---|---|---|---|---|
| | Control | SG 6.25% | SG 14% | | |
| Body length (cm) | 60.6[a] | 58.83[ab] | 55[b] | 4.69 | 0.0119 |
| Anterior height (cm) | 63.8 | 62.66 | 62.83 | 3.62 | 0.6899 |
| Posterior height (cm) | 52 | 51 | 52 | 5.47 | 0.7878 |
| Conformation (1–5) | 3.7[ab] | 4.16[a] | 3.41[b] | 10.86 | 0.0213 |
| Body condition (1–5) | 3.6[ab] | 4.0[a] | 3.08[b] | 11.65 | 0.0065 |
| Thoracic perimeter (cm) | 89.6 | 90.33 | 86.66 | 5.86 | 0.4597 |
| Body compactness (kg/cm) | 0.69 | 0.73 | 0.66 | 10.54 | 0.2634 |

Different letters in the same line differ significantly from each other by Tukey test, at a probability of 5%. CV% = coefficient of variation. Source: Research data (2020).

Regarding initial and final live weight, we expected them to be similar, because the animals were distributed evenly in the treatments and were derived from the same genotype group. The overall average of ADWG (0.263 kg/animal/day) was within the specifications set by the NRC (2007) for lambs with moderate-to-fast growth, with the potential for weight gain in the range of 200 to 300 g/day. Therefore, we infer that the results for ADWG obtained in this experiment were satisfactory. Similar results were observed by Urano et al. (2006), in the confinement of lambs with the inclusion of increasing levels of soybean grains in the feed DM, obtaining an ADWG of 0.277 kg. Similar results to ours were reported by Moreno et al. (2010), who, observing the confinement of Ile de France lambs weaned at 60 days, reported an ADWG of 0.312 kg after 56 days of confinement.

The number of days in confinement for the lambs to reach 60% of the adult weight increased by 14 days with the level of 14% of soybean grains in the diet. This is not desirable, because fewer days in confinement corresponds to greater numbers of animals slaughtered per year and the lower the cost of production, thereby increasing profitability and decreasing the costs of food and facilities. Total weight gain was similar between the control and SG 6.25% groups (17.953 kg and 17.188 kg, respectively); however, the SG 14% group showed lower average daily weight gain during this period.

The average values of DMC were within the range recommended by the NRC (2007) for sheep in this category, with moderate-to-fast growth levels (1.0 to 1.3 kg DM/animal/day).

The average dry matter consumption when expressed as a percentage of live weight was lower in the SG 14% group (Table 3). Similar results were observed by Urano et al. (2006) in sheep fed with increasing levels of soybean grains in the feed DM. Farias et al. (2015) found differences in dry matter consumption with an increase of protected fat in the feed of confined sheep. According to these authors, the nutrient intake was almost constant in the control treatment; however, for the diet including 4.2% of protected fat and with the addition of 5.8% of fat, a decrease in consumption was observed. Fernandes et al. (2011) reported that the confinement of Santa Inês lambs fed with inclusion of 7.6% and 4.8% of protected fat had no influence on DMC.

The average FC was 4.75, greater than the value reported by Urano et al. (2006), who included soybean grains in the feed DM for confined Santa Inês lambs; they observed an average FC of 3.6 and ADWG of 0.277 kg per animal per day. Ribeiro et al. (2011) found an average value of food conversion of 4.26 for confined Santa Inês lambs, lower than the values obtained in the present study. Moreno et al. (2010), observing the confinement of Ile de France lambs, reported an average value of FC of 3.13, below what we found in the present study; however, they reported an ADWG of 0.283 kg, similar to our finding.

Feed containing soybean grain presented significantly greater intake of ethereal extract, due to the more highly elevated values of this fraction in the diets and considering that the treatment with greater inclusion of soybeans led to smaller DMC when expressed as live weight percentage. By contrast, for the feeds with increased amount of lipids, the values of ingested EE increased with an average of 0.056 and 0.061 kg/day of EE, a result similar to this study, in which we found EE values of 0.060 and 0.071 kg/day. Carvalho et al. (2015) studed confinement of Texel and Ideal lambs with diets using four levels of replacement of sorghum silage by soybean husk; the authors observed a linear increase in the consumption of ethereal extract with increased soybean husk inclusion.

The average values of NDF consumption are among the parameters mentioned by Van Soest (1994). Pereira et al. (2008) studied the confinement of lambs and reported an average value DFC intake of 0.414 kg/day and 1.83% LW with diets containing citrus pulp, corn silage, and soybean meal. By contrast, Grandis et al. (2015) studied the confinement of lambs with various inclusion levels of soy cake in feed and recorded average values of NDF intake of 0.467 kg/day and 1.50% LW, values superior to the ones observed in the present study.

ADF, in terms of kg/day, presented average values of 0.169 kg/day, similar to value the value reported by Grandis et al. (2015) (0.186 kg/day). However, when expressed as % LW, the SG 6.25% group presented higher ADF consumption. This might be explained by the selectivity of food by the animals, resulting in irregular leftovers among treatments. Grandis et al. (2015) reported average values of ADF consumption of 0.59% LW in Santa Inês lambs fed with various levels of soy cake replacing soybean meal.

The average value of total protein was 6.57 g/dL (Table 5), within the normal range according to the literature (Kaneko et al. 2008); this may be related to the feed offered. Total proteins are synthesized mainly by the liver, and these are the metabolites that define the protein nutritional status of the animal; in addition, the synthesis rates may define the functionality of the liver, protein levels, and vitamin A levels (González, 2000).

The groups showed average serum albumin levels of of 3.37 g/dL. These values are within the range of normal according to Kaneko et al. (2008). Ziguer et al. (2012), evaluating the metabolic profile of confined lambs using soybean husk associated with various sources of non-protein nitrogen, also did not find any difference for concentrations of albumin. The average serum concentration globulin was 3.19 g/dL. Borburema et al. (2012), assessing Santa Inês lambs fed with Tifton hay and concentrated based on corn and soybean meal, reported globulin levels no differences between treatments.

Plasma urea presented average values of 51.94 mg/dL (Table 5). The concentration of urea in the blood is influenced by how the absorbed amino acids are oxidized and by the absorption of ammonia from the rumen, reflecting the extent of the diet's nitrogen balance (Orskov, 1992). González and Silva (2006) point out that serum levels of urea are directly associated with the amount of protein and energy contained in the feed. This information explains the average concentration of serum levels of urea of the animals from this experiment, because there was greater lipid intake in the diet, shown mainly in treatment SG 14%, which had the highest amount of soybean grain in natura. Nevertheless, all diets presented average levels of urea within the standards considered physiological (23 to 58 mg/dL), according to González et al. (2000). Balaro et al. (2012) assessed the biochemical parameters of Santa Inês lambs in two treatments with diets based on soy meal and corn, adding 5% of protected fat; the authors reported average values of urea for the control group of 53 mg/dL and the group with addition of fat had an average value of urea of 38.50 mg/dL, values similar from those found in this study and within the normal parameters listed in the

literature. Homem Junior et al. (2010) studied supplementation with sunflower grain or protected fat in the confinement of lambs had a compensatory effect on production. Blood urea levels positively correlate with the concentration of ruminal ammonia. These results suggest that lipid in feed reduces rumen ammonia levels, manifesting as reduced blood urea levels.

Our average plasma glucose level among treatments was 141.54 mg/dL, with no significant difference among treatments. These values were above the range of normal, reported to be 50 to 80 mg/dL (Kaneko et al. 2008). Glucose, despite helping define the energy profile of the animal, is a metabolite that undergoes few variations, as it is controlled by efficient homeostatic mechanisms; its content is little influenced by the diet offered to the animal (Kaneko et al. 2008). It is possible that the glucose levels of the animals in our experiment were elevated because of the stress related to blood collection (Kozloski, 2011).

Serum concentrations of triglycerides showed average values of 36 mg/dL. These values are within the average of the standards for sheep (9–50 mg/dL) described by Lopes and Santos (2007). Triglycerides are ways of storing fat in the animal, and the levels can be increased in cases of energy excess in the diet; however, the concentrations of soybean grains used do not influence their concentration in animals.

Concerning in vivo biometry, mean body length in the control treatment was greater than of the SG 14% treatment by 5.6 cm; however, there was no significant difference the SG 6.25% treatment (Table 6). Moreno et al. (2010) recorded mean body length of 61.17 cm, a better result than the obtained in the present study (58.14 cm). The average value for body compactness in the present study was 0.69 kg/cm. Body compactness can be used as a reference because it is an index that objectively estimates the conformation of live animals, with respect to accumulation of muscles in the carcass from two determined values, live weight and body length (Pinheiro et al. 2007; Koritiaki et al. 2012).

Regarding conformation and body condition, SG 14% presented values of 3.41 and 3.08, respectively, lower than the value of the SG 6.25% group, which presented conformation and body condition of 4.16 and 4.0, respectively. However, the control group did not differ from the other groups with respect to conformation and body condition, with measurements of 3.7 and 3.6, respectively. Moreno et al. (2010), assessing in vivo biometric

measures, obtained average values of body condition of 3.9, suggesting the effectiveness of the confinement system and its impact on animal performance.

Body condition score, according to Osório and Osório (2005), is a measure used to estimate the animal's state of completion; it can also be used to estimate the muscle: fat ratio. The animals showed overall average values among the various diets of 3.56, within the categories of slightly fat to fat. This is an important result to be highlighted, because it demonstrates that levels of soybean grain inclusion were efficient regarding the degree of completion only for the SG 6.25% group. Nevertheless, the average value of 3.56 observed this study conforms to the value desired by cold stores directed to the slaughter of lambs (Osório et al. 2012). Biometric measures are more influenced by genetics and body weight than by nutrition and are little influenced by environmental conditions (Koritiaki et al. 2012). Taken together, our data suggest that inclusion of soybean whole grain in natura in diets for confined lambs should be done with caution, because it may cause reduction in the consumption of dry matter and average daily weight gain.

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