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Performance Evaluation of Lambs Fed Tifton 85 Grass Hay and Concentrate Through LIPE® Marker

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Abstract

The research was carried out with the aim of evaluate increasing levels of concentrate supplementation on intake and performance of lambs fed Tifton 85 grass hay adopting LIPE® marker technique. Twenty-four weaned and castrated Santa Inês crossbreed lambs with initial body weight (BW) of 20.99 ± 3.62 kg were distributed in four treatments with Tifton 85 hay exclusive or associated with concentrate levels (0.0, 6.6, 13.3 and 20.0 g kg-1 BW d-1), in a completely randomized design with six animals per treatment. The experimental period lasted 98 days, with the first 14 days for animal adaptation to the new environmental conditions, handling and feeding. The diets were fed ad libitum twice a day. Lambs were weighted at each 14 days. Dry matter intake (DMI) was estimated by the technique of Isolated, Purified and Enriched Lignin (LIPE®) while neutral detergent fiber intake (NDFI) and crude protein intake (CPI) were obtained from the content of their fractions present in the diets. There was an increase in DMI and CPI and a similar response in NDFI with the increasing levels of concentrate. The daily liveweight gain per animal showed a linear response when the levels of concentrate were increased and the highest values were observed when 20.0 g kg-1 BW d-1 of concentrate was fed. The increasing levels of concentrate supplementation allowed greater daily and total body weight gains per lamb and there is a consistent relationship between nutrient intakes and performance in the treatments and the LIPE® marker proved to be an efficient technique to evaluate the DMI by lambs.

Keywords: external digestibility indicator, lamb supplementation, sheep

1. Introduction

1.1 Sheep Meat Production and Consumption in Brazil

The Brazilian production of ovine meat in 2022 was estimated at 141,000 tons, representing 0.45% of the total main meat production of the country which also includes bovine, pig and poultry meat and was estimated at 31.21 million tons, being necessary the import of 4,000 tons to attend the internal market (FAO, 2023).

Despite the cultural influence in the eating habits of the Brazilian population, the growing demand for high-quality meat in the domestic market have been highlighted in the last decades (FIRETTI et al., 2017; REGO et al., 2019), mainly for lamb meat what has increased the search for feed management practices that allow higher productive performances with economic efficiency to sheep farmers and also satisfying the demand of the consumer market.

The annual per capita consumption of sheep meat in Brazil was estimated in approximately 0.5 kg, considered low when compared to consumption of chicken, beef and pork meats of 53.7; 37.0 and 18.3 kg, respectively (FAMASUL, 2023; FAO, 2023). Factors such as eating habits and purchasing power exert a great influence on the sheep meat consumption. In addition, this low consumption in Brazil is also related in the last decades to the quality of the product offered for sale, since poor quality carcasses are commonly on the market, resulting in food taboos among consumers (ALMEIDA JÚNIOR et al., 2004).

In this regard, one of the alternatives is the intensification of the productive process in sustainable, competitive and economically viable systems. Lamb feedlots are one of the best alternatives, mainly in regions where the land prices are higher, since it allows the production of quality meat throughout the year, reduces the age of slaughter by supplying to the market superior carcasses and meat, besides reducing the mortality of the animals due to the lower incidence of worms and greater nutritional control (REGO et al., 2019; SOUSA et al., 2024).

1.2 Research Justification and Objectives

A large number of researches conducted in Brazil showed the increase in concentrate supplementation in sheep herds can be justified under various productive and economic aspects. According to the results reported by Vega-Britez et al. (2024), Suffolk lambs fed tropical grasses pastures supplemented with increasing levels of concentrate, showed better feed efficiency and lower slaughter age. The animals raised on pastures without supplementation showed the worst economic performance. Corrêa et al. (2022) also found better results in carcass traits, commercial cuts and physicochemical parameters of the meat in Santa Inês lambs fed higher levels of concentrate in diets with Tifton 85 grass hay.

Grasses of the genus *Cynodon* have been promising, standing out the Tifton 85 grass, for its characteristics of low cost per kilogram of dry matter harvested, high productivity, high digestibility and good acceptance by the animals. However, few studies have been conducted with sheep and lambs fed hay from this grass evaluating the nutritional value of the feed consumed by the animals, which has been a challenge for technicians and nutritionists (BERNARDI et al., 2020; MACHADO et al., 2022).

One of the alternatives to evaluate the nutritional value of the feed is the use of indicators, which are substances used to estimate fecal production of animals and, consequently, dry matter intake (DMI) such as Isolated, Purified and Enriched Lignin (LIPE®), which is an external indicator of digestibility that presents the shortest period of administration and collection of feces (LANZETTA et al., 2009). LIPE® as an external marker is important in sheep nutritional studies and has been utilized as a potential marker to estimate fecal output in lambs fed with tropical grasses (AMARAL et al., 2022).

Therefore, this work was carried out with the aim of evaluate increasing levels of concentrate supplementation on intake and performance of lambs fed Tifton 85 grass hay adopting LIPE® marker technique.

2. Method

2.1 Ethical Animal Experimentation and Location

The research was approved by the local Committee on Animal Research and Ethics (CEUA - UFES) under protocol no. 078/2012, being in accordance with the ethical principles of animal experimentation. The experiment was conducted in the Experimental Farm of the IFES - Federal Institute of Education, Science and Technology of Espírito Santo, district of Rive, municipality of Alegre, Espírito Santo State (20º45'30" South latitude, 41º27'23" West longitude and 138 m altitude).

2.2 Treatments and Feeding Management

Twenty-four weaned Santa Inês crossbreed lambs were castrated with body weight (BW) of 20.99 kg ± 3.62 kg, distributed (six animals per treatment) in a completely randomized design with four experimental treatments: T1 - 0.0; T2 - 6.6; T3 - 13.3; and T4 - 20.0 g of concentrate per kg BW per day. The experimental period lasted for 98 days with the first 14 days destined to the adaptation of the animals to the new environment, handling and feeding conditions. Throughout the experimental period the environment was maintained with artificial lighting at night.

The lambs were divided into four groups blocked by age and initial weight and housed in collective pens with 12.0 m^2 each, in covered sheepfold, with an area of 2.0 m^2 $animal^{-1}$ and a clay floor with a 10 cm layer of wood shavings, provided of feeder, waterer and mineral salts trough.

The T1 treatment provided sufficient nutrients to meet maintenance requirements and in the T2, T3 and T4 treatments diets were balanced, according to NRC (2007) to achieve moderate growth gain. Concentrate was balanced for 20.0% crude protein (CP) and 73.8% total digestive nutrients (TDN) with soybean meal, wheat meal, ground corn, limestone and mineral premix.

Tifton 85 grass hay was offered *ad libitum* in two daily meals at 7h00 am and 3h00 pm, adjusted to keep leftovers around 10% of the supply, in order to guarantee maximum voluntary intake and to allow the selection of feed by the animals. The concentrate was offered only in the morning feeding at 7h00 am over the hay. The animals had unrestricted access to water and mineral supplement and every day, all feeders and waterers were cleaned. To correct the amounts of concentrate supplied, the animals were weighed at every 14-day intervals after solids fasting of 16 hours. The chemical composition and *in vitro* digestibility of the feeds can be seen in Table 1.

Table 1. Chemical composition and *in vitro* dry matter digestibility of Tifton 85 hay and concentrate (g kg^{-1})

Chemical composition	Tifton 85 hay	Concentrate
Dry matter	918.7	876.1
Crude protein	152.3	200.2
Neutral Detergent Fiber	649.7	137.5
Acid Detergent Fiber	337.4	53.3
IVDMD	621.6	900.0

IVDMD - In vitro dry matter digestibility.

2.3 Feed and Feces Analysis

The feeds were sampled for eight consecutive days per experimental pen in two periods (34th to 41st and 76th to the 83rd day of the experiment), concomitant to the DMI evaluations. The feed samples were conserved at -15ºC to form a composed sample by treatment and by period.

All feed samples were thawed at room temperature, dried in a forced ventilation oven at 55ºC for 72 hours, processed in a Willey-type mill with a 1 mm mesh sieve, packed in hermetically sealed jars, previously identified, and shipped for the Embrapa Dairy Cattle Laboratory (Juiz de Fora - MG) for analysis of DM, CP and neutral detergent fiber (NDF) according to methodology proposed by Silva & Queiroz (2002) and the *in vitro* dry matter digestibility (IVDMD), according to Tilley & Terry (1963).

LIPE® capsules (at doses of 250 mg $animal^{-1}$ day^{-1}) were solubilized in 5 mL of water and the liquid was administered orally with the aid of a cannula coupled to an automatic vaccination gun. After each application, the same volume of water was supplied to the animals to clean the cylinder, according to methodology adapted from Godoi et al. (2009).

The administration of the indicator was performed in two distinct periods (35th to 41st and 77th to 83rd day of the experiment at 12h00), with duration of seven days each, being the first two days destined to stabilize the marker excretion flows in the feces (LIMA et al., 2008). From the third day of administration of LIPE®, feces samples were collected manually and directly from the rectal ampoule of the animals, at the same time (1h00 pm).

Individual stool samples were identified and frozen at -15°C during the collection period. Then, they were thawed at room temperature, homogenized and sent to the Bromatology Laboratory of the Agricultural Sciences Center of UFES - Federal University of Espírito Santo, and then pre-dried at 55°C for 72 hours, ground in a Willey-type mill with 1.0 mm mesh sieve, and again returned to the oven to obtain the dry matter at 105°C.

The fecal samples were stored in hermetically sealed bottles, labeled and sent to the Department of Chemistry of the Institute of Exact Sciences of the Federal University of Minas Gerais (UFMG) for estimation of fecal output (FO) by means of an infrared spectrometer as follows:

$$FO = \frac{\text{Quantity of LIPE}^{®}\text{ fed}}{\text{Concentration of LIPE}^{®}\text{ in feces}} \times 100. \quad (1)$$

LIPE® was determined in the Animal Nutrition Laboratory of UFMG, in a spectrophotometer with infrared spectrum detector (FTIV), model Varian 099-2243. The samples of dried and ground feces at 2.0 mm were pasted with potassium bromide (KBr) and the concentration of LIPE®, according to the methodologies described by Saliba et al. (2015). The FE with the indicator were obtained by the logarithmic ratio of the spectral bands between wavelengths λ1 (1050 ηm) and λ2 (1650 ηm), from equations described by Lanzetta et al. (2009).

The DMI was estimated by the relationship between FO and dry matter indigestibility (DMID), according to the following equation:

$$DMI\ (g\ day^{-1}) = FO\ (g\ day^{-1})\ DMID^{-1}\text{, where:} \quad (2)$$

$$DMID = 1 – IVDMD.$$

The daily DMI expressed in grams per kilogram of body weight were obtained by the equation:

$$DMI\ (g\ kg\ BW^{-1}\ day^{-1}) = DMI\ BW^{-1} \quad (3)$$

Intakes of neutral detergent fiber (NDFI) and crude protein (CPI) in DM were obtained from the contents of these fractions present in the diets.

2.4 Sanitary Protocol

During the first 14 days of adaptation period the animals were vaccinated against clostridiosis (Covexin 10®), orally wormed (Valbazen® 10 Cobalt) after egg counting per gram of feces (ECG). In addition, treatment to control coccidiosis was required by oral and single-dose application of coccidicide (Baycox® Ruminants).

2.5 Statistics and Data Analysis

The results were submitted to the analysis to verify the normality of the residuals distribution (Shapiro Wilk, $P<0.10$). Subsequently, the original data (when necessary) were submitted to analysis of variance, using PROC GLM (SAS v.9.0), and the means were studied by regression, according t test. Significance was declared when $P<0.05$.

The statistical model adopted was as follows:

$Yij = \mu + Tj + eij$; where:

Yij = dependent variable of i replicate and j level of supplementation;

μ = average overall effect;

Tj = effect of j level of supplementation;

eij = the error associated with each observation, supposed NID ~ N (0, σ^2);

i = 1, 2, 3, 4, 5, 6;

j = 0.0; 6.6; 13.3 and 20.0 g kg BW^{-1} day^{-1} in concentrate supplementation.

3. Results

3.1 Intakes

The results showed a linear effect ($P<0.05$) in daily DMI expressed in g day^{-1} and g kg BW^{-1} day^{-1}, with a consistent increase as a function of the increase in the concentrate inclusion in the daily diet. The mean values obtained were 897.43 g day^{-1} and 34.82 g kg BW^{-1} day^{-1}, respectively. No regression model was fitted to the data observed for NDFI. The CPI presented a linear behavior similar to the DMI, due to the higher levels of concentrate and, consequently, the higher participation of this feed in the diet. The mean values obtained were 149.85 g day^{-1} and 5.78 g kg BW^{-1} day^{-1}, respectively (Table 2).

Table 2. Average daily intake of dry matter (DMI), neutral detergent fiber (NDFI) and crude protein (CPI) of Santa Inês crossbreed lambs fed Tifton 85 grass hay associated with increasing concentrate levels

Variable	Concentrate level (g kg BW^{-1} day^{-1} as fed)				Regression equation	R^2	CV (%)
	0.0	6.6	13.3	20.0			
	Intake (g day^{-1})						
DMI	683.17	812.99	973.27	1 120.29	$\hat{Y} = 677.32 + 220.68X$	0.87	5.24
NDFI	443.86	443.66	445.34	436.13	$\bar{Y} = 442.25$	0.45	1.34
CPI	104.05	131.73	165.72	197.91	$\hat{Y} = 102.65 + 47.32X$	0.88	6.81
	Intake (g kg BW^{-1} day^{-1})						
DMI	28.99	33.05	36.66	40.57	$\hat{Y} = 29.1 + 5.7X$	0.41	13.38
NDFI	18.84	18.09	17.01	15.84	$\bar{Y} = 17.4$	0.41	17.84
CPI	4.42	5.35	6.22	7.14	$\hat{Y} = 4.4 + 1.4X$	0.62	12.31

BW - body weight; R^2 - coefficient of determination; CV - coefficient of variation.

The DMI, NDFI and CPI in the two evaluations (from the 34th to the 41st day and from the 76th to the 83rd day), expressed in g day^{-1} as fed (Table 3) were influenced by the evaluations, with higher values ($P<0.05$) observed in the second evaluation. However, when expressed as g kg BW^{-1} day^{-1} the opposite was found to the same variables, being reduced ($P<0.05$) the values in the second evaluation according to the increase in body weight.

Table 3. Average daily dry matter intake (DMI), neutral detergent fiber (NDFI) and crude protein (CPI) of Santa Inês crossbreed lambs, according to the LIPE® assurance (Assessment 1 - from the 34th to the 41st day and Assessment 2 - from the 76th to the 83rd day)

Variable	Intake (g day^{-1} as fed)		Intake (g kg BW^{-1} day^{-1})	
	Evaluation 1	Evaluation 2	Evaluation 1	Evaluation 2
DMI	856.24a	938.63b	37.21b	32.50a
NDFI	433.76a	450.74b	18.93b	16.04a
CPI	141.87a	175.83b	6.14b	5.43a

BW - body weight; Means followed by different letters are significant (P <0.05).

The CPI, expressed in g day^{-1} and g kg BW^{-1} day^{-1}, showed similar behavior to the DMI, resulting from the higher levels of concentrate and, consequently, the greater intake of this nutrient. Also for CPI, the best fit of the data was achieved with the linear model.

3.2 Performances

The inicial (IBW) and final (FBW) body weights of the lambs can be seen on Table 4 that also shows their average daily body weight gains (DBWG) and total body weight gains (TBWG).

Table 4. Performance of Santa Inês crosbreed lambs fed Tifton 85 grass hay associated with increasing concentrate levels

Variable	Concentrate level (g kg BW^{-1} day^{-1} as fed)			
	0.0	6.6	13.3	20.0
IBW (kg)	22.00	22.52	22.95	22.62
FBW (kg)	28.13	31.81	36.10	37.75
DBWG (g)	75.06	111.49	148.48	185.46
TBWG (kg)	6.30	9.36	12.47	15.58

IBW - initial body weight; FBW - final body weight; DBWG - daily body weight gain; TBWG - total body weight gain.

Figure 1 shows the regression equation of DBWG in g of lambs fed Tifton 85 grass hay due to concentrate levels in the diet, explained by a linear regression ($\hat{Y} = 75.06 + 5.52X$) which makes it possible to estimate lambs daily weight gains for the four levels of concentrated supplementation, as follows: 75.06; 111.49; 148.48 and 185.46 g day^{-1} for 0.0; 6.6; 13.3 and 20.0 g kg BW^{-1} day^{-1}, respectively.

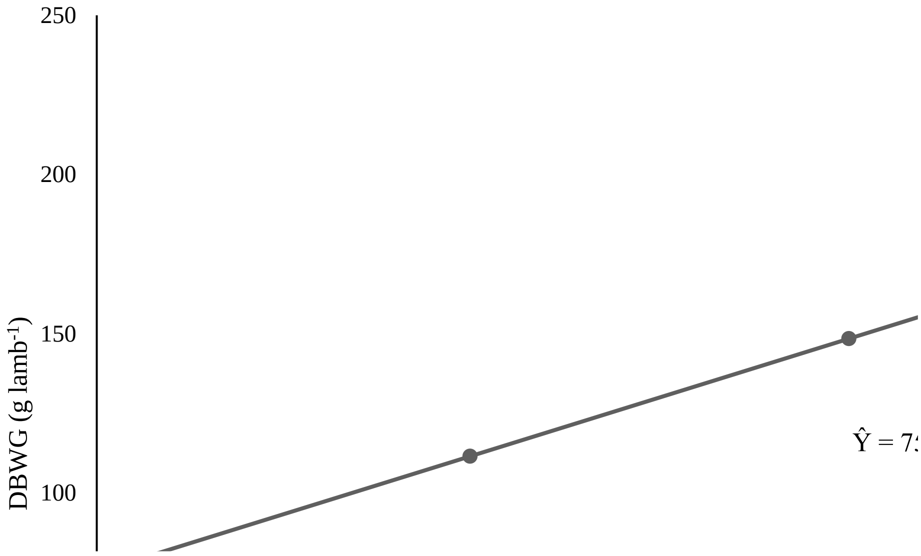

Figure 1. Regression of daily body weight gain (DBWG - g lamb^{-1}) of Santa Inês crossbreed lambs fed Tifton 85 hay due to concentrate levels supplementation

4. Discussion

4.1 Intakes

The increasing daily DMI observed between the four treatments as a linear response due to increasing levels of concentrate in the diets (Table 2) shows the relevance of the supplementation in order to obtain better results in animal intake and performance.

Similar DMI results to those obtained in this experiment, via LIPE® marker, in g day-1 (925; 964; 1,003 and 1,124) and in g kg BW^{-1} day^{-1} (36.3; 38.3; 40.1 and 44.5) respectively, were obtained by Medeiros et al. (2007) studying four levels of concentrate (20, 40, 60 and 80% of DM) on the performance of Morada Nova lambs raised in feedlot.

Corrêa et al. (2022) found higher DMI ranging from 1,070 to 1,510 g day^{-1} evaluating five levels of concentrate in the diet (12, 31, 50, 69 and 88% DM) in Santa Inês lambs (25.84 kg IBW) finished in feedlot fed Tifton 85 grass hay. The authors probably found these higher DMI results because of the higher average IBW and FBW of the lambs and also because of the higher average level of concentrate in the diets they work with.

The DMI recorded in g kg BW^{-1} day^{-1} ranged from 28.99 to 40.57 (from 0.0 to 20.0 g of concentrate kg BW^{-1} day^{-1}) showing an average of 34.82 g kg BW-1 day^{-1} (Table 2) that was considered adequate to meet the requirements (35.0 g kg BW^{-1} day^{-1}) recommended by the NRC (2007).

Considering just the first treatment (0.0 g kg BW^{-1} day^{-1} of concentrate), the DMI obtained (28.99 g kg BW^{-1} day^{-1}) (Table 2), was similar to the obtained by Santos et al. (2012) in Santa Inês sheep (30.0 kg BW) grazing Marandu grass pasture as the only feed, where the authors obtained an average intake of 28.3 g kg BW^{-1} day^{-1}. This result confirms that in absence of concentrate supplementation the intake of tropical grass hay should be similar to that obtained in grazing of tropical grasses where the animals are able to select the forage eaten.

When the two assessment periods are compared according to the LIPE® assurance (Table 3) it is possible to verify that despite the DMI per animal (g day^{-1}) have been greater (P<0,05) in the second period (938.63 g day^{-1}) in comparison to the first (856.24 g day^{-1}), the DMI expressed in g kg BW-1 day-1 showed lower values (P<0.05) in the second period (32.5 vs 37.21 g kg BW-1 day^{-1}). According to Cabral et al. (2008) it happens due to the fact that animals with smaller body size require a greater amount of energy to maintenance per kg BW, due to their greater relative body surface and the greater presence of metabolically active tissues in relation to those with larger body size.

Mertens (1994) highlighted that the DMI is closely related to the size and capacity of the animal's digestive tract and, according to Forbes (1995), the increase in daily DMI and, consequently, of other fractions (NDFI and CPI) is due to the increase in BW, as heavier animals have greater capacity of their gastrointestinal tract and require a greater quantity of nutrients for maintenance. However, when expressed in g kg BW-1 day-1, it reduces with the increase in live weight, attributed to the smaller relative body surface (body surface/live weight) of larger body size animals. Therefore, they are considered more demanding in nutrients per unit of metabolic weight (CABRAL et al., 2008).

Despite the fact that in this evaluation was not possible to fit a regression model to NDFI (Table 2) is well known that the NDFI is highly correlated to the DMI as emphasized by Mertens (1994) and corroborated by Corrêa et al. (2022). The NDFI expressed in g day^{-1} was very similar among the four treatments with the average value of 442.25 g day^{-1} (Table 2). It was expected considering the increase in concentrate:forage ratio in the diets, and consequently an increase in total DMI (g day^{-1}) (Table 2). Similar NDFI of 413.76 g day-1 was reported by Fontenele et al. (2011), in research testing levels of metabolizable energy in the diet of Santa Inês lambs and also by Medeiros et al. (2007) with an average NDFI of 453 g day^{-1} studying four levels of concentrate.

The NDFI expressed in g kg BW^{-1} day^{-1} showed a slight decrease from 18.84 to 15.84 g kg BW^{-1} day^{-1} from the first treatment (0.0 g kg BW-1 day-1 of concentrate) to the last one (20.0 g kg BW-1 day-1 of concentrate) (Table 2). In the second assessment period (Table 3), when the lambs were heavier, similar results were obtained with the average NDFI in g day^{-1} being greater (P<0.05) than in the first period and opposite happening (P<0.05) when considered NDFI in g kg BW-1 day-1 what can be explained by the way that was previously described for DMI in the two assessment periods.

The increasing CPI observed in the Table 2 was expected as the protein content of the concentrate was greater than that in Tifton 85 grass hay (Table 1). These results are corroborated by Panadi et al. (2021), who observed increasing values of CPI in Dorper lambs fed in creep feeding when the animals were supplemented with rations ranging from 140 to 200 g CP kg^{-1}. Lambs fed 200 g CP kg^{-1} showed an average CPI of 223.11 g day^{-1}. Medeiros et al. (2007), studying concentrate levels, obtained similar CPI ranging from 164 to 208 g day^{-1}, with an average of 184.5 g day^{-1}.

Cabral et al. (2008) suggested a CPI of 137 g day^{-1} for gains of 250 g day^{-1}, for lambs with 20 kg of BW, in Brazilian conditions. NRC (2007) suggests that the CPI for growing lambs should be 156 g day^{-1}, a similar value that was obtained in this experiment from the inclusion of 13.3 g kg BW^{-1} day^{-1} in concentrate (165.72 g day^{-1}).

In the two assessment periods were observed in the CPI the same response that was previously observed in DMI and also in NDFI: greater CPI in g day^{-1} in the second period and lower CPI in g kg BW^{-1} day^{-1} in the same period (Table 3). CP is the most limiting nutrient in the tropics and its supplementation via concentrate feeds is important to improve DMI and animal performance (VEGA-BRITEZ et al., 2024). These authors researching three concentrate supplementation levels (0.0, 15.0 and 30.0 g kg BW^{-1} day^{-1}) to Suffolk lambs (22.54 IBW) grazing Aruana and Marandu grasses found average CPI ranging from 67.0 to 154.0 g day^{-1}.

4.2 Performances

Daily and total weight gains (Table 4) showed the same response, being higher with the increase in concentrate supplementation levels, suggesting great consistency between the two variables. Thus, among the diets evaluated, concentrate supplementation with 20.0 g kg BW^{-1} day^{-1} was the one that would have potential for gains greater than 250 g day^{-1} in accordance with the DMI requirements for lambs weighing 20 kg, which is 1,000 g day^{-1} (NRC, 2007), considering the average DMI showed of 1,120.29 g day^{-}1 (Table 2).

The DBWG ranged from 75.06 to 185.46 g (Table 4), increasing as the level of concentrate in the diet became higher in a linear way with the highest DBWG occurred when included 20 g kg^{-1} BW day^{-1} of concentrate to the diet (Figure 1). According to Andrade et al. (2014) the performance observed in this experiment is an aspect of fundamental importance in the production process, allowing animals to be slaughtered earlier.

The greater DMI resulting from supplementation with concentrate enable a greater supply of nutrients to the animals. Increasing average daily weight gains are result of the better quality of the diet ingested by the animals as the level of concentrate in the diet increases (SOUZA et al., 2010; VEGA-BRITEZ et al., 2024).

Corrêa et al. (2022) evaluating concentrate levels in lambs fed Tifton 85 grass hay observed average daily gains that ranged from 70 to 200 g day-1, when considered hay to concentrate ratios from 88:12 to 50:50, that are similar to the ratios of the present research. The gains obtained are close to those found in this research (75.06 to 185.46 g day^{-1}) when considered the 0.0 to 20.0 g kg BW^{-1} day^{-1} of concentrate levels, respectively.

Performance of lambs fed only Tifton grass pasture was greater than that of Tifton grass hay because the animals have a greater ability to select parts of the plant as tender leaves and stems of high nutritional value, while when consuming hay this selection is not fully exercised, since the hay is normally made up of stems and leaves, also with the losses in the drying process, which would lead to lower animal comparative performance. When a pasture is transformed into hay or silage, its quality will be always lower than the original pasture. On the other hand, when combining pasture or hay with higher levels of concentrate, the quality of the diet becomes very similar, providing similar animal performance in both cases.

5. Conclusions

The increasing levels of concentrate in the lamb diets show an increase in dry matter and crude protein intakes and similar response in neutral detergent fiber intake. These intake increases allow greater daily and total body weight gains and show the relevance of the supplementation of lambs fed tropical grasses in order to obtain better results in animal performance. There is a consistent relationship between nutrient intakes and animal performance in the treatments and the LIPE® marker proved to be an efficient technique to evaluate the dry mater intake and the digestibility of the diet by lambs. Considering the difficulty in evaluating the nutritional value of the feed consumed by the animals in the Brazilian tropical conditions, the adoption of LIPE® marker is a fast, safe and accurate method to evaluate the digestibility of the diets.

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Authors contributions

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Competing interests

The authors declare that there is no conflict of interests in the research.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Macrothink Institute.

The journal’s policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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