Small Ruminant Research xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Net protein requirements and metabolizable protein use for growing ram lambs fed diets differing in concentrate level and roughage source

Diego B. Galvani[a,*], Alexandre V. Pires[b], Ivanete Susin[b], Vinícius N. Gouvêa[b], Alexandre Berndt[c], Adibe L. Abdalla[d], Luís O. Tedeschi[e]

[a] Empresa Brasileira de Pesquisa Agropecuária, Embrapa Caprinos e Ovinos, Sobral, CE, 62010-970, Brazil
[b] Departamento de Zootecnia, Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba, SP, 13418-900, Brazil
[c] Empresa Brasileira de Pesquisa Agropecuária, Embrapa Pecuária Sul, São Carlos, SP, 13560-970, Brazil
[d] Laboratório de Nutrição Animal, Centro de Energia Nuclear na Agricultura, Universidade de São Paulo, Piracicaba, SP, 13416-000, Brazil
[e] Department of Animal Science, Texas A&M University, College Station, TX, 77843-2471, United States

ARTICLE INFO

Keywords:
Dietary protein
Metabolizable protein supply
Microbial protein
Protein retention
Sheep

ABSTRACT

Two trials were conducted to determine net protein requirements and the use of metabolizable protein (MP) for growing ram lambs when fed diets with different concentrate levels and roughage quality. In a comparative slaughter trial, eighty-four ½ Dorper × ½ Santa Inês ram lambs (18.0 ± 3.3 kg of BW) were individually penned and divided into 2 diet groups differing in roughage source: low-quality (sugarcane bagasse) roughage (LQR) or medium-quality (coastcross hay) roughage (MQR). In each group, 7 lambs were randomly selected and slaughtered after a 10 days adaptation period (baseline). Other 21 lambs from each diet group were fed *ad libitum* and slaughtered at 25, 35, or 45 kg of BW, and the remaining 28 lambs (14 from each diet group) were submitted to 1 of 2 levels of feed restriction (70 or 50% of the *ad libitum* intake). Body N content and retention were determined. In the second trial, 6 ram lambs (44.3 ± 5.6 kg of BW) were kept in metabolic cages and used in a 6 × 6 Latin square experiment designed to determine N digestibility and microbial N synthesis, and to compute MP supply by the 2 diets and 3 levels of intake. Nitrogen intake and microbial N synthesis were greater for the animals fed the MQR diet than for those fed the LQR diet ($P < 0.05$). Neither the endogenous and metabolic N losses, nor the net protein requirements for growth differed between diets ($P > 0.05$). However, the proportion of MP used for both maintenance and growth was lower for the animals fed the MQR diet ($P < 0.05$), likely because of an excess of MP reaching duodenum of these animals. We concluded that a reduction of the concentrate level in diets for growing ram lambs, achieved by improving the quality of the diet roughage, allows a greater supply of MP and may contribute to reduce diet protein concentration.

1. Introduction

The worldwide growth of the sheep industry in the last decades has been driven by an intensification of farming practices, in order to reduce losses, increase productivity, and maximize profitability. In this sense, nutrition has a major importance since animal feeding accounts for a large proportion of the production costs (Theodoridis et al., 2012); so that correctly meeting the animals' requirements for nutrients plays a key role in improving production efficiency.

Although concentrate feeds are usually the most expensive feed ingredients, several studies have suggested up to 90% of their inclusion in diets for growing lambs, aiming to improve growth performance, feed efficiency, and carcass characteristics (Tripathi et al., 2007; Haddad and Ata, 2009). Additionally, because increasing diet energy concentration seems to improve the efficiency of protein utilization (Schroeder and Titgemeyer, 2008), feeding high concentrate levels could be even more advantageous, since protein is the most expensive nutrient in diets for ruminants. High-concentrate diets, however, are frequently composed of low-quality roughages as fiber source, which may impair energy efficiency (Susenbeth et al., 1998) and, as a consequence, protein efficiency as well (Schroeder and Titgemeyer, 2008). By using greater quality roughages, the concentrate level in diets can be decreased without impairing animal performance (Galvani et al., 2014), but few information is available about the effects of changing fiber source and concentrate level on protein utilization for ruminants.

This study was conducted to determine net protein requirement and the MP use for growing ram lambs fed diets differing in concentrate level and roughage quality.

* Corresponding author.
E-mail address: diego.galvani@embrapa.br (D.B. Galvani).

https://doi.org/10.1016/j.smallrumres.2018.05.012
Received 11 December 2017; Received in revised form 9 March 2018; Accepted 25 May 2018

2. Materials and methods

This study was conducted at the Intensive Sheep and Goats Production System of the Department of Animal Science of the "Luiz de Queiroz" College of Agriculture (ESALQ), University of São Paulo, Brazil. According to the ESALQ's Meteorological Station, throughout the field experiment, the mean temperature was 23.1 °C, and mean minimum and maximum temperatures were 18.3 and 29.6 °C, respectively. All procedures with animals were approved by the Ethics Committee on Animal Use in Research of the ESALQ under the protocol #2008-04.

2.1. Comparative slaughter trial

Eighty-four ½ Dorper × ½ Santa Inês ram lambs were weaned at 56 days of age (18.0 ± 3.3 kg of shrunk body weight; SBW) and used in a completely randomized block design to determine their whole body protein content. Initial SBW was used as the blocking factor. Lambs were treated for internal parasites (Dectomax®, Pfizer Animal Health, Exton, PA, USA; 200 µg of Doramectin per kg of BW), vaccinated against clostridiosis (Sintoxan T®, Merial SA, Montevideo, Uruguay), and housed in individual pens equipped with feeders and automatic waterers. Two groups of animals (n = 42) were formed and fed diets composed by different primary source of dietary roughage: low-quality roughage [LQR; sugarcane bagasse (*Saccharum officinarum* L.)] or a medium-quality roughage [MQR; coastcross hay (*Cynodon* sp.)]. Roughages were classified according their concentrations of CP and sulfuric acid lignin, as well as *in vitro* degradability (Table 1). Within each diet group, animals were ranked according to their initial SBW, forming 7 classes (blocks) of 6 animals each. After an adaptation period of 10 d, in which animals had free access to the feed, 7 animals from each diet group (one animal from each block, within diet) were randomly selected and slaughtered (baseline group). Other 21 lambs from each diet group were randomly assigned to 1 of 3 levels of DMI: *ad libitum* or restricted to either 70 or 50% of the *ad libitum* intake. Slaughter groups consisted of one lamb from each level of intake within block. When the lamb fed the *ad libitum* diet reached 45 kg of SBW, all 3 lambs were fasted and slaughtered, regardless of the BW of the restricted-fed lambs. The remaining 28 lambs (14 from each diet group) were assigned to intermediate slaughter groups, being fed *ad libitum* and slaughtered either at 25 or 35 kg of SBW.

Table 1
Ingredient composition of experimental diets, and chemical composition and particle size of the roughages and total mixed diets.

			Total mixed diet	
	Sugarcane bagasse	Coastcross hay	Low-quality roughage	Medium-quality roughage
Ingredient, % of DM				
Coastcross hay, chopped	–	–	–	30.0
Sugarcane bagasse	–	–	15.0	–
Citrus pulp	–	–	32.6	26.3
Ground corn	–	–	34.9	32.8
Soybean meal	–	–	15.9	9.50
Ammonium chloride	–	–	0.50	0.50
Urea	–	–	0.30	0.18
Mineral premix [a]	–	–	0.80	0.80
Chemical composition				
DM, % as fed	45.6	86.6	75.9	88.4
OM, % of DM	96.5	92.1	95.3	94.4
CP, % of DM	3.94	14.8	16.3	15.8
aNDF, % of DM	84.6	68.2	30.6	34.8
ADF, % of DM	53.1	36.6	16.8	17.6
NFC, % of DM [b]	5.76	5.90	45.2	40.8
peNDF, % of DM [c]	80.9	47.4	20.5	21.3
Lignin, % of DM	12.1	3.50	3.14	2.14

[a] The composition of the mineral premix was: 7.5% P, 13.4% Ca, 1% Mg, 7% S, 14.5% Na, 21.8% Cl, 500 ppm Fe, 300 ppm Cu, 4600 ppm Zn, 1100 ppm Mn, 55 ppm I, 40 ppm Co, 30 ppm Se.

[b] Non-fibrous carbohydrate.

[c] Physically effective NDF, calculated by multiplying the NDF concentration of particles > 1.18 mm by the fraction (%) retained on a 1.18-mm sieve, as suggested by Mertens (1997).

Diets were formulated by using the Small Ruminant Nutrition System (SRNS; Cannas et al., 2004; Tedeschi et al., 2010; http://nutritionmodels.com; Accessed on Aug 26, 2014) model, version 1.8.18. Besides the different roughages, diets were composed of ground corn, citrus pulp, soybean meal, urea, ammonium chloride, and mineral premix (Table 1), mixed in different proportions to make isonitrogenous diets (2.6% N) with approximately 20% of physically effective NDF (peNDF). Nitrogen content of both diets were greater than that recommended by the NRC (2007), aiming to keep a ruminal N and peptide balance near to zero, as predicted by the SRNS model. According to our previous experience (Rodrigues et al., 2008), we assumed that the small differences in the ground corn to citrus pulp ratio observed between diets would not affect our results.

Roughage and concentrate were individually weighed and mixed immediately before feeding, twice daily (08:00 and 16:00 h). For the *ad libitum*-fed groups, the amount of feed offered was adjusted daily in the morning to ensure a 10% refusal (in a fresh basis). In turn, the amount of feed offered to restricted-fed groups was also calculated daily, based on the DMI of the *ad libitum* group in the previous d, expressed as a percent of BW. To allow the most accurate estimation of the amount of feed to be supplied to the animals in the restricted-fed groups, all animals were weighed every 7 days before the morning feeding. Samples of feed offered and orts (approximately 10% of the total) were taken daily and frozen (−20 °C) as composite samples per animal.

Animals were slaughtered after a 16-h fasting period, by stunning with a captive-bolt pistol immediately followed by a complete exsanguination. Following skinning and evisceration, each body component (blood, skin, feet, head, visceral fat, viscera, and carcass) was individually weighed and frozen (−20 °C). The gastrointestinal tract content (GIT), urine, and bile were removed to determine the empty BW (EBW), as follows: EBW, kg = SBW − (GIT + urine + bile).

Carcasses were refrigerated for 24 h at 4 °C and then split in half. The left half carcasses, as well as head and feet were fully ground in a large screw grinder (P-33a-3-789 15HP, Ind. Mec. Herman Ltda., Bom Retiro, SP, Brazil). Every other body component was cut into small pieces and ground with a disintegrator mill (MA-923, Marconi Ltda., Piracicaba, SP, Brazil). All individual samples were homogenized by passing them four times through the grinder, and then samples were stored at −20 °C until chemical analyses.

2.2. Digestibility trial

A 6 × 6 Latin square experiment using six ½ Dorper × ½ Santa Inês rams (mean SBW = 44.3 ± 5.6 kg) was designed to determine N digestion and MP supply of the two diets at the three levels of DMI: *ad libitum* or restricted to either 70 or 50% of the *ad libitum* DMI. Animals were cannulated in the rumen, dewormed (Dectomax®, Pfizer Animal Health, Exton, PA, USA; 200 µg of Doramectin per kg of BW), and kept in cages equipped with feeders, waterers, and apparatuses for collecting feces and urine separately. Diets and feeding procedures were the same as described for the comparative slaughter trial.

The experiment was conducted in six periods of 15 d, including 10 days for diet adaptation and 5 days for data and sample collection.