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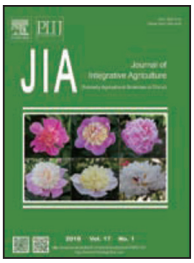

RESEARCH ARTICLE

Energy and protein requirements for maintenance of Hu sheep during pregnancy

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Abstract

This study aimed to determine the effect of stage and level of feed intake on energy metabolism, carbon-nitrogen (C-N) balance, and methane emission to determine energy and protein requirements for maintenance of maternal body including pregnancy tissues during pregnancy using the method of C-N balance. Twenty-one ewes carrying twin fetuses were randomly divided into three groups of seven ewes each in the digestion and respirometry trial at d 40, 100, and 130 of gestation, respectively. Three groups were fed a mixed diet either for *ad libitum* intake, 70 or 50% of the *ad libitu*m intake during pregnancy. The results showed that the apparent digestibility of C and N were increased as feeding levels decreased at each stage of gestation. The daily net energy requirements for maintenance (NE_m) were 295.80, 310.09, and 323.59 kJ kg^{-1} $BW^{0.75}$ (metabolic body weight) with a partial efficiency of metabolisable energy utilization for maintenance of 0.664, 0.644, and 0.620 at d 40, 100, and 130 of gestation, respectively. The daily net protein requirements for maintenance were 1.99, 2.35, and 2.99 g kg^{-1} $BW^{0.75}$ at d 40, 100, and 130 of gestation, respectively. These results for the nutritional requirements of the net energy and protein may help to formulate more balanced diets for Hu sheep during pregnancy.

Keywords: carbon and nitrogen balance, energy, methane emission, protein, pregnancy

1. Introduction

The Hu sheep is an indigenous Chinese sheep breed that is well adapted to the ecological conditions of high temperature and high humidity areas of China and is noted for its precociousness and prolificacy (Yue 1996; Nie *et al.* 2015). In China, the Hu sheep has become one of the dominant breeds for lamb meat production.

The feeding management of sheep in China is largely based on a foreign nutritional system, such as NRC (2007). However, China is such a huge country with various forage

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resources and sheep breeds that it is practically unreasonable to cover all the situations with a foreign standard. Furthermore, in China, nutrient requirements of Hu sheep during pregnancy have not been well established, which limits the development of more efficient feeding systems. Therefore, an accurate assessment of the nutritional requirements of Hu sheep is critical to maximize performance and ensure efficient feed utilization.

This study indicates the energy and protein requirements for the maintenance of Hu ewes using carbon and nitrogen methods during pregnancy, which coincides with animal welfare, as well as the methane emissions as measured by an open-circuit respirometry system. The carbon and nitrogen (C-N) balance has been used to calculate the retained energy (RE), assuming that all energy is retained either as fat or protein (Fernández *et al.* 2012). Therefore, we will further investigate the effect of stage of gestation and level of feed intake on energy metabolism, C-N balance, and methane emission to determine energy and protein requirements for maintenance of Hu sheep during pregnancy using the method of C-N balance.

2. Materials and methods

The experiment was conducted at the Jiangyan Experimental Station of Taizhou, Taizhou City, Jiangsu Province of China. During the research period, a heated indoor facility was used to keep the temperature within the range of (15.50±1.32)–(26.54±1.61)°C. The average relative humidity was (61.25±2.76)%. All trials were conducted in accordance with the Guidelines for the Care and Use of Animals in the College of Animal Science and Technology, Nanjing Agricultural University, China.

2.1. Animals and treatments

Thirty-six multiparous Hu sheep (body weight (BW)= (40.1±1.2) kg) of similar age ((18.5±0.5) mon) and body condition score (BCS) (2.55±0.18; scale 0=emaciated to 5=obese; Russel *et al.* 1969) were selected. After being drenched with 0.2 mg ivermectin per kg of BW against endoparasites, all ewes were synchronized using intravaginal progestagen sponges (30 mg; Pharmp PTY, Herston City, Australia) for 12 d. Estrous behavior was monitored using 3 vasectomized rams at 0800 and 1600 h following the second day of pessary removal. The ewes were artificially inseminated using fresh semen of Hu sheep breed 48 h after sponge withdrawal (d 0 of gestation) and placed in individual pens (3.20 by 0.80 m). Each pen was equipped with feeders and automatic water suppliers. From d 0 to 35 of gestation, ewes were randomly assigned to three groups (n=12): the *ad libitum* (AL) group, a low nutrient restricted group (fed at 70% of AL), and a high nutrient restricted group (fed at 50% of AL). The number of fetuses carried by each ewe was determined by ultrasonography (Asonics Microimager 1000 Sector Scanning Instrument, Ausonics Pty Ltd., Sydney, Australia) at d 35 of gestation. On d 35 of pregnancy, each seven ewes carrying twin fetuses from these three groups were selected and assigned to the three previously corresponding to feed intake in this study. Details of the diets are reported in Table 1 to meet 100% of the NRC (1985) nutrient requirements for pregnant sheep. *Ad libitum* was also expected to meet 100% of the NRC (1985) nutrient requirements for pregnant sheep. Nutrient restriction (70 or 50% of AL) was achieved by feeding three quarters or one-half of the total complete diet calculated to meet 100% NRC requirements. A total of 50% of AL at least covered the existing recommendations for ewes at maintenance during gestation. The choice of a pelleted diet was to prevent possible selectivity and waste and to facilitate accurate measurements of feed intake.

The ewes with *ad libitum* intake were fed once daily at 0800 h and ensured a 10% of refusal. The ewes were all provided with free access to water. The amount of feed offered to the restricted feed intake groups was also adjusted daily and based on the dry matter intake (DMI) of the AL

Table 1 Ingredient and nutrient composition of the experimental diets

Item	Diet 1 (0–90 d of gestation)	Diet 2 (91–150 d of gestation)
Ingredients (% as fed)		
Chinese wild rye	50.0	45.0
Corn	35.12	31.32
Soybean meal	12.00	20.00
Dicalcium phosphate	1.67	2.34
Calcium carbonate	0.41	0.54
Salt	0.50	0.50
Mineral/Vitamin premix[1)]	0.30	0.30
Total	100	100
Nutrient composition (analyzed)[2)]		
DM (% as fed)	90.23	90.36
Ash (% of DM)	7.23	7.14
GE (MJ kg^{-1} of DM)	17.63	18.49
CP (% of DM)	9.98	13.59
Ether extract (% of DM)	4.21	4.59
NDF (% of DM)	37.12	32.57
ADF (% of DM)	20.98	18.93
Ca (% of DM)	0.57	0.81
P (% of DM)	0.45	0.69

[1)] The premix provided the following nutrients per kg of the diet: 30 000 IU VA, 10 000 IU VD, 100 mg VE, 90 mg Fe, 12.5 mg Cu, 50 mg Mn, 100 mg Zn, 0.3 mg Se, 0.8 mg I, and 0.5 mg Co.

[2)] Nutrient levels are measured value. DM, dry matter; GE, gross energy; CP, crude protein; NDF, neutral detergent fibre; ADF, acid detergent fibre.