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Effects of rumen-protected tryptophan on growth performance, fibre characteristics, nutrient utilization and plasma essential amino acids in Cashmere goats during the cashmere slow growth period

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ABSTRACT

Tryptophan (Trp) is a limiting amino acid in growing ruminants and supplementation of Trp in a rumen-protected form may have positive effects on performance in ruminants. Trp may affect cashmere fibre growth by regulating plasma melatonin secretion. From December to February, identified as the cashmere slow growth period, cashmere growth rate slows down and plasma melatonin secretion declines. Thus, Trp supplementation may affect cashmere fibre growth positively during this period.

This study was conducted to investigate the effects of rumen-protected tryptophan (RPT) on Cashmere goats during the cashmere slow growth period. Optimal RPT supplementation level was determined. The Thirty-six Liaoning Cashmere goat wethers (41.63 ± 0.37 kg) aged 1.5-year-old were stratified by weight and randomly assigned to the following treatments: without RPT (control), low RPT (LRPT), medium RPT (MRPT) and high RPT (HRPT) at RPT levels of 0, 2.0, 4.0 and 6.0 g per goat per day, respectively. LRPT and MRPT supplementation increased average daily gain ($P<0.05$) and N retention ($P<0.05$).The length and growth rate of cashmere fibre increased both linearly ($P<0.05$) and quadratically ($P<0.05$) with increasing RPT supplementation. Plasma Trp concentration increased linearly ($P<0.05$) with increasing RPT supplementation. Conversely, RPT supplementation decreased plasma isoleucine, valine and total essential amino acid concentrations ($P<0.05$). In conclusion, RPT supplementation potentially enhanced growth performance, cashmere fibre growth and N utilization in Liaoning Cashmere goat wethers. In experimental conditions of the current trial, the optimum RPT supplementation level was 2.0 g per goat per day during the cashmere slow growth period.

1. Introduction

For many organisms, including humans, tryptophan (Trp) is an essential amino acid (EAA) required as one of the building blocks for protein biosynthesis. It is also the substrate for the biosynthesis of other key metabolic components, such as serotonin, niacin and melatonin. Trp cannot be synthesized by an organism, that organism must obtain Trp as part of its diet. In monogastric animals, a deficiency of Trp induces depression of feed intake and growth performance (Montgomery et al., 1980; Henry et al., 1992). In contrast, in ruminants, most amino acids (AAs), including Trp, are commonly assumed not to be deficient. This is because ruminal fermentation results in the production of microbial protein, which is supplied to the small intestines and delivers a good quality pattern of both essential and non-essential AAs. The amounts of EAAs supplied by microbes are sufficient to support maintenance and normal, but

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not maximal, growth and milk production (Virtanen, 1966; Storm and Ørskov, 1984). However, optimal production of meat, milk and wool may be limited by the availability of certain amino acids. Trp appears to be one limiting amino acid (AA) in growing ruminants during the process of non-protein nitrogen (N) utilization (McLaren et al., 1965; Candlish et al., 1970; Nolte et al., 2008).

Methods have now been developed for the production of AAs that are protected against rumen microbial degradation. This allows diet supplementation with specific AAs that will become available for absorption at the intestinal level. Feeding rumen-protected Trp (RPT) has been observed to increase growth performance of lambs (Nolte et al., 2008) and the wool output of sheep (Reis and Colebrook, 1972), as well as to improve nitrogen (N) utilization in goats (McLaren et al., 1965). However, the impact of RPT on performance and nutrient utilization in Cashmere goats are not yet known.

China is the largest producer of cashmere, with 80 million goats producing 163,950 million kg of fibre, accounting for 50% of the world's total production in 2006 (Zhang et al., 2009). The Liaoning Cashmere goat is the major goat breed found in China and is primarily raised for meat and cashmere fibre production. Cashmere, a down fibre produced by secondary follicles, is the finest and softest animal fibre, with an average diameter of 15 μm, and is used exclusively in luxurious textile products. World market demands still exceed the supply, so prices are consistently stable and higher than for wool or mohair.

In recent years, however, the desire to increase cashmere yield has resulted in a coarsening of the cashmere fibre. For this reason, it is necessary to investigate environmental and genetic manipulations that can both increase cashmere yield and improve cashmere fibre characteristics. Trp supplementation has been observed to increase plasma melatonin levels in chickens, rats, ringdoves, heifers and humans (Hajak et al., 1991; Herichova et al., 1998; Jaworek et al., 2003; Cubero et al., 2006; Kollmann et al., 2008). Meanwhile, melatonin is observed to stimulate cashmere fibre growth (Klören and Norton, 1995). Thus, RPT supplementation could be speculated to positively affect cashmere fibre growth.

Requirements for nutrition vary among Cashmere goats. These change along with nutritional conditions because of the seasonal nature of cashmere production. The non-growth period is from March to July, the cashmere fast growth period is from August to November, and the cashmere slow growth period is from December to February. During the cashmere slow growth period, cashmere growth rate slows down and plasma melatonin secretion declines. In this light, Trp supplementation may be utilized to simulate cashmere fibre growth during this period. The objectives of this study were to investigate the effects of RPT supplementation on growth performance, fibre characteristics, nutrient utilization and plasma EAA concentrations in Liaoning Cashmere goats during the cashmere slow growth period, and then the optimal RPT supplementation level was determined.

2. Materials and methods

2.1. Animals and experimental design

The experiments were carried out at the Liaoning Cashmere goats Breeding Centre, China, from December 2008 to February 2009. The animal care, handling and sampling procedures were approved by the China Agriculture University Animal Care and Use Committee.

Thirty-six Liaoning Cashmere goat wethers, averaging 1.5 years of age and 41.63 ± 0.37 kg initial body weight (BW), were stratified by weight and randomly assigned to the following treatments: without RPT (control), low RPT (LRPT), medium RPT (MRPT) and high RPT (HRPT) with 0, 2.0, 4.0 and 6.0 g RPT per goat per day, respectively. The RPT (containing 33% L-Trp, purchased from the Beijing Feeding Feed Science Technology Co., Beijing, China) was added to the concentrate diet. Diets consisted of 60% Chinese wildrye hay, 10% alfalfa hay and 30% concentrate (on a dry matter (DM) basis) which was composed of minerals and vitamins (NRC, 2007) (Table 1). The concentrate mixture included corn and wheat bran as energy sources and soybean meal as a protein source. The basal diet (on a DM basis) contained 0.09% Trp. The levels of RPT supplementation were chosen based upon the research of Itabashi et al. (1994). According to the conclusion of these researchers, supplementation at 4.0 g/day was suitable for research on RPT feeding. Based on the differences in weight and breed, we set two levels of 2.0 g/day and 6.0 g/day supplementation, aiming to reveal the most feasible accession.

The experimental period lasted 60 days, including a 10-day adaptation period and a 10-day metabolism trial. Goats were housed in an open-sided barn in individual pens (1.0 × 1.5 m). Hay was offered once a day *ad libitum*, and concentrate was fed 300 g daily, divided into two equal meals, at 08:00 h and 16:00 h. Fresh water was available throughout the experimental period.

2.2. Collection of data and samples

Daily feed offerings and refusals were measured to obtain feed intake for each goat. BW was determined before the

Table 1
Ingredients and chemical composition of the basal diet.

Item	Concentration
Ingredient (%, fed basis)	
Chinese wildrye hay	60.0
Alfalfa hay	10.0
Corn	18.2
Wheat bran	3.00
Soybean meal	7.00
Limestone	0.20
Dicalcium phosphate	0.20
NaCl	1.00
Premix [a]	0.40
Chemical composition (DM basis) [b]	
Metabolizable energy (MJ/kg)	10.1
Crude protein (%)	9.87
Dry matter (%)	91.7
Neutral detergent fibre (%)	50.5
Acid detergent fibre (%)	30.4
Calcium (%)	0.46
Phosphorus (%)	0.30
Tryptophan (%)	0.09

[a] Premix contained the following per kilogram: $FeSO_4 \cdot 7H_2O$, 170 g; $CuSO_4 \cdot 5H_2O$, 70 g; $MnSO_4 \cdot 5H_2O$, 290 g; $ZnSO_4 \cdot 7H_2O$, 240 g; $MgSO_4 \cdot H_2O$ 120 g; Na_2SeO_3, 130 mg; KI, 220 mg; $CoCl_2 \cdot 6H_2O$, 510 mg; vitamin A, 30,500,000 IU; vitamin D, 6,100,000 IU; vitamin E 50,000 IU.

[b] Analyzed values except metabolizable energy. Metabolizable energy was calculated by metabolizable energy in ingredient of the basal diet.