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Effect of level of oat hay intake on apparent digestibility, rumen fermentation and urinary purine derivatives in Tibetan and fine-wool sheep

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ABSTRACT

Tibetan sheep are indigenous to the Qinghai-Tibetan Plateau and are raised at an altitude between 3000–5000 m. In contrast, the crossbred fine-wool sheep were introduced to the plateau and are raised at an altitude between 2600 to 3500 m. Tibetan sheep graze grassland all year round while fine-wool sheep require feed supplements during the long cold season. Tibetan sheep were able to utilize dietary nutrients more efficiently than fine-wool sheep when offered adequate energy and protein diets. We questioned whether the responses would still favour Tibetan sheep with limited energy and protein intakes, as is often the case on the Qinghai-Tibetan Plateau. To answer this query, apparent nutrients digestibilities, rumen fermentation characteristics and urinary purine derivatives (PD) were compared between Tibetan and fine-wool sheep when fed oat hay at below maintenance levels: 0.3, 0.5, 0.7 and 0.9 voluntary intake. Five wethers of each breed of similar age and body weight (BW) were used in two concurrent 4 × 4 Latin square designs. Dry matter (DM), organic matter (OM) and neutral detergent fiber (NDF) digestibilities were higher in Tibetan than fine-wool sheep ($P < 0.05$), but were not affected by the level of oat hay intake ($P > 0.10$). As feed intake increased, ruminal pH decreased ($P < 0.01$) and total volatile fatty acid (VFA) concentration increased, both linearly ($P < 0.001$). Moreover, ruminal total VFA concentration ($P < 0.05$), ruminal soluble protein nitrogen (N) and saliva urea-N concentrations ($P < 0.01$) were higher in Tibetan than fine-wool sheep. Urinary total PD and its fractions increased linearly with feeding level ($P < 0.01$). Estimated microbial N synthesis was greater in Tibetan than fine-wool sheep ($P < 0.05$) and increased linearly with the level of oat hay intake ($P < 0.001$). It was concluded that both energy and protein metabolism were used more efficiently in Tibetan than in fine-wool sheep when offered below maintenance intakes, which would allow Tibetan sheep to cope better with the harsh, winter foraging conditions of the Qinghai-Tibetan Plateau.

Abbreviations: ADF, acid detergent fiber; ADG, average daily gain; BW, body weight; CP, crude protein; DE, digestible energy; DM, dry matter; N, nitrogen; NDF, neutral detergent fiber; OM, organic matter; PD, purine derivatives; VFA, volatile fatty acid; VI, voluntary intake

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1. Introduction

The Qinghai-Tibetan Plateau, called the third pole of the earth (Qiu, 2008), covers an area of 2.5 million km^2, of which more than half is grassland (Long et al., 1999). The plateau is known for its extreme harsh conditions, characterized by high altitude, severe cold, low air oxygen, strong ultraviolet radiation and short forage growing season. Pasture availability is often insufficient to support the livestock during the cold period (Weiner et al., 2003).

Tibetan sheep, with a population of 50 million, is indigenous to the Qinghai-Tibetan Plateau and are raised at an altitude between 3000 and 5000 m (Zhou et al., 2015a). In contrast, Gansu alpine fine-wool sheep, with a smaller population of 2.8 million (Li, 2011), are a crossbred sheep introduced to the Qinghai-Tibetan Plateau in the 1980s and are raised at a lower altitude between 2600 and 3500 m (Wang, 2012). The Gansu Alpine fine-wool sheep was developed by crossing Tibetan with Xinjiang fine-wool sheep and then with fine-wool breeds from USSR (Cheng 1984). Today, its genetic make-up is 1/16 of Tibetan sheep and this breed is well-adapted to the harsh conditions of the Qinghai-Tibetan Plateau. Both sheep breeds graze on the grassland all year round, but Tibetan sheep do not receive feed supplement while fine-wool sheep are supplemented with concentrate or oat hay during the cold season (Zhou et al., 2017a).

Previous studies showed that Tibetan sheep exhibited higher dry matter (DM) and fiber digestion and more efficient nitrogen (N) utilization than fine-wool sheep when consuming adequate dietary energy (Zhou et al., 2015a, 2015b). However, under traditional management, energy and nitrogen intakes of Tibetan sheep decrease sharply in the cold season when compared to the warm season and are below maintenance requirements (Xie et al., 1996; Dan et al., 2009). Consequently, dietary N and energy are often concomitantly limited in grazing Tibetan sheep during this time. We questioned whether the digestive responses would favour the Tibetan sheep over fine wool sheep when offered below maintenance energy and protein intakes. In the current study, different levels of below maintenance levels of oat hay were offered Tibetan and fine-wool sheep to simulate the low feed intakes in the cold season. Oat hay is becoming more common as a supplement on the Qinghai-Tibetan Plateau. We compared apparent digestibilities, rumen fermentation characteristics, urinary purine derivatives and microbial N production between these two breeds.

2. Materials and methods

All procedures involving the use of animals were approved by the Animal Care Committee of Lanzhou University.

2.1. Study site

This trial was conducted at Wushaoling Yak Research Facility of Lanzhou University (37°12.4′ N, 102°51.7′ E, altitude 3154 m) from November 2012, to March 2013. The experimental animals were kept in a roofed shelter with 3 walls, in which the air temperature and relative humidity averaged 4 °C and 74%, respectively.

2.2. Animals and diets

Five wether Tibetan sheep (43 ± 2.3 kg, 22 months old) and 5 wether fine-wool sheep (45 ± 3.1 kg, 20 months old) were purchased from nearby herders, and used in two concurrent 4 × 4 Latin square designs. In each of the 4 periods, within each breed, one of the feed levels was offered to two sheep and the other three feed levels was offered to one sheep each. The animals were kept individually in metabolic cages and provided with fresh water *ad libitum*. Six g of salt, consisting of Na_2SO_4 (29%), $NaHCO_3$ (16%) and NaCl (55%), were added to the water each day, as was recommended by the previous owner. Oat hay (Table 1), chopped into 1–2 cm length, was offered as the sole feed. The sheep were allowed 45 days to adapt to the experimental conditions, and to familiarize themselves with the feed, facilities, staff and urine-collection apparatus. Then, the animals were offered oat hay *ad libitum* to determine voluntary intake (VI), and the lowest VI (1013 g/d DM) was used to set the different feeding levels. The dietary treatments were 0.3, 0.5, 0.7 and 0.9 time VI, which were approximately 0.38, 0.64, 0.90 and 1.12 times the digestible energy (DE)

Table 1
The composition and energy content of oat hay.

Items	Concentration
Dry matter, g/kg	885
Organic matter, g/kg DM	929
Crude protein[a], g/kg DM	96
Neutral detergent fiber, g/kg DM	600
Acid detergent fiber, g/kg DM	450
Calcium, g/kg DM	3.9
Phosphorus, g/kg DM	1.8
Digestible energy[b], MJ/kg DM	10.4

[a] Calculated as N × 6.25.
[b] Calculated according to Tables of Feed Composition and Nutritive Values in China (Chinese Feed Database, 2010).