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Effect of dietary *Urtica cannabina* on the growth performance, apparent digestibility, rumen fermentation and gastrointestinal morphology of growing lambs

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ABSTRACT

Dietary supplementation with *Urtica cannabina* is a viable source of available protein and fibre for livestock nutrition. To investigate the effect of *U. cannabina* on gastrointestinal development of growing animals, 32 male, 120-day-old Ujumuqin × small-tailed Han lambs were randomly assigned to one of the four dietary treatment groups: (1) G50 = 500 g/kg concentrate + 500 g/kg mixed forage (control); (2) L50 = 500 g/kg concentrate + 500 g/kg *Leymus chinensis*; (3) U50 = 500 g/kg concentrate + 500 g/kg *U. cannabina*, or (4) L25-U25 = 500 g/kg concentrate + 250 g/kg *L. chinensis* + 250 g/kg *U. cannabina*. The four dietary treatments had similar energy and crude protein (CP) levels but different neutral detergent fibre level. Diets were provided in single pellet form and separately offered for the 57-day experimental period. All lambs were slaughtered after the feeding trial. The results showed the following: (i) there was no differences in dry matter intake or weight gain between groups; (ii) lambs fed the U50 and L25-U25 diets had greater apparent digestibility values of CP ($P = 0.003$) and neutral and acid detergent fibre ($P = 0.020$; $P = 0.030$), as compared to those fed the control diet; (iii) the molar proportion of acetate in rumen fluid increased ($P = 0.039$) and that of butyrate decreased ($P < 0.001$) in the U50 diet, as compared to the other diets; however, total volatile fatty acids was lower ($P = 0.045$) than the L50 and L25-U25 diets; (iv) the papillae width in the dorsal and ventral rumen walls were smaller ($P = 0.039$; $P = 0.046$) in the control group than the other three groups, and corneum thickness in both rumen sides were thinner ($P = 0.027$; $P = 0.050$) in the U50 and L25-U25 groups than in the control and L50 groups; and (v) shallower ($P = 0.012$) crypt and greater ($P = 0.020$) villus to crypt ratio in the jejunum were observed in the U50 and L25-U25 groups than in the control and L50 groups, and there was a tendency for villus height to be increased in the duodenum ($P = 0.083$). We conclude that substitution of mixed forage or *L. chinensis* with *U. cannabina* had the beneficial effect on diet digestibility and gastrointestinal tract traits of growing lambs. In grassland systems, *U. Cannabina* has been found to improve the management of degraded grassland with no detrimental effects on animal performance.

Abbreviations: ADF, acid detergent fibre; ADG, average daily gain; aNDF, neutral detergent fibre; AOAC, Association of Official Analytical Chemists; CD, crypt depth; CP, crude protein; DM, dry matter; DMI, dry matter intake; FCR, feed conversion ratio; NFC, non-fibre carbohydrate; SEM, standard error of the mean; V/C, villus to crypt ratio; VFA, volatile fatty acids; VH, villus height

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1. Introduction

The use of alternative forage resources to feed grazers in the winter reduces damage to the already degraded natural grasslands, leading to improved grassland and livestock productivity. A nonconventional forage with high nutritive value, for example, can be used as a desirable alternative source for feeding ruminants animals (Iñiguez, 2011; Porqueddu et al., 2016). Such nutritious and acceptable feed ingredients are reportedly necessary to stimulate rumen development in young animals, while the quality of these ingredients plays a crucial role in animal growth performance, rumen healthiness, as well as feeding efficacy of the whole diet (Khan et al., 2016; Mollenhorst et al., 2016). Forages vary widely in quality, often measured as differences in crude protein (CP) and fibre contents, and high-quality forage consumption by ruminants resulted in greater volatile fatty acid (VFA) profiles when compared to low-quality forage (Pesta et al., 2016). In ruminants, VFAs produced in the rumen meet 70–80% of the energy requirement for the rumen papillae, particularly concentrations of individual VFAs. There exists some evidence that the development of ruminal papillae is accelerated by acetate, propionate or butyrate concentrations in the rumen of adult sheep (Sakata and Tamate, 1979), goats (4 months of age, Malhi et al., 2013) and calves (7 days of age, Zhang et al., 2017a). Besides, various bioactive phytochemicals, including saponins, which are widely distributed in alfalfa and clovers, have been found to improve performance, ruminant metabolism and gastrointestinal (GI) tract development in ruminants (Patra and Saxena, 2009; Mendel et al., 2016). The morphologic trait in the GI tract (*i.e.,* the epithelium and papillae in the rumen, and villi and crypts of the small intestinal) are the most important indicators to judge the digestive, metabolic and absorptive capacities, as well as future production performance of animals. Therefore, it was postulated that high quality forages with abundant bioactive components, such as alfalfa and nettle, would stimulate the GI morphological traits of ruminants.

Leymus chinensis, commonly known as false wheatgrass or Chinese rye grass, is a dominant species of the meadow steppe/typical grasslands of Inner Mongolia, an autonomous region of northern China, which covers a large area of the eastern Eurasian temperate grassland. *L. chinensis* is one of the most preferred grasses for livestock due to its high palatability and medium nutritive value. However, *L. chinensis* has adopted the morphological trait of dwarfism due to long-term overgrazing, leading to a significant reduction in plant size and population biomass (Ren et al., 2017). Hence, an alternative forage source is needed as a substitute for *L. chinensis* to decrease further degradation of *L. chinensis*-dominated grasslands.

Urtica cannabina, a member of the *Urticaceae* family, is a ubiquitous herbaceous perennial flowering plant with stinging hairs that is available most everywhere. It has a long history of use as a food source in the preparation of soups and curries, and it is used as a fibre supplement as well as a medicinal herb. Flowering *U. cannabina* has a high CP and moderate fibre content, comparable to high-quality alfalfa at a similar growth stage. It has been demonstrated that dietary supplementation of *U. cannabina* could be a viable source of available protein and digestible fibre for livestock nutrition (Zhang et al., 2014). High CP and fibre digestibility of *U. cannabina* is directly related to ruminal VFA production and GI tract development. Moreover, *U. dioica* has a large quantity of tannin and polyphenols (Adhikari et al., 2016) that play key roles in the morphology of the rumen (Yang et al., 2015) and small intestinal (Mendel et al., 2016). To date, however, few studies have investigated the effect of *U. cannabina* as a basic dietary ingredient on animal growth and production. Therefore, the aim of the present study was to determine the effect of *U. cannabina*, as a substitution for mixed grass or *L. chinensis*, in the diet on feed intake, growth performance and nutrient digestibility, as well as rumen fermentation and the histomorphology of the rumen and small intestine in growing lambs. We hypothesised that dietary *U. cannabina* will have greater nutrient digestibility that will result in subsequent stimulation of GI tract development of ruminants.

2. Materials and methods

2.1. Forage

U. cannabina was collected at the flowering stage in early July 2015 from grassland in Xilinguole, Inner Mongolia, China. The forage was cut and collected mechanically, and dried naturally in the field. *L. chinensis* was purchased from Caodu Co., Ltd. (Xilinhaote, Inner Mongolia), then cut and collected by machine in mid-July, and dried naturally. Mixed grass was collected from a local typical grassland on the same date using the same method as for *L. chinensis*. The grassland mainly consists of *Stipa krylovii*, *Cleistogenes squarrosa*, and *L. chinensis*. The nutrient composition of each forage is shown in Table 1.

2.2. Animals and diet

The following experimental procedures, including animal ethics and usage, were approved by the Animal Welfare Committee of Beijing Veterinarians of the Agriculture Ministry of China (Beijing, China). Thirty-two male Ujumuqin × small-tailed Han lambs, approximately 120 days of age with a mean body weight of 30.03 ± 0.63 kg, were allocated to one of the four dietary treatment groups (n = 8 each) and housed in individual 2-m^2 mesh-metal pens with a 6-m^2 activity stadium outside of each pen at an ambient temperature of about 18 °C.

Dietary treatments consisted of a 500 g/kg concentrate and 500 g/kg roughage, on a dry matter (DM) basis, composed of a variety of forage sources supplied in various quantities. The employed roughage sources were either mixed grass hay, *L. chinensis* hay, or *U. cannabina* hay. The lambs received one of the following feed regimens according to the treatment groups: (1) G50 = 500 g/kg concentrate + 500 g/kg mixed grass hay (control); (2) L50 = 500 g/kg concentrate + 500 g/kg *L. chinensis* hay; (3) U50 = 500 g/kg concentrate + 500 g/kg *U. cannabina* hay, or (4) L25-U25 = 500 g/kg concentrate + 250 g/kg *L. chinensis* hay + 250 g/kg *U. cannabina* hay. The four dietary treatments had similar energy and CP levels but different neutral detergent fibre (NDF) level (Table 1).