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Effects of including saponins (Micro-Aid®) on intake, rumen fermentation and digestibility in steers fed low-quality prairie hay

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ABSTRACT

Sixteen ruminally cannulated crossbred steers (529 ± 45 kg initial body weight, BW) were used to evaluate *in situ* dry matter (DM), neutral detergent fiber (aNDF), and N degradation characteristics of low-quality prairie hay, blood urea-N (BUN) and rumen fermentation parameters in steers provided a protein supplement with or without Micro-Aid® (MA; plant derived saponin). Steers were allowed ad libitum access to chopped prairie hay (49 g crude protein (CP)/kg DM and 738 g aNDF/kg DM) and randomly assigned to one of four treatments: (1) no supplement (C), (2) cottonseed meal and wheat middlings: 920 g DM/d (PC; positive control), (3) MA added to PC to supply 1 g MA/d (MA1), and (4) MA added to PC to supply 2 g MA/d (MA2). Steers were individually supplemented 920 g DM once daily at 08:00 along with a vitamin and mineral mix to ensure requirements were met. Orthogonal contrasts were used to determine the effects of protein supplementation, addition of MA and level of MA inclusion. During *in situ* phase, forage samples were incubated for a 96 h period. Protein supplementation increased DM intake (DMI), particulate passage rate (Kp), and rumen digestibility of DM and NDF ($P < 0.001$), but there was no effect on rumen N degradability. The inclusion of MA did not impact DMI in either phase. Compared to PC, MA decreased K_p (27.8 and 22.7 g DM/kg/h, respectively; $P = 0.02$), resulting in an increase in rumen aNDF and DM digestibility ($P < 0.001$). However, there was no influence of MA on apparent total tract digestibility in the metabolism phase. Rumen protozoa concentrations were suppressed ($P = 0.01$) with MA inclusion while lactate concentrations and microbial crude protein (MCP) flow to the small intestine were increased ($P = 0.05$). There was no impact on BUN, rumen ammonia, pH, volatile fatty acid (VFA) concentrations or N balance for MA compared to PC diets. Supplementation improved N balance, MCP synthesis and increased total concentrations of VFA and independent acetate and propionate concentrations. In conclusion, including MA in protein supplements increased rumen DM and a NDF digestibility of forage, reduced protozoa concentrations and increased daily outflow of MCP. This is indicative of increased rumen fermentation rate and may ultimately impact animal performance via increased energy and amino acid supply to the small intestine. However, more research is needed to validate this potential impact on animal performance.

Abbreviations: MA, Micro-Aid®; CP, crude protein; VFA, volatile fatty acid; BW, body weight; DM, dry matter; C, Control; PC, Positive Control; RDP, rumen degradable protein; NEm, net energy maintenance; NEg, net energy gain; K_d, fractional rate constant; aNDF, neutral detergent fiber inclusive of residual ash; ADF, acid detergent fiber inclusive of ash; ADIA, acid detergent insoluble ash; OM, organic matter; RD, rumen degradability; K_p, rate of particulate passage from the rumen; BUN, blood urea-N; RAN, rumen ammonia-N; MCP, microbial crude protein.

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1. Introduction

It is a common practice to supply additional protein to cattle consuming low-quality forage because of its positive impact on performance from increased intake and digestibility (McCollum and Horn, 1990). This results from meeting a deficiency in rumen ammonia-N (RAN) and is thought to be effective when the crude protein (CP) of forage is less than 70 g CP/kg dry matter (DM; McCollum and Horn, 1990). In the Southern Great Plains, it has been reported that standing native range pastures reach this minimum CP content in late July and continue to decline thereafter (McMurphy et al., 2011). This makes it imperative to provide supplemental protein to meet the CP demand and subsequent energy demand in grazing cattle when consuming low-quality native range. However, the cost of supplying purchased and harvested hay and concentrate feeds account for the majority of the nutrition costs associated with a cow–calf enterprise in the Southern Great Plains, which on average is nearly 40% of total operating costs (Lalman, 2008). Therefore, practices to improve efficiency of use of low-quality forage have been the recent focus of research in cattle consuming these diets.

Products such as ionophores can be added to these supplements to improve supplementation efficiency by shifting microbial populations toward the production of propionate and reducing the precursors for methanogenesis. There are limitations to supplying some ionophores to grazing cattle and producers are continually looking for options to improve efficiency while still having the option to market their cattle for use in natural finishing programs. Micro-Aid® (MA; DPI Global, Porterville, CA, USA) is a plant derived, dry or liquid feed additive for use in animal feeds. It is manufactured from a purified extract of the *Yucca schidigera* plant that grows in the southwest United States and Mexico and contains saponins. Saponins are either triterpenoids or steroids in nature and have a hydrophobic aglycone, more commonly named sarsapogenin, attached to a sugar (Wina et al., 2005). The interest in steroidal saponin technology, like those in MA, can be attributed to their known lytic action on rumen protozoa (Wallace et al., 1994). This action is believed to be due to their affinity to membrane sterols, particularly cholesterol (Glauert et al., 1962). The results of defaunating the rumen include, but are not limited to decreased bacterial proteolysis, improved N conservation, decreased methanogenesis, and a shift in VFA production toward propionate, which all improve animal efficiency. These benefits to animal efficiency may be a direct effect of reduced protozoa concentrations or mere functions of the yucca extract itself.

There are numerous products on the market utilizing saponin technology. However, not all manufacturers use the same procedures to harvest the phytogenic extract and incorporate it into an animal feed product. Most manufacturers mechanically macerate, grind and dry the trunk and root of the plant to produce a yucca powder; others squeeze these plant parts in a press to produce a yucca juice (Cheeke, 2000; Oleszek et al., 2001). These processes can yield differing concentrations of saponins in these products. Singer et al. (2008) assayed four commercial products, including MA, for their saponin concentrations and MA was reported to have 181.6 g sarsaponins/kg of DM compared to 189.1, 170.6 and 95.4 g sarsaponin/kg of DM for DK sarsaponin 30®, Alltech De-Odorase®, and Monterey Sarsaponin 15®, respectively. This suggests that MA is one of the more highly saponin concentrated products on the market and research is needed to determine if MA has an impact on fiber digestion in cattle consuming low-quality forage and supplemented with additional protein.

The objectives were to investigate the effects of two different MA inclusion rates, in a protein supplement, on *in situ* rumen degradation of low-quality forage and its components, rumen fermentation parameters, N metabolism, and total tract digestibility of low-quality forage and its components to determine if production efficiency could be improved with the use of MA. The hypotheses was that the inclusion of MA in supplements offered to forage-fed cattle would reduce protozoa populations and subsequently increase rumen digestibility of low-quality forage, improve N metabolism, and total tract digestibility of low-quality forage, ultimately improving production efficiency.

2. Materials and methods

This experiment was conducted at the Nutrition and Physiology Barn located on campus at Oklahoma State University in accordance with an approved Oklahoma State University Animal Care and Use Committee protocol.

2.1. Animals and diet

Sixteen ruminally cannulated, crossbred steers (529 ± 45 kg initial body weight; BW) were housed individually in slatted floor pens (2.4 m × 4.6 m) during *in situ* digestibility determination and individual stanchions for the metabolism phase of the trial. During both periods, steers were allowed ad libitum access to chopped prairie hay (5 cm; 930 g/kg DM, 46 g CP/kg DM, 8.67 MJ net energy maintenance (NEm)/kg DM, 3.69 MJ net energy gain (NEg)/kg DM, 757 g aNDF/kg DM, 42 g acid detergent insoluble ash (ADIA)/kg DM. Hay was harvested in late July 2008 from an old world bluestem (*Bothriochloa ischaemum*) meadow. Steers were randomly assigned to one of four supplement treatments in a completely randomized design. Supplement treatments (Table 1) included, (1) no supplement (C), (2) cottonseed meal and wheat middlings: 920 g DM/d (PC; positive control), (3) MA added to PC to supply 1 g MA/d (MA1), and (4) MA added to PC to supply 2 g MA/d (MA2). Treatment levels for MA were recommended by manufacturer based on previous proprietary research. Steers were provided 920 g DM of supplement once daily in order to meet rumen degradable protein requirements (RDP; NRC, 1996). A vitamin and mineral mix was provided in feed pans with supplement daily to all steers. Steers had continuous access to fresh water and diets were fed at 08:00 for 10 days prior to initiation of the study to allow for ruminal adaptation.