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Whole cottonseed supplementation improves performance and reduces methane emission intensity of grazing beef steers[1]

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ABSTRACT

The objective of this experiment was to determine the effect of level of whole cottonseed (WCS) supplementation on ADG and enteric CH_4 emissions of steers grazing tallgrass prairie in the summer. Steers (n = 18; initial BW = 316 ± 23 kg) were trained for 3 wk to use a portable, automated head-chamber system (GreenFeed; C-Lock Inc., Rapid City, SD). Steers were then offered from 0 to 2.9 kg/d (as fed) WCS in individual feeders for 43 d. Body weight was measured weekly before feeding. Total fat concentration of the diet (supplement + forage) at the greatest supplement intake was estimated to be 8.3% of DM. Body weight gain increased linearly as supplement intake increased ($P = 0.01$). Because of inadequate use of the automated head-chamber system by steers at the 0-kg WCS level, this level was excluded from further analysis. In supplemented steers, there was a tendency ($P = 0.1$) for a quadratic relationship between CH_4 emissions (g/animal per d) and supplement intake, with minimum CH_4 at 2.0 kg of supplement (WCS + bait) per day. Emission intensity (g of CH_4/kg of BW gain) also responded quadratically ($P < 0.004$) and was minimized at approximately 2.2 kg of supplement intake per day. The results of this experiment suggest that if WCS supplementation is used to mitigate CH_4 emission intensity in stocker cattle grazing tallgrass prairie in the early summer, a dose near 2 kg/d is suggested.

Key words: beef cattle, enteric methane, grazing, fat, whole cottonseed

INTRODUCTION

As much as 12% of the GE consumed by grazing cattle can be lost to the environment as CH_4 (Johnson and Johnson, 1995). Methane is a potent greenhouse gas and has 28 times the global warming potential of CO_2 (IPCC, 2013). Because of the negative effect that enteric CH_4 emission has on the GE utilization of beef cattle (NASEM, 2016) and the environment (Shepherd, 2011), there is a need to develop strategies to reduce CH_4 emissions without reducing net return to the beef cattle enterprise. Supplemental fat may reduce CH_4 emissions through 3 possible modes of action. First, fat may cause a reduction in DMI, which directly reduces CH_4 emissions (Eugène et al., 2008; Rabiee et al., 2012; Hristov et al., 2013). Second, unsaturated fatty acids may provide an alternative hydrogen sink to the rumen environment as they become saturated (Czerkawski et al., 1966; Dong et al., 1997; Johnson et al., 2002). However, this latter mode of action may only play a more minor role in the mitigation of enteric CH_4 (Hristov et al., 2013). Finally, fat (especially certain medium-chain fatty acids) may alter the rumen microbiome, depressing protozoa and archaea populations (Enjalbert et al., 2017). Supplemental fat has reduced CH_4 production in vitro (Dong et al., 1997) and in sheep fed oleic, linoleic, and linolenic acids (Czerkawski et al., 1966). Beauchemin et al. (2007) observed a reduction in CH_4 emissions when beef heifers were supplemented with tallow, sunflower oil, or whole sunflower seeds when these diets contained a total fat concentration of 5.9% of dietary DM. Whole cottonseed (**WCS**) is a popular and effective supplement to improve ADG of beef cattle grazing on the southern Great Plains (Rogers et al., 2002) because of its greater concentrations of RDP and ME. However, its effect on CH_4 emissions in forage diets is largely unknown (Johnson et al., 2002; Grainger et al., 2008). Thus, the objective of this experiment was to determine whether ADG and CH_4 emissions of stocker cattle are affected by level of WCS supplementation. We hypothesized that the added fat from WCS would depress CH_4 while also improving ADG.

The authors declare no conflict of interest.

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MATERIALS AND METHODS

All procedures used in this experiment conformed to the FASS Ag Guide (FASS, 2010). They were approved by the Oklahoma State University Institutional Animal Care and Use Committee (#AG-16–9).

Location and Pasture

The experiment was conducted between May 23, 2016, and July 5, 2016 (43 d) on a pasture dominated by warm-season, perennial grass located at the Oklahoma State University Bluestem Research Range, 11 km southwest of Stillwater, Oklahoma (36.073666, −97.186378; elevation, 331 m). The frost-free growth period is from April to October (Bodine and Purvis, 2003). Annual precipitation averages 1,069 mm with 63% occurring from d 120 to 300 of the year (1997–2017 data, OK Mesonet site "Marena," 2.7 km southwest of research location; McPherson et al., 2007). During the experiment, precipitation (221 mm) was 68% of normal and mean air temperature (22.3°C) was 99% of normal. The site is characterized as sandy loam savannah (R084AY075OK, Soil Survey Staff, Natural Resources Conservation Service, USDA, 2017). Predominate plants were characteristic for this ecological site and included big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), Indiangrass (*Sorghastrum nutans*), and little bluestem (*Schizachyrium scoparium*) and introduced forages, such as old world bluestem (*Bothriochloa ischaemum*).

Direct estimates of forage mass in the pasture were not available; however, this site annually produces approximately 4,500 kg of DM/ha (Soil Survey Staff, Natural Resources Conservation Service, USDA, 2017) in normal environmental conditions. Stocking rate was typical of commercial management, and forage allowance was not considered to limit animal performance (Sollenberger et al., 2005). To characterize nutritive value of the pasture, 3 samples of forage were collected during the experiment at approximately 21-d intervals by clipping all available forage to ground level inside 6 randomly placed quadrats. These samples were dried in a forced-air oven at 50°C, ground to pass a 1-mm screen, and submitted to a commercial laboratory for nutritive analysis. Forage contained 4.1 ± 0.2% CP, 43 ± 0.3% ADF, and 68 ± 0.6% NDF on a DM basis and was consistent across the 43-d experiment. Forage samples contained the previous year's growth, and it is likely that the actual diet the animals selected exceeded these values (Kirch et al., 2007).

The pasture contained free access to piped municipal water at the barn where supplementation occurred, and near the automated head-chamber system (**AHCS**; GreenFeed; C-Lock Inc., Rapid City, SD; described in the following). No major topographic restrictions inhibited animal access to the pasture or supplementation sites. No supplements (minerals and so on) were offered except the experimental supplements described below. Steers grazed the pasture continuously during the experiment except during the daily supplementation event described below.

Acclimation

Twenty-two crossbred *Bos taurus* steers (BW = 317 ± 23 kg; age approximately 8 mo) were acclimated to the individual feeding stalls (described below) and AHCS. This system allows the measurement of CH_4 and CO_2 emission and O_2 consumption by grazing ruminants. During the acclimation period (21 d, May 2 to May 23, 2016), the animals were pastured with the AHCS with the alley panels removed as described by Gunter and Bradford (2017). To encourage consistent use of the AHCS, the alley panels were then put in place and gradually narrowed until one animal at a time could enter and use the AHCS. Beginning the second week of acclimation, the steers were offered WCS. The WCS supplement was offered in individual feeding stalls in a pole barn adjacent to the paddock and separate from the AHCS. The AHCS was approximately 350 m away from the barn. To train the steers to eat the WCS, 0.9 kg of WCS was mixed with a protein supplement that the steers were fed before the experiment. As the second week progressed, less protein supplement was added until the steers consumed only WCS. During the third week of acclimation, 1.8 kg of WCS was offered to each steer.

Animals and Feeding

After acclimation, 18 steers were selected that most consistently used the AHCS. Steers were stratified by AHCS visits, and 3 steers were randomly assigned to each WCS supplementation level (0, 0.9, 1.8, 2.7, 3.6, or 4.5 kg of WCS/d on an as-fed basis). During the first 2 wk of the experiment, animals were housed in a 6-ha pasture to keep the steers closer to the AHCS. After 2 wk, the pasture was expanded to 16 ha by removal of a temporary fence. Each day at 0800 h, all steers were gathered and driven to the barn and were offered supplemental WCS in 1.8 × 0.9 × 0.6-m individual stalls (0-kg WCS steers were held in a small pen). Steers were allowed 30 min to consume WCS, and then the steers were returned to the pasture (with access to the AHCS) and orts were weighed. Actual intake of WCS was used in further analysis of the relationship between WCS supplementation and ADG and CH_4. Steers were weighed (unshrunk) weekly before feeding at 0730 h on validated scales, and ADG was estimated by regressing on date within steer. On d 6, a steer from the 0-kg WCS level was replaced with another steer because of an unrelated health issue.

Methane Measurement

Methane emissions were recorded by the AHCS each time an animal visited. During a visit to the AHCS, air is drawn around the animal's head and shoulders to capture the exhaled breath cloud. This air is sampled and sub-