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The effect of dietary coconut kernels, whole cottonseeds and sunflower seeds on the intake, digestibility and enteric methane emissions of Zebu beef cattle fed rice straw based diets

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ABSTRACT

Methane emissions from ruminant livestock are problematic with respect to the energy utilization efficiency of animal feed as well as environmental sustainability due to such emissions being a major greenhouse gas source. The objective of this experiment was to determine the methane emissions and feeding performance of two breeds of Zebu beef cattle fed rice straw based diets with oil plant inclusion. Eight mature bulls (four Thai native and four Brahman crossbred beef cattle weighing 290 ± 10.2 and 401 ± 29.7 kg (mean $\pm$ SD), respectively) were assigned to a replicated 4×4 Latin square design with 21 day periods. The following dietary treatments were assigned: 1=control diet, 2=whole cottonseed diet, 3=whole sunflower seed diet and 4=coconut kernel diet. The animals were individually placed in metabolic cages and respiration chambers to determine feed intake, total tract digestibility and methane emissions. The two cattle breeds were not different in their dry matter intake per body weight (or metabolic body weight) and digestibility, but the corresponding values for the oil plant dietary treatments were less ($P < 0.001$) than those for the control diet. All of the oil plant treatments decreased ($P < 0.001$) the dry matter and NDF digestibility compared to the control diet, but the oil plants had no effect on ruminal pH, ammonia nitrogen or total volatile fatty acid concentration. The methane emissions of the Brahman crossbred beef cattle were greater ($P < 0.001$) than those of the Thai native cattle (135.4 and 171.5 L/day), but there was no difference ($P > 0.05$) when corrected for dry matter intake, organic matter intake, metabolic size or gross energy intake. The methane emission rate was reduced ($P < 0.001$) by up to 50.1% by the oil plant feeding strategy compared to the control diet. The methane emission rate of the base line typical feeding system in the control diet (10.4%) appeared to be much greater than the Intergovernmental Panel on Climate Change value of 6.5% for cattle fed low-quality crop residues or by-products. Our results demonstrated that methane emissions did not differ between Zebu beef cattle when corrected for metabolic body weight and feed or gross energy intake. The inclusion of oil plants in the diets, such as the coconut kernel, sunflower seed and cottonseed, affects intake, digestibility and potentially be used as an enteric methane mitigation feeding strategy.

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1. Introduction

The Food and Agriculture Organization of the United Nations (FAO) reported that greenhouse gas emissions from the livestock sector represent 18% of the global greenhouse gas emissions and that the enteric methane emissions from ruminant represent 37% of the greenhouse gas that contributes to climate change in the livestock sector (Steinfeld et al., 2006). Methane is produced by methanogenic Archaea during feed energy utilization within the rumen. The loss of methane energy from ruminant livestock is also a critical priority regarding feed energy utilization and animal productivity (Blaxter, 1989; Johnson and Johnson, 1995; Kurihara et al., 1999). Therefore, methane mitigation feeding strategies are a priority for improving animal productivity and environmental sustainability (Beauchemin et al., 2011; Capper and Buaman, 2013; De Vries and De Boer, 2010; Ogino et al., 2004, 2007).

Feeding strategies with a high potential for reducing methane emissions and improving rumen fermentation efficiency using dietary manipulation have been extensively reviewed (Capper and Buaman, 2013; Eckard et al., 2010; Mitsumori and Sun, 2008; Shibata and Terada, 2010). Herbaceous and extract plant secondary compounds (*e.g.*, phenol tannins or saponin) have recently been demonstrated to reduce methane emission and alter methanogen populations (Manasri et al., 2012; Sommart et al., 2012; Staerfl et al., 2012). The addition of oil plants to ruminant diets also likely increased dietary energy density strategic feeding, modifying rumen digestion and fermentation processes to mitigate methane production (Blaxter and Czerkawski, 1966; Capper and Buaman, 2013; Cieślak et al., 2006; Lovett et al., 2003; Machmüller et al., 2000). This assumption was confirmed by the results of Jordan et al. (2006b), who reported that feeding treatment diets combined with whole soybeans or refined soy oil decreased enteric methane by approximately 25.3% and 39.1%, respectively. Grainger et al. (2010), who included cottonseed in the diet, and McGinn et al. (2004), who studied sunflower oil supplementation, reduced methane emissions by 17.1% and 21.5%, respectively. Using an *in vitro* technique, Chuntrakort et al. (2011) demonstrated that the supplementation of cottonseed, sunflower seed and coconut kernels reduced methane emissions by approximately 9.0% compared to a control diet. However, research that focuses on feeding strategies for enteric methane mitigation *in vivo* using a respiration chamber in the tropics remains limited.

Cattle and buffalo populations are four times greater in tropical developing countries than developed countries (FAO, 2012); however, meat production is lower, which indicates that ruminant production efficiency is poor. The Brahman (Zebu cattle; *Bos indicus*) is the predominant breed in cattle production in the tropics. The tropical feed resources available for ruminants in developing countries are typically scarce and of poor quality. According to the Intergovernmental Panel on Climate Change (IPCC) guidelines for global or national inventories, which estimates methane from enteric fermentation emissions using a Tier 2 approach, a default value of 6.5% for the proportion of methane energy emission to gross energy intake (methane emission rate, Y_m) was established based on limited data from Zebu (IPCC, 2006; Kurihara et al., 1999; Steinfeld et al., 2006).

Therefore, the purpose of our study was to compare the effect of dietary oil plant supplementation on the methane emissions in two breeds of Zebu (Thai native and Brahman crossbred cattle).

2. Materials and methods

This experiment was conducted at the Khon Kaen Animal Nutrition Research and Development Center, Khon Kaen Province, Thailand (16.34°N, 102.82°E), from November 11, 2010, to February 23, 2011. All animal related procedures were conducted in accordance with the Guide for the Care and Use of Experimental Animals (Curtis and Nimz, 1988) with permission of the Graduate School, Khon Kaen University.

2.1. Animals, experimental design and diets

Four male Thai native cattle (mature stage, age 3 years, weighing 290 ± 10.2 kg (mean ± SD)) and four Brahman crossbred cattle (mature stage, age 4 years, weighing 401 ± 29.7 kg (mean ± SD)) were arranged in a replicated 4×4 Latin square design using animal breed in a separate square with four periods and four treatment diets. Each experimental period lasted 21 days. The feed ingredient, formulation and chemical composition of the four dietary treatments are shown in Table 1. The four dietary treatments were supplemented with oil plants: 1 = control diet, 2 = whole cottonseed diet, 3 = whole sunflower seed diet and 4 = coconut kernel diet. The oil plant was formulated to replace a portion of the concentrate to obtain isonitrogenous dietary treatments. The feed ingredients and oil plant (whole cottonseed, whole sunflower seed) feedstuffs were obtained from Khon Kaen dairy feed and local suppliers in Khon Kaen province. Coconut kernels were obtained from a Khon Kaen fresh market. After collection, the coconut was sundried for 2 days and then stored in a tightly closed plastic bag in a dry place before weekly use.

The animals were fed the assigned dietary treatments at 09.30 and 17.30 each day at a fixed rate of $1.2 \times ME_m$ (metabolizable energy for maintenance), with ME_m equal to 484 kJ/kg $BW^{0.75}$ according to the Working Committee of Thai Feeding Standard for Ruminant (WTSR, 2010). The animals were weighed individually using a calibrated electronic scale (Fx11, capacity 2000 kg, ALLflex New Zealand Limited, New Zealand) on the initial day of each experimental period before the commencement of the experiment, and their body weights determined the feed allocation. The animals were kept in individual pens and provided with clean water and mineral blocks (FNZ Red Lick, Thai Serve Co. Ltd.; NaCl 930.00 g, Mg 2.00 g, Zn 0.77 g, Mn 0.50 g, Co 18.00 g, I 0.05 g, Se 0.01 g, Cu 0.22 g, other 2.50 g) at all times. The vitamin supplement AD_3E (Phoenix, Belgium; vitamin A 300,000 IU, vitamin D_3 100,000 IU, vitamin E acetate 50 mg; 1 mL per 50 kg live weight use) was provided intra-muscularly to all animals at the beginning of the experiment.