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Effects of soybean meal or canola meal on milk production and methane emissions in lactating dairy cows fed grass silage-based diets

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ABSTRACT

This study evaluated the effects of soybean meal (SBM) and heat-moisture-treated canola meal (TCM) on milk production and methane emissions in dairy cows fed grass silage-based diets. Twenty-eight Swedish Red cows were used in a cyclic change-over experiment with 4 periods of 21 d and with treatments in 2 × 4 factorial arrangement (however, the control diet without supplementary protein was not fed in replicate). The diets were fed ad libitum as a total mixed ration containing 600 g/kg of grass silage and 400 g/kg of concentrates on a dry matter (DM) basis. The concentrate without supplementary protein consisted of crimped barley and premix (312 and 88 g/kg of DM), providing 130 g of dietary crude protein (CP)/kg of DM. The other 6 concentrates were formulated to provide 170, 210, or 250 g of CP/kg of DM by replacing crimped barley with incremental amounts of SBM (50, 100, or 150 g/kg of diet DM) or TCM (70, 140, or 210 g/kg of diet DM). Feed intake was not influenced by dietary CP concentration, but tended to be greater in cows fed TCM diets compared with SBM diets. Milk and milk protein yield increased linearly with dietary CP concentration, with greater responses in cows fed TCM diets compared with SBM diets. Apparent N efficiency (milk N/N intake) decreased linearly with increasing dietary CP concentration and was lower for cows fed SBM diets than cows fed TCM diets. Milk urea concentration increased linearly with increased dietary CP concentration, with greater effects in cows fed SBM diets than in cows fed TCM diets. Plasma concentrations of total AA and essential AA increased with increasing dietary CP concentration, but no differences were observed between the 2 protein sources. Plasma concentrations of Lys, Met, and His were similar for both dietary protein sources. Total methane emissions were not influenced by diet, but emissions per kilogram of DM intake decreased quadratically, with the lowest value observed in cows fed intermediate levels of protein supplementation. Methane emissions per kilogram of energy-corrected milk decreased more when dietary CP concentration increased in TCM diets compared with SBM diets. Overall, replacing SBM with TCM in total mixed rations based on grass silage had beneficial effects on milk production, N efficiency, and methane emissions across a wide range of dietary CP concentrations.

Key words: crude protein, dairy cow, methane emissions, nitrogen efficiency

INTRODUCTION

On dairy farms, finding the most efficient ways to convert plant protein into nutritious milk for human consumption is a key factor in improving farm profitability and decreasing environmental emissions. Soybean meal (**SBM**) is a common human food worldwide. It is also the most commonly used protein supplement for pigs and poultry and, in addition, is fed widely to dairy and beef cattle. However, marginal milk protein yield responses are small in cows fed grass silage-based diets (Huhtanen et al., 2011). Inclusion of canola meal (**CM**) in dairy rations increases DMI and yield of milk and milk protein compared with SBM (Huhtanen et al., 2011), and also compared with other protein sources (Martineau et al., 2013). The positive effects of CM on milk production have been attributed to increased His supply (Shingfield et al., 2003) and, more recently, to increased absorption of EAA (Martineau et al., 2014).

Most comparisons of CM and SBM in dairy cow diets performed to date have used separate feeding of forages and concentrates, although TMR systems have become more common. Feeding dairy cows with TMR or using frequent feedings compared with 2 feedings per day decreases rumen ammonia concentration (Carroll et al., 1988) and increases rumen pH (Robinson and McQueen, 1994). These results indicate better synchrony of ruminal degradation of protein and carbohydrates, which can improve the efficiency of microbial protein

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synthesis. It is possible that this improved efficiency of microbial protein synthesis in cows fed TMR frequently can reduce the quality requirement on the protein supplement, specifically with regard to effects on N utilization efficiency. The first aim of this study was therefore to investigate the production responses to graded levels of SBM or heat-moisture-treated CM (**TCM**) supplementation in dairy cows fed TMR based on grass silage and crimped barley. Higher levels of supplementation than in previous studies (Rinne et al., 1999; Shingfield et al., 2003) were also tested to identify the optimal dietary levels of CP from the 2 protein supplements used. The second aim was derived from Murphy et al. (1982) and Bannink et al. (2006) who with stoichiometric equations showed that it seems like ruminal fermentation of dietary CP result in less CH_4 production than fermentation of carbohydrates. Therefore, we found it to be of high interest to study this in a production trial comparing increased dietary CP concentration and the 2 most common protein supplements, SBM and CM.

MATERIALS AND METHODS

All animals were registered and cared for according to guidelines approved by the Swedish University of Agricultural Sciences Animal Care and Use Committee and the National Animal Research Authority, and the experiment was carried out in accordance with the laws and regulations controlling experiments performed with live animals in Sweden.

Experimental Design and Animals

The production trial was conducted at the Department of Agricultural Research for Northern Sweden, Swedish University of Agricultural Sciences, Umeå (63°45′N; 20°17′E). Twenty-eight lactating Swedish Red dairy cows at a mean 88 DIM (SD = 27) and yielding 34.9 kg milk per day (SD = 6.6) at the start of the trial were used. The experiment was conducted using a cyclic changeover design in 4 periods, with 2 replicates of 2 blocks (Davis and Hall, 1969). The treatments were provided in a 2 × 4 factorial arrangement consisting of 2 protein supplements (SBM and TCM) and 4 levels of CP concentration. The control diet without protein supplement was not repeated between SBM and TCM treatments, which resulted in a total of 7 experimental diets. Each period lasted for 21 d, divided into 14 d of adaptation and 7 d of data recording and sampling. The cows were assigned to blocks according to parity and milk yield. Within the block, the cows were randomly allocated to 1 of the 7 treatments. The cows were kept in an insulated loose-housing system and were milked twice a day, at 0600 and 1500 h. They were fed TMR ad libitum, with free access to drinking water. A stationary feed mixer (Nolan A/S, Viborg, Denmark) processed the rations, which were then delivered with automatic feeder wagons into feed troughs 4 times a day (0330, 0800, 1300, and 1730 h). During the entire trial, each cow had access to the same 2 feed troughs. The amount of feed delivered to the feed troughs was monitored daily to allow ad libitum feeding, and the feed troughs were cleaned daily.

Diets

The formulation of the experimental diets is given in Table 1. The 7 dietary treatments consisted of 600 g/kg of DM of silage, supplemented with 100 g/kg of DM of a premix manufactured to meet mineral and vitamin requirements (Fodercentralen, Umeå, Sweden), and 300 g/kg of DM of crimped barley aiming for a concentrate CP concentration of 130 g/kg of DM. The concentrate CP was manipulated by replacing crimped barley with SBM or TCM to reach concentrate CP concentrations of 170, 210, and 250 g/kg of DM. The DM concentration of all feeds was determined once a week and the TMR was adjusted accordingly during the whole trial. The forage consisted of 2 silages (50:50 on DM basis) harvested from different primary growth grass swards in Umeå, both dominated by timothy along with some red clover. The silages were harvested with a mower conditioner and precision-chop forage harvester between June 10 and 15, 2012, and stored in bunker silos. They were preserved using an acid-based additive (PromyrTM XR 630, Perstorp, Sweden) provided at a rate of 3.5 L/t. The crimped barley (778 g/kg of DM) was rolled using a mill (Murska 1400 S2 × 2, Murska, Ylivieska, Finland) adjusted to 0.3 mm between the rollers, treated with 3.5 L/t of propionic acid, and stored in airtight bags (1.6 m × 60 m, Ltd. Rani Plast Oy, Terjärv, Finland). The SBM used in the study was solvent-extracted (Lantmännen, Umeå, Sweden). The TCM was the commercial product ExPro-00SF from AarhusKarlshamn Ltd. (Malmö, Sweden). ExPro-00SF consists of solvent-extracted CM containing low levels of glucosinolates and erucic acid treated by an industrial heat-moisture procedure.

Recordings and Sampling

Individual feed intake was recorded daily throughout the trial in Roughage Intake Control feeders (Insentec B. V., Marknesse, the Netherlands), but the data used for statistical analysis were limited to d 15 to 21 in every period. The cows were weighed before the start of the trial and subsequently after morning milking on