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Effect of substituting soybean meal and canola cake with grain-based dried distillers grains with solubles as a protein source on feed intake, milk production, and milk quality in dairy cows

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ABSTRACT

The growth of the bioethanol industry is leading to an increase in the production of coproducts such as dried distillers grains with solubles (DDGS). Both corn-based DDGS and grain-based DDGS (gDDGS; defined as originating from grain sources such as barley, wheat, triticale, or a mix, excluding corn) appear to be relevant sources of feed and protein for dairy cows. To date, most of the studies investigating DDGS have been performed with corn-based DDGS. The objectives of this study were to determine the effects of the proportion of gDDGS in the diet on feed intake, milk production, and milk quality. The present experiment involved 48 Holstein cows in a replicated 3 × 3 Latin square design with 3 grass-based dietary treatments consisting of 4, 13.5, and 23% gDDGS on a dry matter (DM) basis (L, M, and H, respectively) as a replacement for a concentrate mix. The concentrate mix consisted of soybean meal, canola cake, and beet pulp. Dry matter intake and energy-corrected milk yield were not affected by the proportion of gDDGS in the diet. Daily milk yield decreased with the H diet compared with the L and M diets. The percentage of fat in milk was higher when cows were fed the H diet compared with the L and M diets, whereas milk fat yield was not affected by dietary treatment. The M diet had a higher percentage of protein in milk compared with the L and H diets. Milk protein yield was similar for the L and M diets; however, it decreased for the H diet. Milk taste was not affected by the proportion of gDDGS in the diet or when milk was stored for 7 d. Linoleic acid and conjugated linoleic acid *cis*-9,*trans*-11 in milk increased with increasing proportion of gDDGS. To conclude, gDDGS can replace soybean meal and canola cake as a protein source in the diet of dairy cows. Up to 13.5% of the diet may consist of gDDGS without negatively affecting milk production, milk quality, or milk taste. When gDDGS represents 23% of dietary DM, milk production is reduced by 1.6 kg/d, whereas energy-corrected milk production is numerically reduced by 1 kg.
Key words: dairy cow, dried distillers grains with solubles, protein source, coproduct

INTRODUCTION

The growth of the bioethanol industry is resulting in increased production of coproducts, such as dried distillers grains with solubles (**DDGS**). The composition and quality of DDGS vary (Belyea et al., 2010) depending on the type of feedstock used (typically corn or another type of grain, such as wheat, barley, or triticale), the processing steps used during ethanol production, and the subsequent mixing and drying of distillers grains and solubles (Azarfar et al., 2012; Li et al., 2012; Pedersen et al., 2014). It has been documented that DDGS is a relevant feed for dairy cows because it is high in CP protein and fiber; however, thus far, most experiments have been conducted using corn-based DDGS (**cDDGS**) in combination with corn silage-based diets (De Boever et al., 2014; Pedersen et al., 2014). The high content of CP in both cDDGS (271–364 g/kg of DM; Pedersen et al., 2014) and the other grain-based DDGS (**gDDGS**; wheat DDGS with 303–383 g of CP/kg of DM; Pedersen et al., 2014) makes DDGS an interesting alternative feed protein source. The proteins in DDGS are moderately resistant to ruminal degradation and are a good source of RUP (55.6 and 59.3% of CP for wheat and wheat-and-corn gDDGS, respectively, and 69.8% of CP for cDDGS; De Boever et al., 2014). Christen et al. (2010) tested 4 different sources of feed protein: soybean meal, high-protein cDDGS, cDDGS, and canola

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meal. The diets were formulated to be isonitrogenous at 16% CP and isolipidic at 4.7% fat. Christen et al. (2010) found that DMI, milk yield, protein yield, and fat yield were similar for the 4 treatments. Oba et al. (2010) arrived at a similar conclusion when comparing 4 different sources of protein: triticale-based DDGS, cDDGS, soybean meal, and canola meal. Results for the effects of DDGS on fat content in milk are variable; however, most of the studies reported no changes in milk fat content when cows were fed DDGS diets compared with other diets (Kleinschmit et al., 2006; Janicek et al., 2008). Overall, cDDGS had no negative effect on milk yield and milk composition (Christen et al., 2010; Oba et al., 2010; Benchaar et al., 2013).

When testing the effects of increasing the proportion of cDDGS in the diet (0, 10, 20, and 30% of DM) at the expense of corn and soybean meal, Benchaar et al. (2013) found that milk yield, DMI, and milk protein yield increased with increasing proportion of cDDGS, whereas milk fat yield was not affected by the proportion of cDDGS. The meta-analysis of Hollmann et al. (2011), based on 16 studies, reported an increase in milk yield with increasing proportion of cDDGS in the diet, peaking at 1.2 kg of additional milk/d at 21% cDDGS of diet DM basis. Milk fat concentration was not affected by dietary cDDGS when the diet contained less than 21% of cDDGS (Hollmann et al., 2011). Reported effects of cDDGS on milk fat content have been variable among studies, making it difficult to define the optimum inclusion level of cDDGS in the diet. Leonardi et al. (2005) found no change in milk fat content when the proportion of cDDGS increased from 0 to 15% of dietary DM. Overall, the inclusion of cDDGS, up to 20% of dietary DM, would increase milk yield and maintain milk components (Leonardi et al., 2005; Anderson et al., 2006; Kleinschmit et al., 2006). Janicek et al. (2008) also found no negative effect on lactation performance when including up to 30% cDDGS of diet DM basis; however, above 30% inclusion, the DMI and milk yield decreased (Owen and Larson, 1991; Kalscheur, 2005). Lysine was the most limiting AA for milk protein synthesis when cDDGS replaced soybean meal (Owen and Larson, 1991; Kleinschmit et al., 2006).

In Europe and Canada, wheat and grain blends are commonly used as substrates for bioethanol production (De Boever et al., 2014), and in Northern Europe, gDDGS are exclusively used in dairy feeds. Few studies have focused on the inclusion of gDDGS in a feed ration for dairy cows. Triticale-based DDGS seems to have the same advantages as cDDGS (Oba et al., 2010) and does not impair the productivity of lactating dairy cows (Greter et al., 2008), encouraging further investigations into the use of gDDGS. To our knowledge, the inclusion of gDDGS as a protein feed in a grass-clover-based diet for dairy cows, as used in Northern Europe, has not been studied yet. The present experiment involved 3 grass-clover-based diets with different ratios of 2 feed protein sources: gDDGS (originating from triticale, wheat, and barley) and a soybean–canola mix. The objective was to determine the effects of increasing the proportion of gDDGS in the diet on feed intake, milk production, and milk quality. We hypothesized that the inclusion of gDDGS at the levels tested would not have negative effects on milk production, milk quality, or milk taste.

MATERIALS AND METHODS

Experimental Facilities and Animals

The experiment was approved by the Animal Experiments Inspectorate under the Danish Veterinary and Food Administration and was carried out from March to May 2013 at the Danish Cattle Research Centre at Aarhus University, Foulum, Denmark. A total of 48 Danish Holstein cows (18 primiparous and 30 multiparous) were included in the experiment. The animals were housed as one group in a loose housing system with slatted floors and cubicles with mattresses and sawdust as bedding. Cows had free access to water and automatic feed bins (RIC system, Insentec, Marknesse, the Netherlands). The automatic milking unit (**AMU**; DeLaval AB, Tumba, Sweden) was equipped with a device for delivering and recording the amount of concentrate and refusals.

Experimental Design

The experimental animals were blocked according to parity (primiparous and multiparous), milk production (average of 38 ± 9 kg of milk/d), and DIM (average of 88 ± 78 DIM when starting the experiment) and randomly assigned to treatments within blocks. The experiment was organized as a replicated 3 × 3 Latin square design with 3 dietary treatments. Sampling occurred during the third week of each period. The cows received a partially mixed ration (**PMR**) ad libitum in automatic feeders. Feed was added to feeders 4 times/d to minimize feed sorting effect. Cows also received restricted amounts of concentrate in the AMU (3 kg of concentrate/d). If a cow ate less than the daily 3 kg of concentrate allowed in the AMU, the amount not eaten (up to 1.5 kg) was allowed on top of the 3-kg allowance on the following day. Each group of cows had access to one third of the available automatic feeders for the PMR, with an average of 2 cows/feeder. During diet rotation, the cows kept the same feeders to avoid any perturbation effect. The composition of the 3 diets is