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Effect of grain- or by-product-based concentrate fed with early- or late-harvested first-cut grass silage on dairy cow performance

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ABSTRACT

This study compared the effects of a grain-based conventional concentrate (GC) and a concentrate based on agro-industrial by-products (BC), fed with grass silage harvested at early (ES) or late (LS) maturity stage, on dairy performance, CH_4 and CO_2 emissions, and metabolic status of dairy cows. Twenty lactating Nordic Red cows averaging 81 d in milk and 31.9 kg of milk/d pre-trial were assigned to a replicated 4 × 4 Latin square design. Dietary treatments were in a 2 × 2 factorial arrangement. The silages were harvested 2 wk apart from the same primary growth grass ley. The GC was made from oats, barley and wheat, and soybean meal, whereas the BC contained sugar beet pulp, wheat bran, canola meal, distillers dried grains, palm kernel expeller, and molasses. The diets were fed ad libitum as total mixed rations and were formulated from 661 g/kg of silage, 326 g/kg of concentrate, and 13 g/kg of minerals on a dry matter basis. The BC supplied the cows with less energy. Despite this, milk yield and composition were unaffected by concentrate type, except that milk protein was 0.7 g/kg lower in cows fed BC than in those fed GC. These results were accompanied by a 44 g/kg decrease in total-tract digestibility of crude protein and a 54 g/kg increase in neutral detergent fiber digestibility for cows fed BC. Cows fed ES on average consumed 2 kg/d more dry matter and yielded 3.5 kg/d more milk, 149 g/d more protein, and 141 g/d more fat than cows fed LS. There were few interaction effects between concentrate and silage sources on daily intake and dairy performance. However, edible feed conversion ratio (human-edible output in animal/potentially human-edible feed) showed greater improvements with ES than LS when replacing GC with BC. Feeding diets with late-cut silage generally reduced digestibility and energy utilization efficiency, but improved N utilization efficiency. Feeding LS also led to greater CH_4 yield and CH_4/CO_2 ratio, and higher plasma concentration of nonesterified fatty acids. Plasma parameters reflecting energy metabolism and inflammation were all within the normal ranges, indicating that the cows were in good health during the experiment. In conclusion, a conventional concentrate can be replaced by agro-industrial by-products without compromising production in early lactation dairy cows. However, silage maturity has a stronger effect on the production traits of dairy cows than type of concentrate.

Key words: by-products, dairy cow, energy utilization, grass silage, milk production

INTRODUCTION

In many farming systems worldwide, a large proportion of feed resources fed to dairy cows could instead be used directly as human foods, or utilized with higher efficiency in poultry and pig production. Demand to increase food production and to secure national food supply is growing (FAO, 2011; Eisler et al., 2014). Feeding agro-industrial by-products has recently been suggested as an efficient option to improve sustainability in terms of human-edible output, calculated as animal products minus potentially human-edible input of feedstuffs, in dairy production systems (Ertl et al., 2015b, 2016).

A total recorded use of agro-industrial by-products of 535,989 t in commercial feeds for farm animals was recorded in Sweden in 2014 (Swedish Board of Agriculture, 2014). As much as 80% of the by-products was used for ruminants and most of that was produced nationally. Some previous studies have demonstrated that soybean meal (**SBM**) can be successfully replaced with canola meal (**CM**) in grass silage-based diets to dairy cows without compromising production (Shingfield et al., 2003; Huhtanen et al., 2011; Martineau et al., 2013). However, in Sweden imported canola by-products cover 20% of the total amount of agro-industrial by-products used in ruminant production systems, while at the

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same time there is a surplus of dried distillers grain (**DDG**), which is exported to Europe (Swedish Board of Agriculture, 2014). Efficient use of non-human edible feed resources produced nationally could improve the resource efficiency of dairy food production. Additionally, restrictions on use of animal protein and genetically modified crops in the European Union (**EU**) motivate use of available agro-industrial by-products as alternative dietary ingredients for dairy cows.

Previous research has mainly focused on replacing single feed ingredients with agro-industrial by-products in diets to dairy cows. Apart from replacing pulses, an objective has often been to investigate and develop lower starch feeding strategies, to improve farm profitability and animal health in dairy production (e.g., Voelker and Allen, 2003; Dann et al., 2014; Ertl et al., 2016). Wheat bran and sugar beet pulp (**SBP**) are the most widely used nonforage fiber sources (**NFFS**) derived from agro-industries in Swedish ruminant production systems (Swedish Board of Agriculture, 2014). While milk production responses vary, some studies report improved or equivalent dairy performance when replacing grain-based concentrate with NFFS (Bradford and Mullins, 2012). Ertl et al. (2016) concluded that inclusion of additional fiber sources such as SBP and wheat bran does not impair milk production compared with supplementing with an organic grain-based concentrate. However, care should be taken in extrapolating these results to dairy cows earlier in lactation.

Compared with CM, wheat DDG contains less CP (387 vs. 315 g/kg of DM; Franco et al., 2017) and is a poorer source of lysine (49 vs. 25 g/kg of CP; Maxin et al., 2013). Martineau et al. (2013) established in a meta-analysis that replacement of protein supplements other than SBM, including DDG, with CM induces positive responses in milk and milk protein yield across a variety of forages.

The objective of this study was to compare a concentrate made solely from agro-industrial by-products, supplemented with equal amounts of CM and DDG as protein sources, with a conventional grain-based concentrate supplemented with SBM as the protein source, fed with 2 grass silages harvested at different maturity stages to lactating dairy cows. We hypothesized that a concentrate made completely from agro-industrial by-products, containing equal amounts of CM and DDG as protein sources and combined with early harvested grass silage, would not compromise dairy production or negatively affect environmental emissions. Parameters studied in the experiment included dairy cow performance, diet digestibility, energy and N utilization, CH_4 and CO_2 emissions, and plasma blood parameters indicative of cow metabolic status.

MATERIALS AND METHODS

The experiment was carried out during autumn 2015 at Röbäcksdalen research station, Swedish University of Agricultural Sciences in Umeå, Sweden (63°45′N; 20°17′E). The study was carried out with the permission of the Swedish Ethics Committee on Animal Research (Umeå, Sweden) and in accordance with Swedish laws and regulations regarding EU Directive 2010/63/EU on animal research.

Cows, Experimental Design, and Diets

Twenty lactating Nordic Red cows (12 multiparous and 8 primiparous) were used in a replicated 4 × 4 Latin square design. At the beginning of the experiment, the multiparous cows were on average (mean ± SE) at 86 ± 9.1 DIM, 633 ± 20.8 kg of BW, and producing 34.4 ± 0.92 kg of milk/d. The corresponding figures for the primiparous cows were 72 ± 9.6 DIM, 538 ± 16.3 kg of BW, and 28.0 ± 1.15 kg of milk/d. The cows were housed in an insulated loose housing barn and milked twice per day, at 0600 and 1500 h. The cows were fed a TMR ad libitum and given free access to water. The diets were mixed using a TMR mixer (Nolan A/S, Viborg, Denmark) and delivered in the feed troughs 4 times per day by an automatic feeding wagon. The cows were blocked according to milk yield and parity, and randomly assigned to treatments within block. Each experimental period lasted 21 d, and data recordings and samplings were conducted during the last 7 d.

The dietary treatments were in a 2 × 2 factorial arrangement, consisting of a grain-based concentrate (**GC**) or a concentrate made from agro-industrial by-products (**BC**), fed with either early- (**ES**) or late-harvested grass silage (**LS**; Table 1). The grass silages had different predicted digestible OM concentration (**DOM**; 744 and 662 g/kg of DM) and were harvested 2 wk apart (June 17 and July 1, 2015) from primary growth of a third-year timothy (*Phleum pratense*) ley. An acid-based additive (Promyr XR 630, Perstorp, Sweden) was used at a rate of 3.5 L/t to preserve the silages, which were ensiled and stored in bunker silos after wilting overnight. The concentrates were produced by Lantmännen Lantbruk AB (Malmö, Sweden) and composed to be isonitrogenous. The GC was formulated from (g/kg of feed) oats (273), barley (273), wheat (273), and SBM (141); the BC consisted of (g/kg feed) SBP (579), wheat bran (42), palm kernel cake (30), DDG (160), and heat-treated CM (141). The diet combining GC and ES was formulated to support milk production up to 35 kg of ECM (LUKE, 2017).