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The effect of by-product inclusion level on milk production, nutrient digestibility and excretion, and rumen fermentation parameters in lactating dairy cows offered a pasture-based diet

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ABSTRACT

The objective of this study was to investigate the effects of replacing barley and soybean meal with increasing levels of by-products on production, digestive, and metabolic parameters in early-mid lactation dairy cows offered perennial ryegrass-based pasture. Forty-eight (32 multiparous and 16 primiparous) dairy cows that were 64 ± 24 d in milk were assigned to 1 of 4 pasture-based dietary treatments (n = 12) in a randomized block design experiment that ran for 70 d. Treatments consisted of a perennial ryegrass-based pasture and 1 of 4 supplementary concentrates: BP35, BP55, BP75, and BP95 containing 35, 55, 75, and 95% by-products, respectively, in the concentrate on a dry matter basis. The by-products used were soyhulls, dried distillers grains, and palm kernel extract in equal proportions. Barley and soybean meal were replaced as by-product inclusion level increased. In this study, intakes of pasture dry matter (15.7 kg) and total dry matter (21.1 kg) were not affected by treatment. Similarly, milk production parameters (milk yield, milk composition, somatic cell count, and urea) were not different between treatments. Unsaturated fatty acids were lower in the milk of cows offered BP35 and BP55 compared with those offered BP75 and BP95. Concentrations of β-hydroxybutyrate, nonesterified fatty acids, and other blood metabolites were within normal range and did not differ between treatments, and cow body condition score and body weight were also not different. Equally, N was unaffected by diet. Blood urea N was lower in the BP75 group compared with BP35. This study demonstrated that barley and soybean meal can be replaced with soyhulls, dried distillers grains, and palm kernel extract without affecting milk production, digestive, or metabolic parameters in dairy cows offered a pasture-based diet.

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INTRODUCTION

One of the fundamental advantages of ruminant production systems is the ability to convert low-quality feedstuffs into meat and milk that are digestible by humans. This has been an advantage to Ireland as well as other temperate regions of the world where high yields of quality pasture are achievable, allowing for relatively low cost systems of dairy production (Dillon et al., 2008). However, pasture growth is seasonal and it can be difficult to achieve sufficient intake to support the nutrient requirements of the dairy cow, particularly those cows yielding in excess of 25 kg (2 kg of fat and protein)/d (Purcell et al., 2016). In these instances, dairy cows require supplementation to complement grazed grass, but the type of supplement offered may have an important bearing on both the economic and environmental performance of the dairy farm.

Cereals and soybean meal are commonly used to bridge the gap between nutrient supplied by pasture and that required by the dairy cow. However, supply and demand forces of the international market have seen large fluctuations in the price of cereals and soybean meals (Sinclair et al., 2014), creating uncertainty in dairy production systems that are more reliant on these feeds. To this end, the dairy industry has been exploring the use of alternative by-products such as palm kernel expeller (**PKE**, Kolver, 2006; Dias et al., 2008), soyhulls (**SH**, Ipharraguerre et al., 2002; Aikman et al., 2006), and dried distillers grains (**DDGS**, Schingoethe et al., 2009; Abdelqader and Oba, 2012) for use in the diet of the lactating dairy cow. These feeds are advantageous for ruminant diets compared with cereals and soybean meal as they are not utilizable as human foodstuffs and their use in pig and poultry diets is limited, reducing competition for these feeds. However, the perceived negative effects of by-products on animal performance have limited their use, with

many recommendations quoting low inclusion levels in the diet (Ewing, 1998).

Irish dairy farmers operate predominantly pastoral-based, seasonal-calving milk production systems, and consequently a large portion of nutrient losses (nitrogen, N) occur when animals are outdoors grazing (Hyde et al., 2003; Casey and Holden, 2005). Additionally, modern dairy production systems operate within set environmental standards (S.I., 2010) with inputs of N to the farm system often limited. Because PKE and DDGS contain relatively high concentrations of N, it will be important to quantify any changes in the excretion of N as a result of increased inclusion levels of these feed ingredients.

Limited data are available on the use of these by-products in pasture-based dairy production systems and less still where combinations of by-products are offered. Therefore, the objective of this study was to investigate the effects of replacing barley and soybean meal with increasing levels of by-products on production, digestive, and metabolic parameters in early-mid lactation dairy cows offered perennial ryegrass-based pasture.

MATERIALS AND METHODS

All procedures described in this experiment were approved by the animal research ethics committee at University College Dublin and conducted under experimental license from the Irish Medicines Board under European directive 2010/63/EU and S.I. no. 543 of 2012.

Thirty-two multiparous and 16 primiparous dairy cows (*Bos taurus* strain Holstein Friesian) were selected from the spring calving dairy herd at University College Dublin Lyons Research Farm, Celbridge, Co. Kildare, Ireland (53°17′56″ N, 6°32′18″ W). The cows were then blocked on DIM (means ± SD; 64 ± 24) and assigned to 1 of 4 pasture-based dietary treatments (n = 12) in a randomized block design experiment that ran for 70 d. Blocks were balanced for parity, pre-experimental milk yield, and BCS. Treatments consisted of a perennial ryegrass based pasture and 1 of 4 supplementary concentrates: BP35, BP55, BP75, and BP95 containing 35, 55, 75, and 95% by-products in the concentrate on a DM basis. The by-products used were SH, DDGS (dried distillers grains with solubles), and PKE in equal proportions on a DM basis (Table 1). To formulate the BP55 ration, 2 kg of BP35 and 1 kg of BP95 were mixed at each milking, whereas BP75 was formulated by mixing 1 kg of BP35 and 2 kg of BP95 at each milking. Mixing was achieved using 2 separate feed lines in an automatic, in-parlor concentrate dispensing system linked to cow electronic identification (FeedRite, Dairy Master Ltd., Kerry, Ireland). The treatments were formulated to be iso-nitrogenous (16% CP).

Animals were grazed in a single group and were offered fresh allocations (10 kg of DM/cow) of pasture twice daily (20 kg of DM/d, total). Pregrazing herbage mass was determined using the quadrat and shears method. Briefly, an area (0.25 m^2) was cut using a handheld shears (Gardena Accu 90, Gardena GmbH, Ulm, Germany) to a height of 4 cm at 6 random locations throughout the paddock. Each 0.25 m^2 of grass was then collected and weighed; a sample of pasture was also taken for determination of DM and routine chemical analysis (Table 1). Average pregrazing herbage mass was 1,839 ± 174 kg of DM/ha, whereas postgrazing herbage mass was 485 ± 147 kg of DM/ha.

Data and Sample Collection

Animals were milked twice daily at 0700 and 1600 h with milk output and milk sampling facilitated using a milk metering and sampling system (Weighall, Dairy Master Ltd.). Samples of milk were taken once weekly during Wednesday (p.m.) and Thursday (a.m.) milking and pooled on a per cow basis according to yield. Body weight and BCS were determined at the beginning and the end of the experimental period. Body weight was measured using a weigh cell (Tru-Test Weighing Systems, Auckland, New Zealand) located in the dairy facility, whereas BCS was determined using a scale of 1 to 5 with increments of 0.25 according to Edmonson et al. (1989).

Blood samples were collected by jugular venipuncture once weekly following am milking. Samples for the determination of nonesterified fatty acids (**NEFA**), and BHB, bilirubin, urea N, P, gamma glutamyl transferase (**GGT**), and glutamate dehydrogenase (**GLDH**) were collected into a 10-mL Vacutainer (REF 367896, BD-Plymouth, Plymouth, UK). Samples were allowed to clot for 24 h at 4°C before centrifuging at 2,100 × *g* for 20 min at 4°C for extraction of serum. Blood samples for glucose were harvested into a 4-mL gray-top Vacutainer (REF 368921, BD-Plymouth, UK) and centrifuged immediately postsampling at 2,100 × *g* for 20 min at 4°C for extraction of plasma. Samples of serum and plasma were stored at −20°C pending analysis.

Rumen fluid was harvested by an esophageal scoop (Flora Rumen Scoop, Prof-Products, Guelph, Canada) following am milking once weekly. Rumen fluid pH was measured immediately postsampling using a pH meter (Orion 3 Star pH, Thermo-Scientific, Waltham, MA). Samples were strained through 4 layers of cheesecloth, and a 4-mL subsample was drawn off and then mixed