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Effects of replacing rapeseed meal with fava bean at 2 concentrate crude protein levels on feed intake, nutrient digestion, and milk production in cows fed grass silage–based diets

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ABSTRACT

The objective of this study was to evaluate the production and physiological responses of dairy cows to the substitution of fava bean for rapeseed meal at 2 protein supplementation levels in grass silage–based diets. We used 6 primiparous and 6 multiparous Finnish Ayrshire cows in a cyclic changeover trial with a 2 × 3 factorial arrangement of treatments. The experimental diets consisted of formic acid–treated timothy-meadow fescue silage and 3 isonitrogenous concentrates containing either rapeseed meal, fava bean, or a 1:1 mixture of rapeseed meal and fava bean at low and high inclusion rates, resulting in concentrate crude protein (CP) levels of 15.4 and 19.0% in dry matter. Silage dry matter intake decreased linearly when rapeseed meal was replaced with fava bean, the negative effect being more distinct at the high CP level than the low (−2.3 vs. −0.9 kg/d, respectively). Similarly, milk and milk protein yields decreased linearly with fava bean, the change tending to be greater at the high CP level than the low. Yield of milk fat was lower for fava bean compared with rapeseed meal, the difference showing no interaction with CP level. Especially at the high CP level, milk urea concentration was higher with fava bean compared with rapeseed meal indicating better utilization of protein from the rapeseed meal. The apparent total-tract organic matter digestibility did not differ between treatments at the low CP level, but digestibility was higher for fava bean than for rapeseed meal at the high CP level. Plasma concentrations of essential amino acids, including methionine and lysine, were lower for fava bean than for rapeseed meal. Compared with rapeseed meal, the use of fava bean in dairy cow diets as the sole protein supplement decreased silage intake and milk production in highly digestible formic acid–treated grass silage–based diets.

Key words: fava bean, rapeseed meal, dairy cow, grass silage

INTRODUCTION

The self-sufficiency of protein used in animal feeding in Europe is low. High prices, traceability, and consumer concerns about the use of genetically modified protein feeds such as soybean meal in animal nutrition has brought out an interest in more economical and ecological ways of producing home-grown protein for animal feed markets. Fava bean (*Vicia faba*) is a suitable crop for temperate climate cultivation, and its use in crop rotations has several beneficial effects for land use and the environment, apart from its symbiotic fixing ability of atmospheric nitrogen gas with rhizobia (Nemecek et al., 2008; Jensen et al., 2010). Such low-protein feed self-sufficiency in Europe could be improved by increasing the cultivated area and use of grain legumes in animal feed. In addition to conventional cereal grains, dairy cow rations are commonly supplemented with soybean or rapeseed meal in corn- or grass silage–based diets. Rapeseed meal has been reported to be a superior protein source compared with soybean meal in grass silage–based dairy cow diets (Huhtanen et al., 2011), but the amount of rapeseed produced in northern Europe is inadequate to cover the high amount of protein needed for modern ruminant nutrition.

The relatively high content of CP (30% in DM) and starch (38% in DM) in fava bean (Luke, 2015) make it a potentially suitable protein and energy source for dairy cow feeding. However, the AA profile of fava bean protein is different from that of rapeseed or soybean. The concentration of His in fava bean is similar to that in rapeseed or soybean meal but the Met content is lower (Jezierny et al., 2010). Histidine is considered the first-limiting AA in milk production in grass silage–based diets (Vanhatalo et al., 1999; Korhonen et al., 2000). Owing to the low concentration of sulfur-containing AA in fava bean protein, its use as a sole protein supplement in high-producing dairy cow rations may limit milk yield similarly to peas, as have been suggested by Vander Pol et al. (2008).

Another challenge of using fava bean in ruminant nutrition is the high rumen degradability of its CP, which is over 0.80 in many feed evaluation systems (NRC,

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2001; INRA, 2004; Luke, 2015). Owing to the high rumen degradability of CP, fava bean may be more suitable to low-protein forage, such as corn silage–based dairy cow rations (Wilkins and Jones, 2000). On the other hand, the rumen degradability of starch in fava bean is lower than that of cereal grains (Offner et al., 2003) and when fava bean is fed as a substitute for cereal grains, the site of starch digestion can partly shift from the rumen to the small intestine (Larsen et al., 2009). This may have a positive effect on the performance of dairy cows, because grass silage–based rations might lead to a shortage of glucose (Vanhatalo et al., 2003).

Data on the effects of feeding fava bean as a replacement especially for rapeseed meal in grass silage–based dairy cow diets is rather limited, to our knowledge. Substitution of either soybean or rapeseed meal with fava bean in supplemented cereal grain–based concentrate at a rate of 10 to 35% had no adverse effects on DMI, milk yields, or milk protein yields in early studies conducted on corn silage or brome hay diets (Ingalls and McKirdy, 1974; Ingalls et al., 1980), or in more recent studies conducted on corn silage–based TMR or oat hay diets (Melicharová et al., 2009; Tufarelli et al., 2012). In contrast, Mordenti et al. (2007) substituted soybean with a mixture of fava bean and pea in an alfalfa hay–based TMR diet and found a decrease in silage intake and milk yield. Milk yield also decreased when rapeseed was substituted with other grain legumes, such as peas, in grass silage–based diets (Vanhatalo et al., 2004).

The objectives of this study were to evaluate the nutritional value of fava bean as a replacement for rapeseed meal, and to determine the production and physiological responses of dairy cows fed 2 different amounts of fava bean in grass silage–based diets. We hypothesized that (1) total substitution of rapeseed meal with fava bean would decrease milk yield, but partial substitution may not affect milk yield; (2) the increasing level of CP in the concentrate would increase milk yield independently from the protein source used; and (3) the low concentration of Met in fava bean would limit yields of milk and milk protein compared with rapeseed meal.

MATERIALS AND METHODS

Animals, Experimental Design, and Diets

The experimental procedures were approved by the National Animal Ethics Committee in Finland. Six primiparous (127 ± 10.7 DIM) and 6 multiparous (103 ± 19.2 DIM) Finnish Ayrshire cows were allocated randomly to a cyclic changeover trial (Davis and Hall, 1969) with 3 periods of 21 d. The mean parity of the multiparous cows was 2.17. Cows were weighed on 2 consecutive days at the beginning of the experiment (613 ± 77.1 kg of BW for primiparous, and 645 ± 76.0 kg of BW for multiparous) and at the end (620 ± 62.9 kg of BW for primiparous, and 604 ± 70.7 kg of BW for multiparous). Two observers performed body condition scoring using a scale of 1 to 5 according to Edmonson et al. (1989) at the beginning and end of the experiment. The average BCS was 3.25 at both time points.

Six experimental concentrates were tested in a 2 × 3 factorial arrangement of treatments consisting of 2 concentrate CP levels (low and high), and 3 types of protein sources. The 3 cereal-based concentrates contained isonitrogenous amounts of rapeseed meal (**R**), fava bean (**F**), or a 1:1 mixture of rapeseed meal and fava bean (**RF**) at 2 concentrate CP levels of 15.4% (low) and 19.0% (high) in DM. Primiparous cows received 10 kg and multiparous cows 12 kg of concentrates as fed per day. Concentrates were given in equal amounts at 0600, 0830, 1230, 1700, and 1930 h. The amounts of fava bean in the concentrate were 1.3 and 3.1 kg of DM/d for primiparous and 1.6 and 3.7 kg of DM/d for multiparous cows at the low and high CP levels, respectively. The amounts of rapeseed meal were 1.1 and 2.7 kg of DM/d for primiparous and 1.4 and 3.2 kg of DM/d for multiparous cows at the low and high CP levels, respectively. The ingredients and chemical composition of the concentrates are shown in Table 1. The pelleting process of the concentrates involved steam conditioning (steam temperature 100°C) for 15 to 20 min, during which the moisture content of the feed increased up to 18%, pelleting in a die chamber where the temperature rose rapidly to 80°C, and cooling and drying to gain a moisture content of 12% in the finished concentrate feeds.

Wilted grass silage was made from first-cut timothy (*Phleum pratense*) and meadow fescue (*Festuca pratensis*) sward grown at Helsinki (60°10′N, 24°56′E) and ensiled in a bunker silo with formic acid–based additive (760 g of formic acid and 55 g of ammonium formate, AIV 2 Plus; Kemira Ltd., Helsinki, Finland) at a rate of 5 L/t of fresh herbage. Grass silage was fed ad libitum 3 times a day, at 1030, 1500, and 1800 h to about 5% of orts. Orts were collected daily before the 1030 h feeding. During the experiment, cows were housed in individual tie stalls and had free access to fresh water and salt blocks. Daily feed intake was measured for each animal using an electronic feed intake monitoring system (Insentec BV, Marknesse, the Netherlands) equipped with separate concentrate troughs. Cows were milked twice daily, at 0600 and 1700 h.

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