Partial replacement of grass silage with faba bean whole-crop silage in the diet of dairy cows

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Abstract

Grain legumes are an interesting alternative to grass as cattle forage owing to their nitrogen fixing ability and high biomass production. The objective of this study was to investigate the effect of a mixture of grass silage and faba bean-spring wheat (*Vicia faba – Triticum aestivum*) whole-crop silage (FB) on feed intake, nutrient utilization and milk production of dairy cows. Eight multiparous Finnish Ayrshire cows averaging 100 d in milk and producing 45 kg d^{-1} milk were used in a replicated 4×4 Latin square study. Experimental treatments consisted of timothy-meadow fescue (*Phleum pratense – Festuca pratensis*) silage (GS) and a mixture of GS and FB (1:1 on a dry matter (DM) basis). Both forages were fed *ad libitum* and supplemented with 13 kg d^{-1} of concentrate containing 2.0 or 3.5 kg rape seed meal (RSM). The crude protein content of the concentrate was 175 or 200 g kg^{-1} DM, respectively. Replacing half of the GS with FB maintained silage DM intake and milk yield despite the lower digestibility of FB silage. Increasing RSM in the diet had no effect on milk yield but significantly decreased milk fat concentration with both forages.

Keywords: *Vicia faba*, *Triticum aestivum*, whole crop silage, dairy cow

Introduction

Bi-crop cultivation of legumes and cereals was reported to have a positive effect on dairy production, farm economy and environment (Hauggaard-Nielsen *et al.*, 2008). The nitrogen fixing ability of legumes and their potential to improve the protein self-sufficiency adds special interest to this topic. In boreal growing conditions, grain legumes, like white lupin (*Lupinus albus*) and faba bean (*Vicia faba*), do not always have time to ripen for seed production. Therefore, having a relatively high biomass production capacity, grain legumes are an interesting alternative to grass as cattle forage. Although the energy value of faba bean silage is slightly lower than that of grass silage, the growth or milk production results using faba bean silage-based diets have been reported to be comparable to those based on grass silage or other whole-crop silages (McKnight and MacLeod, 1977; Ingalls *et al.*, 1979).

The current experiment compared the effects of grass silage (GS) and a mixture of GS and faba bean-wheat whole-crop silage (FB) on feed intake, nutrient utilization and milk production of dairy cows. Further, the effects of protein supplementation of the silages were studied.

Materials and methods

A mixture of faba bean (cv. Kontu, seed rate 200 kg ha^{-1}) and wheat (*Triticum aestivum,* cv. Marble, 94 kg ha^{-1}) was sown and fertilized with 50 kg N ha^{-1} on 22 May 2013 at the University of Helsinki (60°N, 25°E). At harvest 75 days after sowing, wheat was at the dough stage and the seeds of faba bean were green and filled the pod cavity, which corresponds to the growth stage of 80 according to Weber and Bleiholder (1990) and Lancashire *et al.* (1991). Grass silage was harvested on 10 June 2013 from a primary growth of mixed timothy (*Phleum pratense* L.) and meadow fescue (*Festuca pratensis* Huds.) sward. Both forages were mown using a mower conditioner, harvested with a self-loading wagon after wilting, treated with a formic acid-based additive and ensiled in bunker silos.

Eight multiparous Finnish Ayrshire cows averaging 100 d in milk and producing 45 kg d^{-1} milk were used in a replicated 4×4 Latin square study with 21 d periods and 2×2 factorial arrangement of treatments. Experimental treatments consisted of GS and a mixture of GS and FB (1:1 on a dry matter (DM) basis) and two amounts of rape seed meal (RSM) as a protein supplement. Both forages were fed *ad libitum* and supplemented with 13 kg d^{-1} of concentrate containing 2.0 or 3.5 kg RSM. The crude protein (CP) content of the concentrate was 175 or 200 g kg^{-1} DM, respectively. Feed intake and milk production data was subjected to analysis of variance using the MIXED procedure of SAS® (version 9.3) to analyse the effects of forage type, protein supplementation and their interaction.

Results and discussion

Part of the faba bean field ripened prematurely, which, together with the warm wilting conditions, explains the relatively high DM concentration of FB silage (Table 1). The DM yield of faba bean-wheat bi-crop was 5,500 kg ha^{-1}, the proportion of wheat being only 0.10. The fermentation quality of both silages was good as evidenced by low pH and concentration of volatile fatty acids. Grass silage had slightly lower CP concentration but clearly higher concentration of neutral detergent fibre and *in vitro* digestible organic matter (DOMD) than FB-silage. The chemical composition of FB was in agreement with Pursiainen and Tuori (2008).

Replacing GS partially with FB had no effect (P>0.05) on DM intake or milk, fat and protein yields despite the lower DOMD value (678 vs 611 g kg^{-1} DM) of FB than GS (Table 2). The results are in agreement with the results of replacing grass-legume silage with faba bean silage (Ingalls *et al.*, 1979; McKnight and MacLeod, 1977) and replacing grass silage with cereal whole-crop silages (Jaakkola *et al.*, 2009). Increasing the amount of RSM decreased milk fat content and fat yield (P<0.05) and as a result the energy corrected milk (ECM) yield tended to be lower with the higher CP content of the concentrate (P<0.10). Higher RSM content increased milk urea content in both silage diets. However, the increase was significantly higher in GS-FB (interaction P<0.01).

No significant treatment effects were observed in feed conversion rate ECM kg^{-1} DM. Feed N utilization (milk N/N intake) was impaired when the amount of RSM was increased (P<0.01). Inclusion of FB silage in the diet had no effect on nitrogen utilization for milk protein synthesis.

Conclusions

Partial replacement of grass silage with faba bean-wheat silage maintained animal performance despite the lower digestibility of faba bean-wheat silage. Thus, mixing grass silage and a bi-crop silage of grain

Table 1. Chemical composition of experimental silages.[1]

	Grass silage (GS)	Faba bean-wheat silage (FB)	Mixture (1:1) of GS and FB
Dry matter, g kg^{-1}	288	389	325
Crude protein, g kg^{-1} DM	155	165	160
NDF, g kg^{-1} DM	517	433	477
Starch, g kg^{-1} DM	na	115	65
pH	3.97	3.96	4.00
NH_4-N, g kg^{-1} N	65.2	58.0	58.7
WSC, g kg^{-1} DM	93	94	96
Lactic acid, g kg^{-1} DM	47	17	33
Volatile fatty acids	13.0	6.1	9.9
In vitro DOMD, g kg^{-1} DM	678	611	642

[1] DM = dry matter; NDF = neutral detergent fibre; WSC = water soluble carbohydrates; DOMD = digestible organic matter in the dry matter; na = not analysed.

Table 2. The effect of treatments on feed intake, milk production and feed utilization.[1]

Silage	GS		FB-GS		SEM	Significance		
Concentrate CP, g kg^{-1} DM	175	200	175	200		Silage	CP	Interaction
n	8	7	6	8				
Dry matter intake								
Silage, kg d^{-1}	13.6	13.9	14.5	13.7	0.48	0.466	0.529	0.261
Concentrate, kg d^{-1}	11.3	11.3	11.3	11.3				
Total, kg d^{-1}	25.0	25.2	25.8	25.0	0.48	0.459	0.550	0.272
Milk production and composition								
Milk, kg d^{-1}	35.5	35.4	36.1	35.8	1.02	0.226	0.565	0.760
ECM, kg d^{-1}	38.1	36.8	38.4	37.1	0.81	0.608	0.062	0.975
Fat, g d^{-1}	1,634	1,542	1,630	1,542	42.0	0.955	0.033	0.957
Protein, g d^{-1}	1,249	1,231	1,268	1,252	23.6	0.329	0.693	0.958
Lactose, g d^{-1}	1,571	1,562	1,604	1,600	49.8	0.077	0.690	0.895
Fat, g kg^{-1}	46.0	44.6	46.5	43.6	1.45	0.795	0.032	0.444
Protein, g kg^{-1}	35.4	35.5	35.8	35.3	0.84	0.726	0.511	0.377
Lactose, g kg^{-1}	44.3	44.1	44.4	44.7	0.30	0.138	0.816	0.322
Urea, mg (100 ml)$^{-1}$	30.5	32.0	33.7	39.7	1.22	<0.001	<0.001	0.002
Efficiency of utilization								
ECM/DM intake, kg kg^{-1}	1.55	1.49	1.52	1.52	0.044	0.907	0.290	0.397
Milk N/N intake	0.298	0.277	0.291	0.279	0.060	0.678	0.007	0.389

[1] GS = grass silage; FB = faba bean-wheat silage; CP = concentrate crude protein content; DM = dry matter; ECM = energy corrected milk yield.

legumes and cereal for dairy cow diets can be recommended. Increasing protein supplementation of the silages had no beneficial effects on feed intake or milk yield but it significantly decreased milk fat content and feed N utilization for milk protein.

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