Livestock Science 128 (2010) 123–132

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci

Effect of toasting field beans and of grass-clover: Maize silage ratio on milk production, milk composition and sensory quality of milk

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ARTICLE INFO

Article history:
Received 30 April 2009
Received in revised form 29 October 2009
Accepted 30 November 2009

Keywords:
Dairy cows
Milk fat composition
Organic
Toasting
Sensory characteristics

ABSTRACT

The effect of toasting field beans and of grass-clover: maize silage ratio on milk production, milk composition and the sensory quality of the milk was investigated in a 2*2 factorial experiment. Toasting of field beans resulted in lower milk contents of both fat (44.2 versus 46.1 g/kg, $P=0.02$) and protein (33.5 versus 34.2 g/kg, $P=0.008$), whereas milk production, urea and somatic cell contents were unaffected compared with the untreated field beans. Increasing the proportion of maize silage (from 9 to 21% of DM) in the ration decreased the content of urea in milk ($P=0.002$), whereas milk production and milk content of fat and protein were unaffected. Milk from cows fed the high proportion of maize silage had a lower ($P=0.04$) long-chain fatty acid content (≥C18). Furthermore, milk from cows fed the high proportion of maize silage had a lower (13–26%) content of luteine ($P=0.03$), 13-*cis*-β-carotene ($P=0.04$) and β-carotene ($P=0.05$). Toasting of field beans compared with untreated field beans did not affect the milk content of carotenoids and had only small effects on fatty acid composition. Regarding the sensory quality, the four treatments resulted in milk being characterized by a distinctly fatty mouthfeel and creamy flavour and a pronounced sugar-sweet taste and creamy odour. The higher proportions of maize in the feed resulted, in general, in milk characterized by a significantly more intense maize odour ($P<0.05$). The effect of field bean toasting in combination with a high proportion of maize in the feed resulted in milk characterized by a significant and distinctly sour feed odour ($P<0.05$). In conclusion, toasting field beans did not improve milk production, and toasted field beans in combination with a high proportion of maize in the feed resulted in milk with negative sensory characteristics. Increasing the proportion of maize silage at the expense of grass-clover silage did not affect milk production, but decreased the milk content of long-chain fatty acids, as well as the content of carotenes.

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1. Introduction

In Northern Europe, grass-clover is the main feed component for organic dairy cows, often combined with a large amount of barley and other cereals (Mogensen, 2004). This feed composition, however, with high proportions of cereals (>4.6 kg) and fresh grass-clover (>9.3 kg DM) has been found to be correlated with a high incidence of liver abscesses (Jørgensen et al., 2005). Liver abscesses are probably caused by a decreased rumen pH, which is a characteristic of the metabolism of barley and other feeds that have a high level of rumen-degradable starch (Arieli et al., 1995; Tothi et al., 2003). Heat treatment has been found to decrease rumen starch degradability of barley, wheat (Arieli et al., 1995) and field

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doi:10.1016/j.livsci.2009.11.011

beans (Lund et al., 2007). Field beans could, therefore, be an alternative to cereals as a feed concentrate for high-yielding organic dairy cows, since the heat treatment of field beans, furthermore, has shown a positive effect on the protein value due to decreased rumen protein degradability (Lund et al., 2004). Field beans can, additionally, be grown organically under Northern European conditions with a crop yield similar to that of spring barley (Ingvorsen et al., 2007).

Maize silage could be an alternative to grass-clover silage as part of the forage in the organic feeding ration for high-yielding cows. This is desirable from a feed supply point of view due to a higher expected maize crop yield compared with grass-clover. The composition of the roughage in the dairy cow ration, i.e. proportions of grass and maize silage, has been found to affect the milk content of fatty acids (Havemose et al., 2004) and carotenoids (Nielsen and Lund-Nielsen, 2004) as well as a number of significant flavour components in the milk and thereby the sensory characteristics of the milk (Frandsen et al., 2003; Croissant et al., 2007).

The hypothesis of the present study was that the toasting of field beans could improve the energy and protein values of the ration for high-yielding organic dairy cows compared with untreated field beans, and thereby improve milk production. A possible interaction of this effect with the grass-clover: maize silage ratio of the ration and a possible effect on milk composition and flavour were investigated as well.

2. Materials and methods

2.1. Experimental design

An experiment was conducted from the 5th of November to the 23rd of December 2007 at The Organic Research Station Rugballegaard at Research Centre Bygholm, Horsens. The experiment included a two-week pre-period followed by a five-week experimental period.

The experiment was conducted as a 2*2 factorial experiment. The first factor was type of field bean, either untreated or toasted. The second factor was maize silage proportion, either low or high level (9 and 21% of DM, respectively).

2.2. Feeding

Table 1 shows the composition of the four total mixed rations (TMR) fed in the experimental period. During the two-week pre-period (covariate period), all cows received the same TMR (grass-clover silage 49% of DM, maize silage 17% of DM, oats 10% of DM, untreated field beans 12% of DM, toasted field beans 12% of DM). The TMRs were mixed by a Cormall feed-mixer and fed ad libitum once a day after the morning milking. Dry matter content was determined every week and used for TMR formulation. All the ingredients were organically grown in Denmark. The field beans (*Vicia faba* L.; variety Marcel) were processed at a commercial feedstuff factory. The untreated field beans were rolled. The toasted field beans were toasted (Dan toaster) at 140 °C for 90 s and rolled after cooling.

2.3. Animals

Forty-eight Danish Holstein cows (600 (59) kg live weight, 2.7 (0.4) in BCS, 150 (74) DIM, 32.6 (5.6) kg ECM) were blocked according to days in milk and parity (1st, 2nd or older) and randomly allocated to the four treatments. The cows in the four treatment groups were housed separately in four groups in straw-bedded cubicles with slatted floor and one eating place per cow. The cows were milked twice a day at 4.00 a.m. and 3.00 p.m. The veterinarian treated only one cow (from treatment TL, for mastitis) during the experimental periods, indicating that the health status of the experimental cows was very good.

2.4. Measurements

2.4.1. Animal production

Feed intake was recorded on group basis. The scale on the feed-mixer automatically registered the amount of feed mixed and offered per treatment group. The leftovers per treatment group were weighed daily before next feeding. Samples of all feeds were taken every week and stored frozen. One representative sample from each feedstuff was analysed for DM, ash, crude protein, crude fat, starch (Helrich, 1990) and aNDF (Van Soest, 1994). For maize and grass-clover silage, *in vitro* digestibility of organic matter (Tilley and Terry, 1963) was analysed.

For both types of field bean effective rumen protein degradability (EPD) and total tract protein digestibility (TPD) were determined *in situ*. Rumen degradability of protein was determined using the nylon bag technique (Ørskov and McDonald, 1979; Weisbjerg and Hvelplund, 2005). Bags were incubated in the rumen of three dry cows for 0, 2, 4, 8, 16, 24 and 48 h and the nitrogen residue determined by the Kjeldahl procedure. For each feedstuff the disappearance from the bags was corrected for the loss of particles that were not soluble but small enough to pass the nylon bag pores (Weisbjerg et al., 1990). The total tract digestibility was determined using the mobile bag technique (Hvelplund et al. 1992; Weisbjerg and Hvelplund, 2005). True intestinal digestibility of ruminally undegraded dietary protein (dUDP) was calculated according to Hvelplund et al. (1992). Water-soluble protein, potentially degradable protein and fractional rate of degradation of potentially degradable protein were estimated based on an exponential model (Ørskov and McDonald, 1979). Effective rumen protein degradability was calculated assuming a fractional rate of passage of 0.05 h^{-1}. For field beans, the amount of amino acids absorbed in the small intestine (AAT) and the protein balance in rumen (PBV) was calculated based on

Table 1
Composition of the total mixed rations (TMR) for the four treatments, % of dry matter.[1]

Treatment	UL	TL	UH	TH
Field beans	Untreated	Treated	Untreated	Treated
Maize silage	Low	Low	High	High
Field beans, untreated	21.3	0	21.3	0
Field beans, toasted	0	21.3	0	21.3
Oats	8.5	8.5	8.5	8.5
Maize silage	8.6	8.6	21.3	21.3
Grass-clover silage, 1st cut	28.8	28.8	28.8	28.8
Grass-clover silage, 3 rd cut	32.9	32.9	20.1	20.1

[1]Furthermore 50 g mineral and vitamin mixture was fed per cow per day (9% Ca, 1.9% P, 5.2% Mg, 13.3% Na, 7.1% S, 3810 mg Mn/kg, 4762 mg Zn/kg, 953 mg Cu/kg, 38 mg Co/kg, 119 mg J/kg, 33 mg Se/kg, 476 ie vit-A/kg, 76 ie vit-D/kg, 2281 mg vit-E/kg).

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