Rumen fermentation and milk fat composition of dairy cows fed linseed and hay or fresh grass

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Abstract

The linolenic acid (18:3*n*-3) content of dairy milk is generally rather low because dietary polyunsaturated fatty acids are biohydrogenated in the rumen to a large extent. However, it was suggested that biohydrogenation of 18:3*n*-3 could be lower when it is derived from forage compared to oilseeds. Therefore, the aim of the present study was to investigate the effects of dietary 18:3*n*-3 on rumen fermentation and milk fat composition when six ruminally canulated cows were fed either a linseed supplemented diet (L) or a grass diet (G). While dry matter intake did not differ between treatments, daily uptake of oleic (18:1*n*-9), linoleic acid (18:2*n*-6) and 18:3*n*-3 was higher ($P < 0.01$) in treatment L. Compared to treatment G, ruminal pH, ammonia concentration and bacterial counts were decreased ($P < 0.05$) in treatment L. The 18:3(*n*-3) concentration in blood plasma and milk was higher ($P < 0.01$) in treatment L compared to G and resulted in a higher apparent transfer rate of 18:3*n*-3 into the milk fat. Concentrations of CLA and 18:1*t*10/11 were increased ($P < 0.01$) in the milk fat of cows fed the diet G compared to cows fed the diet L. No significant differences occurred between the treatments concerning the calculated desaturase activity in the mammary gland.

Keywords: CLA, dairy cow, grass, linseed, linolenic acid, milk fat

Introduction

In general, dietary unsaturated fatty acids are biohydrogenated in the rumen by micro-organisms to a large extent thereby decreasing their availability for being absorbed as such in the small intestine. This is one reason for the high concentration of saturated fatty acids in milk fat and its consumption has been associated with higher risk of cardiovascular diseases. In order to decrease ruminal biohydrogenation different feeding strategies were suggested with the aim of increasing the content of linolenic acid (18:3*n*-3), in particular, which is known to exert various beneficial physiological effects (Williams, 2000).
Although linseed and fresh grass both contain a high proportion of 18:3*n*-3, Wachira *et al.* (2000) speculated that the biohydrogenation rate of 18:3*n*-3 differs depending on the source. Linolenic acid in linseed is predominantly bound to triacylglycerols, whereas in grass the predominant form is glycolipids. The latter could be less susceptible to rumen lipolysis and biohydrogenation due to their location in the cell structure (Wachira *et al.*, 2000). Therefore, the aim of the present study was to compare the influence of linseed and fresh grass on rumen fermentation and milk fat composition when fed to dairy cows.

Materials and methods

The study was carried out according to a cross-over design with six multiparous ruminally canulated Brown Swiss cows, averaging 19.1 kg d^{-1} milk yield and 150 d in milk. The cows were either fed a diet of ground linseed and hay (L) or fresh grass (G). The cows were adapted to the respective diets for 16 d followed by a 5 d experimental period. The diets were offered

twice a day at 07:00 and 16:30 h. Two cows refused to eat the linseed and hence feed was directly introduced through the canula into the rumen. During the experimental period, feed intake was recorded daily and milk yield and milk constituents were quantified over three consecutive days at each milking. On day three of the experimental period, rumen fluid was sampled at 06:00, 08:00, 10:00 and 16:00 h in order to determine ruminal pH, ammonia and numbers of rumen protozoa and bacteria. The following day blood samples were collected by jugular vein puncture at the same time points. The diets were analysed for nutrient content using standard procedures. The fatty acid composition of feed, milk and plasma were determined by gas chromatography.
The statistical evaluation was carried out by ANOVA techniques for a cross-over design using PROC MIXED (SAS, Version 8.00, SAS Institute Inc., Cary, NC, USA). Rumen fluid properties and fatty acid composition of the plasma were analysed as repeated measurements.

Results and discussion

Total daily dry matter (DM) intake did not ($P > 0.05$) differ between treatments (16.9 kg). However, the intake of total fatty acids, stearic (18:0), oleic (18:1*n*-9), linoleic acids (18:2*n*-6), and 18:3*n*-3 were respectively 267, 15, 92, 57 and 95 g d^{-1} higher ($P < 0.001$) in treatment L compared to treatment G. The 18:3*n*-3 proportion expressed as the percentage of the total C16 and C18 fatty acids was higher in treatment G (Figure 1).

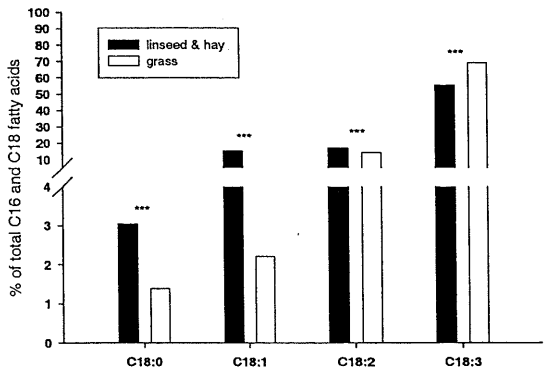

Figure 1. Proportion of C18 fatty acids in the feed consumed expressed as the percentage of total C16 and C18 fatty acids. ***, $P < 0.001$.

The milk yield (17.8 kg d^{-1}), fat (4.1 %), protein (3.5 %) and lactose (4.8 %) content were not influenced by the dietary treatments. As expected, the milk of cows in treatment G had a higher ($P < 0.001$) urea content (G: 336 mg L^{-1} and L: 250 mg L^{-1}). This was in line with the higher ($P < 0.05$) ammonia concentration in the rumen fluid (G: 6.9 mmol L^{-1} and L: 5.3 mmol L^{-1}). Ruminal pH was lower ($P < 0.01$) in treatment L (6.3) compared to treatment G (6.7) but were above values which could have negatively influenced lipolysis and biohydrogenation (Van Nevel and Demeyer, 1996). Compared to treatment G, total bacterial count was decreased ($P < 0.001$) in treatment L (L: 1.8×10^{10} mL^{-1} and G: 2.7×10^{10} mL^{-1}) supporting the hypothesis that fatty acid release rate from triaclyglycerols is higher than from glycolipids (Wachira *et al.*, 2000). However, ciliate count was not affected by treatments (1.6×10^{5} mL^{-1}) although these microbes should be even more susceptible to the antimicrobial effect of unsaturated fatty acids than bacteria (Harfoot and Hazelwood, 1997).
When discussing the results of the blood plasma fatty acid profile it should be considered that the fatty acid concentration is not only affected by the diet, but also by ruminal

biohydrogenation, absorption as well as tissue turn over rate. The proportion of 18:3*n*-3 in the blood plasma was lower in treatment G compared to treatment L (Figure 2). Concomitantly, the increase of the 18:1*t*10/11 concentration in the plasma was greater in group G than in group L suggesting a higher biohydrogenation of 18:3*n*-3 to 18:1*t*11 in the rumen. Furthermore, the CLA proportion was higher in treatment G compared to treatment L which could indicate a higher isomerisation of 18:2*n*-6 to CLA or, a higher endogenous desaturation of 18:1*t*11 to CLA.

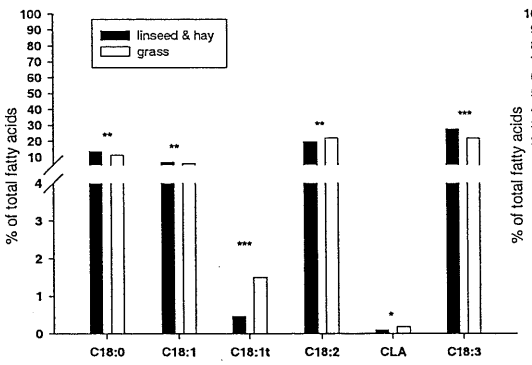

Figure 2. Fatty acid profile of the blood plasma. ***, $P < 0.001$; **, $P < 0.01$; *, $P < 0.05$.

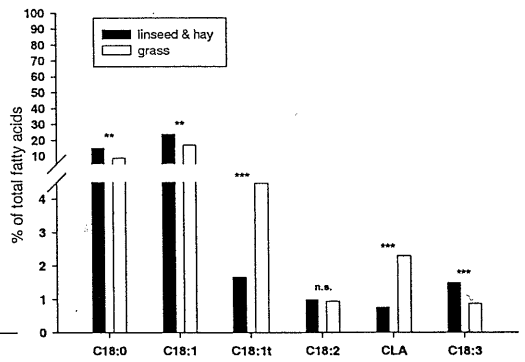

Figure 3. Fatty acid profile of the milk fat. ***, $P < 0.001$; **, $P < 0.01$; *, $P < 0.05$.

In both treatments the proportions of 18:3*n*-3 and 18:2*n*-6 were much lower in the milk fat than in plasma lipids (Figure 3). The differences regarding 18:3*n*-3, 18:1*n*-9 and 18:0 shifted in favour of treatment L while the opposite occurred regarding 18:1*t*10/11 and CLA. The ratio of the desaturase pairs (18:1*n*-9/18:0, $P = 0.12$ and CLA/18:1*t*10/11, $P = 0.29$) suggested that desaturase activity in the mammary gland was not affected by the diet. Because of the endogenous metabolism the present data does not allow determination of the true transfer rate of fatty acids into the milk fat. However, when comparing dietary intake and excretion into the milk, the apparent transfer rate of 18:3*n*-3 was higher ($P < 0.05$) in treatment L and the apparent transfer of 18:2*n*-6 was higher ($P < 0.001$) in treatment G.

Conclusions

No clear conclusion can be drawn about differences in biohydrogenation of this fatty acid deriving either form linseed or grass because of the different intake of 18:3*n*-3 as well as total fatty acids. Despite the lower dietary 18:2*n*-6 and 18:3*n*-3 intake with the grass diet, the relative and absolute amount of CLA was significantly higher in treatment G compared to treatment L.

References

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