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Influence of forage type and concentrate proportion, given to dry goats, on the duodenal microbial fatty acid composition

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SUMMARY – An experiment with 14 duodenal cannuled goats was undertaken to determine the effects of forage source and of forage level on lipid content and fatty acid (FA) composition of microbial lipids. Lucerne hay (LH) or maize stover (MS) was given chopped to goats in a mixed diet with concentrate at three forage/concentrate levels (100 or 70 or 40%, on the DM basis). The lipid content and the FA composition were determined from the microbial cell mass taken in the duodenal fluid. The total lipid content of the microbial cell mass varied from 10.2 to 20.2% (/DM) of which about half were FA. This lipid content and FA content increased with proportion of concentrate in the diet. The even-straight saturated FA content was higher with LH than with MS. It increased from 65.8 to 81.5% when the forage percentage of the diet decreased from 100 to 40%. The branched-chain FA content and the odd FA content strongly increased with percentage of forage in the diet, that stressed the FA synthesis in the rumen by microorganisms with forage based diet.

Key words: Microbial lipid, fatty acids, duodenum, forage, concentrate, goat.

RESUME – *"Influence du type de fourrages et de la proportion de concentrés donnés aux chèvres en période sèche sur la composition des acides gras microbiens dans le duodénum". Une expérience a été conduite avec 14 chèvres équipées d'une canule duodénale pour déterminer l'influence du type de fourrage et du taux de fourrage dans la ration sur la teneur en lipides et la composition en acides gras (AG) des lipides microbiens. Du foin de luzerne (FL) ou de la canne de maïs (CM) sont offerts hachés en ration mixte avec du concentré avec 3 niveaux de fourrage/concentré (100 ou 70 ou 40%). La teneur en lipides et la composition en acides gras ont été déterminée sur la masse cellulaire microbienne prélevée au niveau duodénal. La teneur en lipides de la masse cellulaire microbienne varie de 10,2 à 2,2% (MS) dont la moitié est constituée d'AG. Ces teneurs en lipides et en AG augmentent avec le pourcentage de concentré dans la ration. La teneur en AG saturés à chaîne linéaire et à nombre de carbone pair est plus élevée avec FL qu'avec CM. Elle augmente de 65,8 à 81,5% quand le pourcentage de fourrage dans la ration décroît de 100 à 40%. Les teneurs en AG ramifiés et en AG impairs augmentent fortement avec le pourcentage de fourrage dans la ration ; ce qui souligne l'importance de la synthèse d'acides gras dans le rumen par les micro-organismes avec un régime à base de fourrage.*

Mots-clés : *Lipides microbiens, acides gras, duodénum, fourrage, concentré, chèvre.*

Introduction

The rumen microorganisms represent a considerable source of energy available for the host ruminants. Dietary factors such as level of feed intake, amount of concentrate i.e., changes in the supply of fermentable organic matter (OM), greatly influence growth and composition of differents species of microorganisms present in rumen (Mc Allan and Smith, 1976; Hespell and Bryant, 1979; Wanderley *et al.,* 1987). But available informations refer mainly to nitrogen supply in duodenum of ruminants. The only papers dealing with variation in lipid content and composition of rumen microorganisms were obtained with fat supplementation in the diet (Bauchart *et al.,* 1990; Weisberg *et al.*, 1992).Therefore the objective of the present experiment was to investigate the effects of two forages at three levels on lipid content and fatty acid composition of the microorganisms flowing to the duodenum to understand the relationship between diet composition and deposited body fatty acid composition.

Material and methods

Fourteen dry Alpine or Saanen goats equipped with a cannula in the proximal duodenum were used. They were fed twice a day, at about 110% of energy requirements, with a mixed diet composed

of forage and concentrate. The forage, either lucerne hay (LH, chopped in blade, 5 mm length) or maize stover (MS, chopped, 2 mm length), was included at three levels in the diet (100, 70, or 40% /DM). The calculated metabolizable energy content of the diets varied from 2.2 to 2.7 Mcal/kg DM. Samples of duodenal fluid were collected on each goat, on 3 consecutive days, and then pooled by diet. The microbial digesta were isolated from fresh digesta by differential centrifugation. It was the second pellet of centrifugation of the duodenal fluid (30,000 g, 30 min after 800 g, 30 min). The microbial lipids (ML) were first extracted with chloroform-methanol (Folch *et al.*, 1957) and further with ethanol, chlorhydric acid and chloroform and then, they were purificated by saponification. The fatty acids (FA), were separated by capillary GLC on a DB-wax column (JW, 60 m x 0.25 mm x 0.25 µM; L x D x e) and then identified from their ECL and by their spectre of fragmention from electronic impact (Ion Trap Finnigan Mat, ITD 800).

Results

The lipid and FA content of the microbial cell mass was higher in LH than in MS (14.2 and 7.0 vs 10.2 and 5.2%/DM, respectively for lipid and FA content with MS vs LH alone). The FA content of ML increased about 20 and 80% in MS and about 25 and 60% in LH when the forage content of the diet decreased from 100% to 70 and 40%, respectively (Fig. 1).

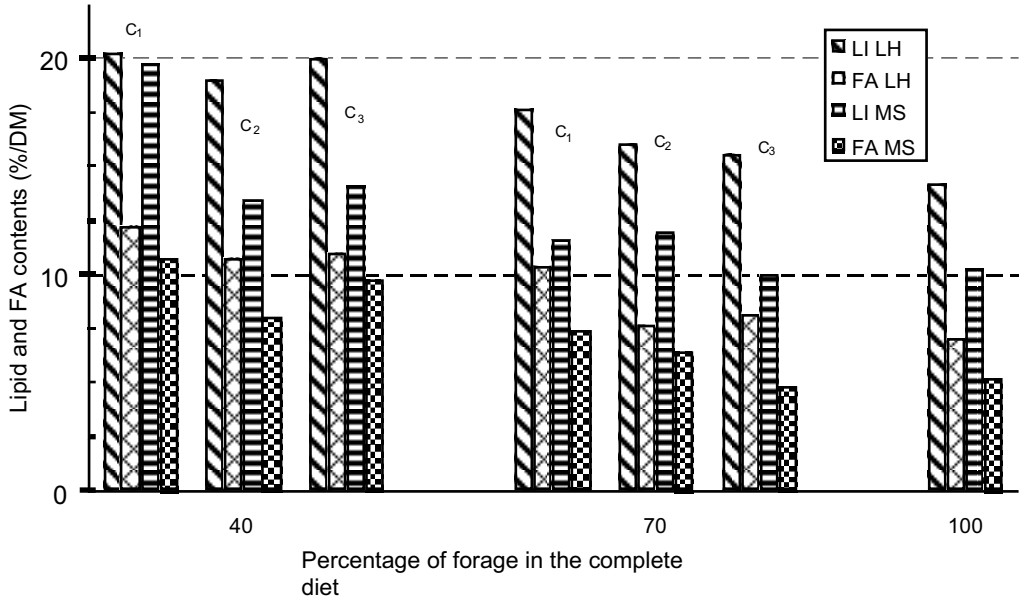

Fig. 1. Variations of the lipid and FA contents of the duodenal microbial cell mass according to diets offered to goats.

About 50 FA were separated from the ML. The ML were constituted by a high proportion of long straight-chain FA (between 60.9 to 84.4%). The even saturated FA content of ML increased of about 25% when the percentage of forage in the diet decreased from 100 to 40% ($P < 0.001$, Fig. 2) in account of the variations of the C18:0 percentage which represented about 90% of the even saturated FA percentage. The other even straight chain FA percentage of ML varied on the opposite of the C18:0 percentage. The C18:0 percentage was lower with MS than with LH (24.1 vs 36.5%, respectively). It strongly increased until to more than 50% when the level of forage decreased in the diet ($P < 0.001$). This increase is more important with MS than with LH (P interaction = 0.07). The unsaturated FA percentage of the ML was less than 10% in every sample. The difference in the unsaturated FA percentage of ML was low in respect to nature or percentage of forage in the mixed diet. Most of the monounsaturated FA decreased when the level of forage decreased in the diets. The diene FA percentage was about 1% in these samples of ML. No triene FA were found in any ML. The percentage of the diene FA of ML were significantly lower with LH than with MS ($P < 0.001$) but was not influenced by the level of forage in the diet.

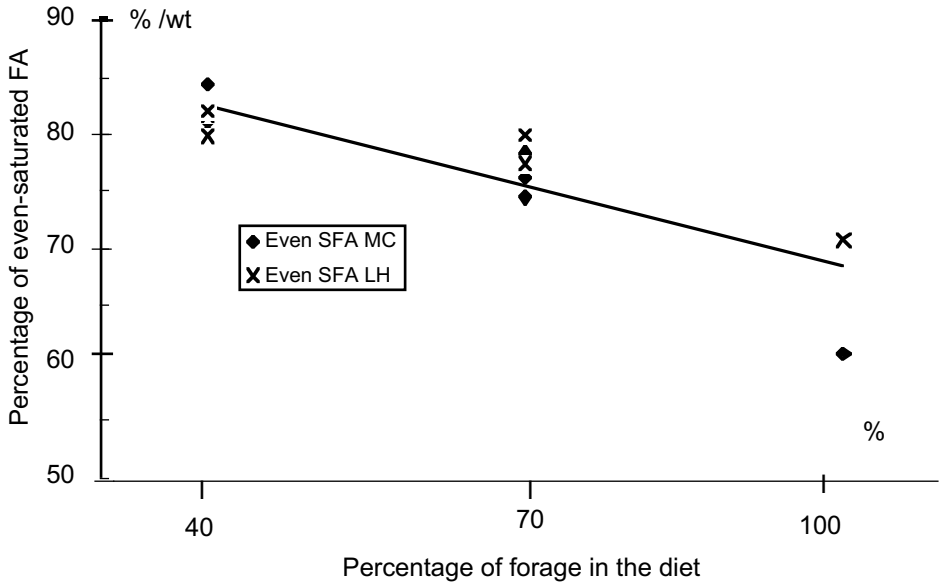

Fig. 2. Evolution of the even saturated fatty acid content of the microbial cell mass with the forage content of the diet.

The oddFA and the branched-chain FA (BCFA) percentages were relativement important in any ML. The BCFA were mainly constituted by isoFA and anteisoFA. The oddFA and the BCFA percentage in ML were influenced by nature of forage in mixed diet ($P < 0.01$) or distributed alone (11.6%, 7.3%; 8.8 vs 6.8, 5.9, 9.0%, respectively for isoFA, anteisoFA and oddFA, with MS vs LH alone). The oddFA and the BCFA percentages strongly increased (200 to 300%) with the increase of the level of forage in the diets (Fig. 3). They were negatively linked to the lipid content of the microbial biomass. The increase of oddFA and BCFA percentage in the microbial cell mass grown with diets rich in hay compared to obtained microbial grown with diets rich in concentrate stressed the adaptation of microorganism population for an increasing synthesis of particular long-chain fatty acids characterized by lower melting point than the relative even straight chain FA. This increasing in oddFA and BCFA synthesis could be an answer to a decrease in availability of FA of low melting point like monounsaturated FA and polyunsaturated FA as the content of oddFA + BCFA + monounsaturated FA + polyunsaturated FA by g of DM of the microbial cell mass did not significantly vary. It emphasized the functionnaly role of oddFA and BCFA to maintain the proper fluidity of membrane lipids in agreement of results of Ifkovitis and Ragher (1968), which shown the relatively constancy of structural rumen bacterial lipids and with the increase in fat content of bacterial cells associated with cytoplasmic lipid droplet (Legay-Carmier *et al*., 1987).

Conclusions

The type and the proportion of forage in the diet showed a marked effect on FA content and FA composition of microbial cell mass. Results suggested that variations of composition of diets could influence microbial flow to the duodenum of particular fatty acids such as branched-chain and odd-chain fatty acids which can be incorporated in adipose tissues and in milk.

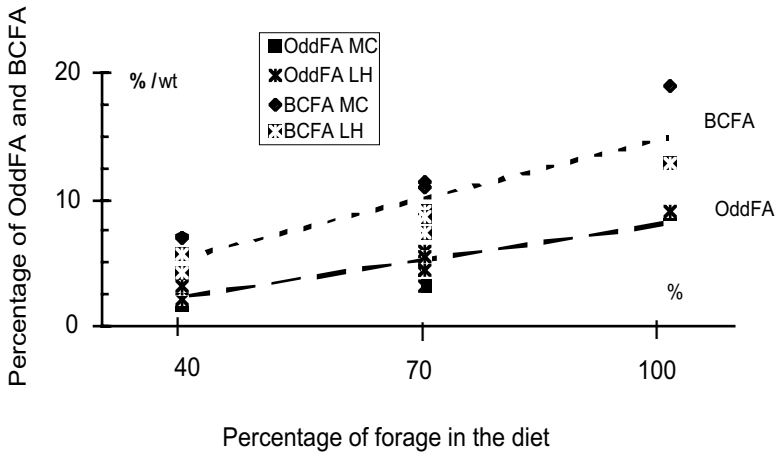

Figure 3. Evolution of the oddFA and of the BCFA content of the microbial cell mass with the forage content of the diet.

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