PRODUCTIVE CAPACITY OF GRASS-CLOVER SWARD AS A SOURCE OF SUBSTRATE FOR MICROBIAL PROTEIN SYNTHESIS IN THE RUMEN OF SHEEP

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ABSTRACT

Herbage dry matter (DM) yield, microbial protein (MP) synthesis in the rumen, protein degradability in the rumen and digestibility of protein and organic matter were continuously measured during the first growth of grass-clover sward. MP synthesis in the rumen was measured by means of urinary purine derivative excretion and protein degradabilitiy by means of the nylon bag technique. Between 21 April and 8 June the concentration of crude protein (CP) in herbage decreased from 185 to 80 g kg^{-1} DM. Protein degradability in the rumen decreased from 0.72 to 0.61, true protein digestibility from 0.96 to 0.89, organic matter digestibility from 0.83 to 0.56 and MP synthesis from 136 to 92 g kg^{-1} DM intake. The estimated concentration of digestible undegradable protein (DUDP) in herbage decreased from 45 to 23 g kg^{-1} DM and the concentration of metabolizable protein from 130 to 82 g kg^{-1} DM. DM, CP, DUDP, MP and metabolizable protein yields increased during the experiment from 1983 to 9974, from 359 to 740, from 82 to 213, from 261 to 879 and from 250 to 780 kg ha^{-1} respectively. MP contributed from 0.62 to 0.73 of metabolizable protein. The results indicate that the potential of grass-clover sward for the production of microbial protein in the rumen is similar to its potential for direct protein production on the meadow.

INTRODUCTION

Microbial protein contributes about two thirds of the amino acids absorbed by ruminants. Based on the number of ruminant animals it was estimated that worldwide 0.8 milliard tons of microbial protein is produced annually (Flachowsky et al., 2003). The estimated quantity exceeds the world cereal and soybean protein production for several times.

In temperate latitudes grassland herbage is a major source of feed for ruminants. It is characterized by high protein concentration. However, due to extensive protein degradation in the rumen, the potential of herbage to supply the energy for microbial growth in the rumen may be considered as more important than the production of herbage protein *per se*.

The objective of present work has been to quantify the potential of grass-clover sward to supply a substrate for microbial protein production in the rumen and to compare it with a direct supply of digestible undegradable protein. Concentrations and yields of metabolizable protein were also estimated.

MATERIAL AND METHODS

Herbage dry matter (DM) yield, microbial protein (MP) synthesis in the rumen, protein degradability in the rumen and digestibility of protein and organic matter were continuously measured during the first growth of grass-clover sward. The proportion of legumes (*Trifolium pratense* and *Trifolium repens*) ranged from 0.10 to 0.25 (w/w on dry matter basis). The main grass in the sward was Phleum pratense (0.46), followed by *Lolium perenne* (0.25), *Festuca pratensis* (0.25), *Dactylis glomerata* (0.03) and *Festuca rubra* (0.01).

Microbial protein synthesis in the rumen, true protein digestibility and organic matter digestibility were measured using four wether sheep. The animals weighed 62 kg on average. They were kept in metabolism cages with free access to fresh water. They were fed fresh herbage which was mown daily at the level of 1120 g DM per day. The diet was given to animals in two equal meals at 7.30 and 19.30 hours. The quantity of urine and faeces was measured daily. Samples from three consecutive days were pooled for further analyses. The presumption that faeces was excreted with a delay of 24 h was taken into account, i.e. the sample collected at the given time was attributed to feed consumed between 36 h and 12 h earlier. True protein digestibility was calculated by taking into account the fact that acid detergent insoluble protein was the only truly undigested feed protein fraction which appeared in the faeces (Van Soest, 1994). Microbial protein synthesis was estimated by means of urinary purine derivative excretion as described by Chen *et al.* (1991).

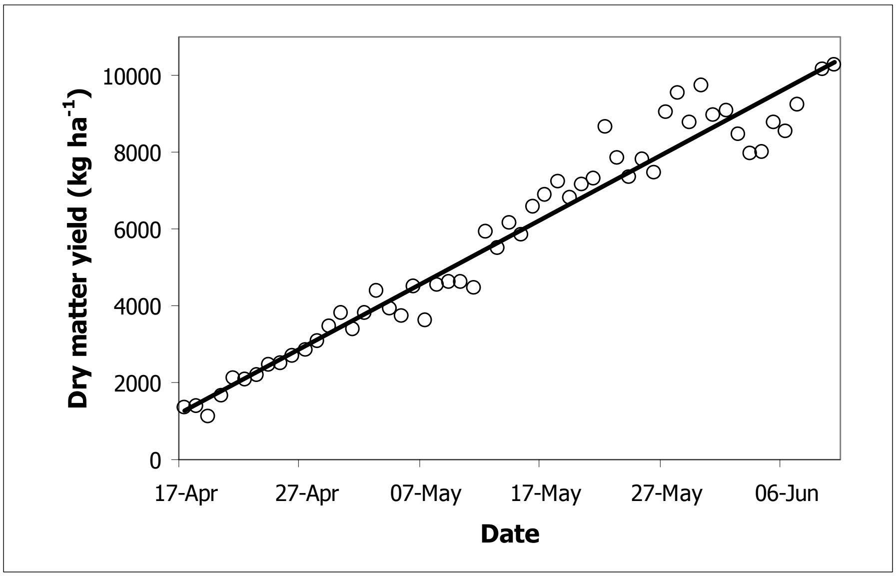
Ruminal protein degradabilities were determined every six days using the *in sacco* method as described by Ørskov *et al.* (1980). Fresh samples were weighed into nylon bags and incubated in the rumen of three sheep for 3, 6, 12, 24, 48 and 72 h. In order to remove microbial matter from undigested material from nylon bags a modified frozen–rethawing technique according to Kamel *et al.* (1995) was used. Data of protein degradabilities were fitted to the equation $p = a + b (1 - e^{-ct})$ (Ørskov and McDonald, 1979). Effective degradabilities (EPD) of protein were calculated as EPD = $a + bc/(c + k)$ (Ørskov and McDonald, 1979) where a, b and c represent parameters from the estimated degradation curve and k fractional outflow rate, which was fixed to 0.05 h^{-1}.

Concentration of digestible undegradable protein (DUDP) was estimated on the basis of information on in sacco degradability and true digestibility, i.e. as a difference between undegradable dietary protein (UDP) and protein truly undigested within the total digestive tract. Metabolizable protein was estimated as a sum of DUDP and digestible microbial true protein (DMTP). DMTP was estimated as microbial protein × 0.75 × 0.85 (AFRC, 1992).

RESULTS

Dry matter production

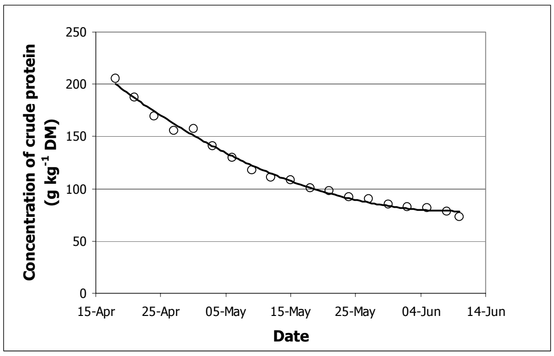
Dry matter (DM) yield increased during the experiment linearly from 1983 kg ha^{-1} on 21 April to 9974 kg ha^{-1} on 8 June (values calculated from linear regression equation, Graph 1). The average daily DM production was 168 kg ha^{-1}. Relative to other experiments with the same grass-legume mixture (Verbič Ja., unpublished results) the DM production in the present experiment can be considered as relatively high.



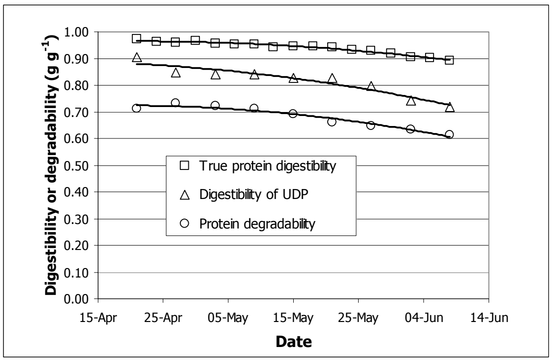
Graph 1. Dry matter yield in dependence on the date of harvest.

Herbage composition and its protein value

With advancing maturity the concentration of crude protein in herbage decreased from 185 to 80 g kg^{-1} DM (Graph 2). Along with a decrease of protein concentration, a decrease of ruminal protein degradability and true protein digestibility in total digestive tract were also observed (Graph 3). As a result the estimated concentration of digestible undegradable protein in herbage declined from 45 to 23 g kg^{-1} DM (Graph 5). The results indicate that only 0.24 to 0.29 of ingested protein can be directly utilised by ruminant animals. The rest of protein is either i) captured by rumen microorganisms and indirectly utilised as a microbial protein, ii) excreted as a surplus of rumen degradable protein (predominantly via urine) or iii) inevitably lost via faeces as truly undigestible protein.



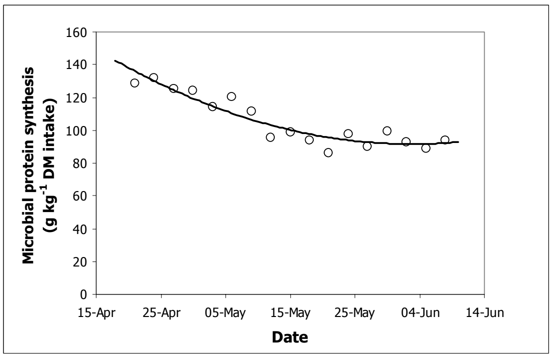
Graph 2. Changes in concentration of crude protein during the ageing of grass-clover sward.



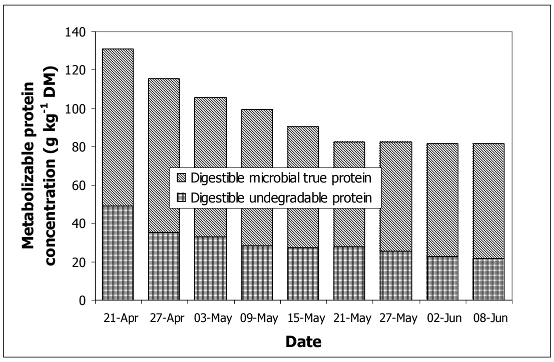
Graph 3. Changes in true protein digestibility in total digestive tract, ruminal protein degradability and digestibility of undegradable dietary protein (UDP).

Between 21 April and 8 June microbial protein synthesis in the rumen decreased from 136 to 92 g kg^{-1} DM intake (values calculated from regression equation, Graph 4). Rapid decline was observed only at early growth stages (before 15 May) while thereafter microbial protein synthesis remained stable. One of the factors responsible for the reduction of microbial protein synthesis was certainly a decline in organic matter digestibility which decreased constantly from 0.83 to 0.56 as the season progressed. However, it can not explain why the microbial protein synthesis remained stable after the middle of May. Detailed analyses of data (Verbič et al., 2002) showed that relatively high protein production during that period may be due to higher efficiency of microbial protein synthesis which coincided with the increase of cellulolytic activity of rumen fluid.

Between 21 April and 21 May the concentration of metabolizable protein decreased from about 130 g kg^{-1} DM to about 80 g kg^{-1} DM (Graph 5). There were no further changes after that period. Microbial protein contributed the major part of metabolizable protein (0.62 to 0.73, Graph 5).



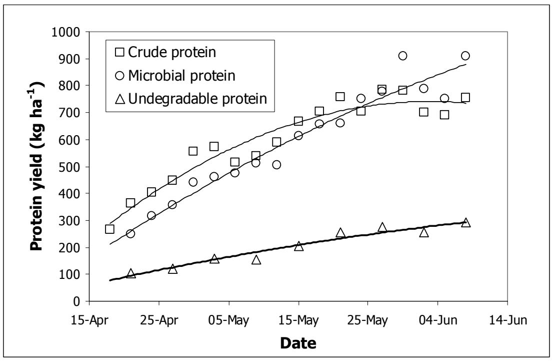
Graph 4. Microbial protein synthesis in the rumen of sheep expressed per unit of dry matter intake.



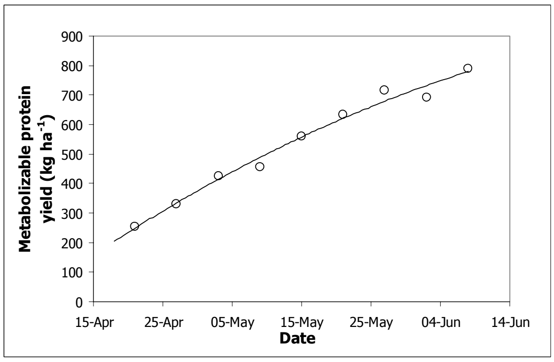
Graph 5. Changes in the concentration of metabolizable protein during the ageing of grass-clover sward and its structure.

Protein production

Productive capacity of grass-clover sward is presented in Graphs 6, 7 and 8. The results indicate that the potential of grass-clover sward for the production of microbial protein in the rumen is similar to its potential for direct protein production on the meadow (Graph 6). However, large seasonal differences were observed. During the early vegetative stages the rate of crude protein accumulation (18.5 kg ha^{-1} day^{-1}) exceeded the production rate of substrate for microbial growth which enabled daily increase of 16.8 kg microbial protein ha^{-1} (Graph 8). With advancing maturity the potential for direct protein production on the meadow decreased at faster rate than the potential for the production of microbial protein and fell to zero at the beginning of June. At the same time the potential for microbial protein production still increased for about 9 kg ha^{-1} day^{-1}.

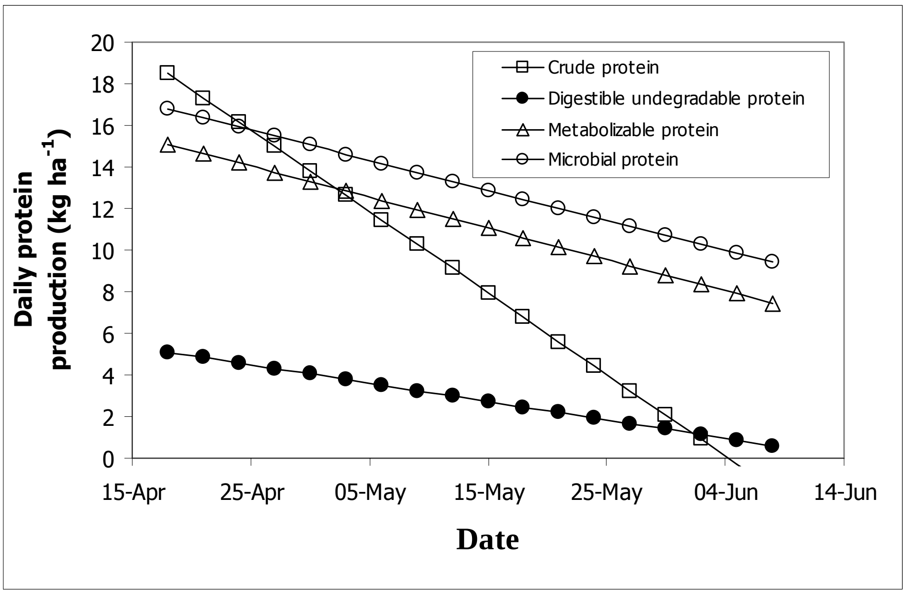


Graph 6. Cumulative yields of crude protein, undegradable protein and microbial protein which results from the fermentation of herbage in the rumen.



Graph 7. Cumulative metabolizable protein yield of the grass-clover sward.

Metabolizable protein yield increased during the experiment from 250 kg ha^{-1} on 21 April to 780 kg ha^{-1} on 8 June (values calculated from regression equation, Graph 7). Average daily metabolizable protein production was 11.0 kg ha^{-1}. It declined from 15.1 kg ha^{-1} at the beginning of experiment to 7.4 kg ha^{-1} at the end of experiment (Graph 8).



Graph 8. Seasonal dynamics of protein production estimated as a first derivative of cumulative production functions presented in Graphs 6 and 7.

CONCLUSIONS

The results indicate that the potential of grass-clover sward for the production of microbial protein in the rumen is similar to its potential for direct protein accumulation. There are seasonal differences in the production potential. During the early vegetative stages the rate of crude protein accumulation exceeds the production rate of substrate for microbial growth. Later net protein accumulation in herbage fell to zero while the potential of grass-clover for microbial protein production still increased for about 9 kg ha^{-1} day^{-1}.

ACKNOWLEDGEMENTS

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LITERATURE

Chen, X.B., Ørskov, E.R. Hovell, F.D.DeB., 1991. The use of intragastric infusion in studies on excretion of purine derivatives as a measure of microbial protein supply in ruminants. In: Protein Metabolism and Nutrition (Eggum, B., Boisen, S., Borsting, C., Danfær, A., Hvelplund, T. Eds.), National Institute of Animal Nutrition, Foulum, 67-70.

Flachowsky, G., Lebzien, P., Strobel, E., 2003. Biotechnikum Pansen – Potenziale und Grenzen. Züchtungkunde 75, 46-65.

Kamel, H.E.M, Sekine, J., Suga, T., Morita, Z., 1995. The effect of frozen-rethawing technique on detaching firmly associated bacteria from in situ hay residues. Can. J. Anim. Sci. 75, 481-483.

Ørskov, E.R., Hovell, F.B.DeB., Mould, F., 1980. The use of nylon bag technique for the evaluation of feedstuffs. Trop. Anim. Prod. 5, 195-213.

Ørskov, E.R., McDonald, I., 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. J. Agric. Sci. 92, 499-503.

Van Soest P.J., 1994. Nutritional ecology of the ruminant, Cornell University Press, Ithaca, 467 p.

Verbič, J., Babnik, D., Verbič, J., Resnik, M. 2002. The effect of ageing of grass-clover sward on protein degradability and microbial protein synthesis in the rumen of sheep. In: Multi-function grasslands. Quality forages, animal products and landscapes (Durand, J-L., Emile, J-C., Huyghe, C., Lemaire, G. Eds.), AFPF, Versailles cedex, 174-175.