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SCIENCE DIRECT
Animal Feed Science and Technology
118 (2005) 79–91
ANIMAL FEED SCIENCE AND TECHNOLOGY
www.elsevier.com/locate/anifeedsci

Efficiency of microbial protein synthesis on red clover and ryegrass silages supplemented with barley by rumen simulation technique (RUSITEC)

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Received 3 October 2003; received in revised form 5 August 2004; accepted 13 September 2004

Abstract

Bacterial protein supply from the rumen is frequently low in animals fed on silage-based diets, partially because of the lack of rumen available sources of energy. An in vitro experiment was designed to determine the optimum rate of inclusion of rolled barley to optimise rumen efficiency of bacterial protein synthesis (E_{BPS}) of diets comprising a typical ryegrass silage (GR; crude protein (CP) = 139 g/kg dry matter (DM); water soluble carbohydrates (WSC) = 71 g/kg DM; NH_3–N = 133 g/kg N; pH 4.23) or red clover silage (RC; CP = 168 g/kg DM; WSC = 28 g/kg DM; NH_3–N = 80 g/kg N; pH 4.12). Both silages were mixed with increasing proportions of barley grain (0, 150, 300 and 450 g/kg DM). Treatments were tested using the rumen simulation technique (RUSITEC), replicated in three independent 10-day incubation periods (blocks). Artificial saliva was infused at a rate of 0.5 ml/min, and on day 4 of incubation $^{15}NH_4SO_4$ was added as a microbial marker. Ammonia–N and pH of the effluent were above 50 mg/l and 6.6, respectively, in all treatments and at all time points measured. Inclusion of barley grain reduced the effluent concentrations of acetic, propionic and total volatile fatty acids ($P \leq 0.06$). Apparent digestibilities of DM (DM*AD*) and organic matter (OM*AD*) did not differ

Abbreviations: AA, amino acids; ADF, acid detergent fibre; AD*FD*, ADF digestibility; BY, bacterial yield; CP, crude protein; E_{BDMS}, efficiency of bacterial DM synthesis; E_{BPS}, efficiency of bacterial protein synthesis; DM, dry matter; DM*AD*, DM apparent digestibility; N, nitrogen; NAD, N apparent digestibility; NDF, neutral detergent fibre; NDF*D*, NDF digestibility; NPN, non-protein N; OM*AD*, organic matter apparent digestibility; RC, red clover; GR, ryegrass; SAB, solid associated bacteria; VFA, volatile fatty acids; WSC, water-soluble carbohydrates

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doi:10.1016/j.anifeedsci.2004.09.008

between RC or GR silages, but RC had lower ($P < 0.001$) neutral and acid detergent fibre digestibilities than GR silage. The effluent concentrations of acetic, propionic, butyric and total volatile fatty acids from GR was higher ($P < 0.05$) than from RC diets. Inclusion of barley grain linearly ($P < 0.06$) reduced the effluent acetic, propionic and total volatile fatty acid concentrations, but increased DM*AD*, OM*AD* and efficiency of bacterial dry matter synthesis (E_{BDMS}). However, there was no clear response in E_{BPS} from GR silage supplemented with barley, but in RC silage, E_{BPS} increased up to a barley inclusion rate of 300 g/kg DM. It is concluded that rumen microorganisms reduced the amount of substrate fermented in correspondence with the increment in barley grain. The E_{BPS} increased in RC silage by adding barley at rates of up to 300 g/kg DM. Conversely, the addition of barley to GR silage had no apparent effect on E_{BPS}.

Keywords: Microbial protein synthesis; Red clover silage; Ryegrass silage; RUSITEC

1. Introduction

There is unequivocal evidence that diets containing a high proportion of silage support low levels of microbial protein synthesis in the rumen (ARC, 1980; Thomas and Thomas, 1985; Dewhurst et al., 2000). Despite the lack of a complete explanation for this, the poor ATP yield of silage fermentation products (Thomas and Thomas, 1985), the reduced availability of rumen degradable carbohydrates, the high proportion of total nitrogen (N) present as non-protein N (NPN, Thomas and Thomas, 1985), and the limited supply of dietary amino acids (AA, Oh et al., 1999), all contribute to reduce the efficiency of N utilisation by rumen microorganisms and thus to the whole animal. Silages frequently have a poor balance between rapidly rumen-degradable sources of energy and the concentration of highly soluble forms of N. Forage legumes typically contain low concentrations of water-soluble carbohydrate (WSC) and dry matter (DM), and have a high buffering capacity, which makes them particularly susceptible to poor fermentation accompanied by high levels of proteolysis during ensilage. Thus, the addition of readily available energy such as sugar or starch to diets based on fresh or ensiled grass has positive effects on microbial protein supply and N utilisation by ruminants (Chamberlain et al., 1985; Keady et al., 1998; Reynolds et al., 2001). With the exceptions of maize and sorghum, more than 90% of the starch in cereal grains is normally fermented in the rumen (Castillo, 1999), making cereals good supplements to silages in ruminant diets. Hence, carbohydrate availability in the rumen of legume silage-fed ruminants has the potential of improving the efficiency of N capture by rumen microorganisms, reducing not only the requirement of expensive sources of dietary protein, but also reducing N excretion from the animal and subsequently reducing the output of N to the environment.

Degradation of plant proteins in the silo results from plant and microbial enzyme activity (McDonald et al., 1991). Proteolytic activity can break down an important proportion of the original plant protein, but there is a wide variation between species. For example, despite similar inherent proteolytic activity in red clover (RC; *Trifolium pratense*) and lucerne (*Medicago sativa*, Papadopoulos and McKersie, 1983), RC silage usually contains significantly less NPN than similar silages made from lucerne (Papadopoulos and McKersie, 1983; Albrecht and Muck, 1991). Polyphenol oxidases present in RC leaves appear to