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Efficiency of utilisation of different diets with contrasting forages and concentrate when fed to sheep in a discontinuous feeding pattern

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Abstract

The effects of feeding different levels of forages and concentrate, in a discontinuous feeding pattern, on the efficiency of feed utilisation and rumen function were studied using rumen fistulated sheep. Experiment 1 was a 4×4 latin square design to determine the whole tract digestibility and rumen characteristics of diets comprising 15% (C15), 25% (C25), 35% (C35) and 45% (C45) concentrate (energy-dense dairy pellets) with the rest of the diet being a combination of fresh short rotation ryegrass (*Lolium mutiforum*) and conserved (lucerne hay and maize silage) forages. In Experiment 2, the rumen degradation characteristics of feed ingredients were determined using the nylon bag technique. Daily dry matter intake (either expressed as g/kg LW or g/kg $W^{0.75}$) was 10% lower ($p=0.03$) for the C15 diet compared with C25, C35 and C45 diets. The apparent *in vivo* digestibility of dry matter (DM) for C15 diet was 4% higher ($p=0.04$) than the C35 and C45 diets which may be attributed to the high quality of the forage (ryegrass) used.

Fibre digestibility decreased as proportion of concentrate in the diet increased. However, this was unlikely due to changes in the rumen fermentation pattern, as neither pH (6.1±0.23) nor ammonia concentration (24.4±6 mg/dl), were different ($p>0.05$) among diets. Instead, the lower fibre digestion was most likely the result of different type and proportion of fibre among diets, as total rumen degradability and rate of fibre degradation in the rumen were higher ($p=0.001$) for ryegrass than for other feedstuffs. There was no significant difference in total nitrogen balance and urinary allantoin excretion among diets, which indicated similar total microbial protein synthesis (MPS). The asynchrony observed, for N and energy availability in the rumen for different diets using Sinclair et al. [Sinclair, L.A., Garnsworthy, P.C., Newbold, J.R., Buttery, P.J., 1993. Effect of synchronizing the rate of dietary energy and nitrogen release on rumen fermentation and microbial protein synthesis in sheep. J. Agric. Sci. 120, 251–263] equation, was due to the feeding pattern used in this study leading to excess of N in relation to total organic matter digested in the rumen. In conclusion, feeding concentrates in the diets as PMR with conserved forages in a discontinuous feeding pattern may be valuable to develop feeding strategies in a pasture based system for high producing dairy cows without affecting the rumen system.

Keywords: Forage(s); Concentrate; Rumen parameters; Fibre digestion; Microbial protein synthesis

1. Introduction

Forages are the primary source of nutrients for ruminant animal production, but in order to achieve high production/cow at the farm level more supplementary

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feed is needed in the form of high energy-dense concentrates (Garcia and Fulkerson, 2005). In the Australian dairy industry, for instance, the use of concentrates has increased substantially over the past few years (Fulkerson and Doyle, 2001). Concentrates are used more frequently to address the large variation in seasonal pasture growth, variability in rainfall within the year, the desire to exploit the genetic production potential of animals and the price incentives provided by milk processors to produce milk at times of low pasture growth (Garcia and Fulkerson, 2005). However, when fed twice-a-day at milking, the response to feeding high amounts of concentrates is low (Fulkerson et al., 2000; Walker et al., 2001) likely due to the adverse influence on rumen environment. In this regard, feeding high levels of concentrates, over short periods during milking, causes decrease in rumen pH leading to a decrease in fibre digestion (Dixon and Stockdale, 1999). However, the effect of a drop in rumen pH is likely to be dependent on the type of fibre being fed; thus, more rapidly digested fibre is less likely to be affected than slowly degraded fibre. Poore et al. (1990) found that concentrate level in the diet has more influence on the passage rate of low (wheat straw), than of high, quality forage (lucerne hay). Similarly, Grant (1994) noted a greater reduction in fibre digestibility of bromegrass hay than lucerne hay when rumen pH was lowered *in vitro* through addition of raw sorghum starch.

Many studies have looked at the effects of the ratio of forage to concentrate on dry matter intake and digestive function in sheep using complete diets (e.g. Carro et al., 2000; Valdes et al., 2000), or supplementing concentrates to grazing dairy cattle (e.g. Fulkerson et al., 2006). However, less work has been undertaken on feed efficiency, rumen characteristics and synchrony of diets varying in the proportion of fresh pasture, conserved forages (and therefore changing the fibre type) and concentrates typically fed to dairy cows.

It is commonly accepted that levels up to about 35% concentrate do not adversely affect fibre digestion. However, even diets with over 35% concentrate will not necessarily affect fibre digestion, as this will depend on other factors such as fibre type, frequency and method of feeding the extra concentrate (Garcia and Fulkerson, 2005). Thus, feeding the extra concentrate as partial mixed ration (PMR) is less likely to affect rumen pH and therefore fibre digestion. In addition, this practice can result in better nitrogen to energy synchronisation in the rumen in comparison to the traditional concentrate/grazing system. This is because the relatively longer periods that occur in the latter system between feeding concentrates to cows in the dairy and grazing are avoided. We used rumen fistulated sheep to test the above hypothesis that there is no effect of increased levels of concentrate in the diet on rumen pH but MPS can be improved when fed as PMR in a discontinuous feeding pattern. The use of sheep as a model is supported by several authors (e.g. Thomas and Campling., 1977; Aerts et al., 1984) who reported small differences between sheep and cattle in terms of feed utilisation and rumen degradability characteristics (Nandra et al., 2000). It has also been reported (Doreau et al., 2000) that difference between sheep and cattle is evident only when diets with >60% concentrate are fed. Recently, the development of a new support system to feed dairy cows in the UK (Feed into Milk) has concluded that differences between cows and sheep (in terms of ME supply), were minimal (Thomas, 2004).

2. Materials and methods

Two experiments were conducted using rumen-fistulated Border Leicester castrate male sheep (with average weight of 55±1.3 kg) housed in individual metabolism crates in a temperature controlled animal house. In Experiment 1, four diets with different forage to concentrate ratio were fed in a latin square design to determine the digestibility coefficients, rumen characteristics and allantoin excretion, as a measure of microbial protein synthesis (MPS). In Experiment 2, the rumen degradation characteristics of the different feed ingredients used in Experiment 1 were determined.

2.1. Experiment 1

2.1.1. Animals and diets

The metabolic crates were designed so that the animals had enough space to sit and stand freely. The animals had free access to drinking water and separators were attached to the floor of the crates to collect faeces and urine. The four diets offered *ad libitum* comprised 15% (C15), 25% (C25), 35% (C35) and 45% (C45) concentrate (dairy pellets) with the remaining of the diet

Table 1
Chemical composition (g/kg DM); and metabolisable energy (ME) in MJ/kg DM of different feed ingredients used for the formulation of different diets

Chemical composition (g/kg DM)	Pellets	Ryegrass	Lucerne hay	Maize silage
Organic matter	863	839	888	933
Crude protein	204	261	220	63
Neutral detergent fibre	161	409	378	484
Acid detergent fibre	71	234	299	297
Hemicellulose	95	191	89	199
Water soluble carbohydrates	66	143	34	27
In vitro DMD (%)	81.7	76.8	67.0	61.3
Metabolisable energy (MJ/kg DM)	11.1	11.2	9.7	9.6