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The Effect of Concentrate Supplementation on Nutrient Flow to the Omasum in Dairy Cows Receiving Freshly Cut Grass

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ABSTRACT

An experiment was carried out to determine the effect of increasing the amount of grain-based concentrate (0, 3, or 6 kg/d) on nutrient flow to the omasum, rumen fermentation pattern, milk yield, and nutrient use of dairy cows. Harvested timothy-meadow fescue grass was fed individually 3 times daily to 6 rumen-cannulated Holstein-Friesian cows in a duplicated 3 × 3 Latin square experiment. Grass was offered as 6 equal meals daily, and concentrates were fed as 2 equal meals daily. Nitrogen, microbial N, and neutral detergent fiber (NDF) flow from the rumen were measured using an omasal sampling technique in combination with a triple marker method [CoEDTA, Yb, and indigestible NDF (INDF) as markers]. Concentrate supplementation linearly decreased ruminal pH, N degradability, ammonia N concentration, and molar proportion of acetate and increased the molar proportion of butyrate. Supplementation of grass with concentrates linearly increased dry matter intake (DMI), microbial N synthesis, N, and NDF flow to the omasum, and ruminal and total tract NDF digestibility decreased linearly. Decreases in NDF digestibility in response to concentrates was primarily related to a decrease in the rate of digestion. Increased DMI overcame the negative effects of concentrate on NDF digestion, resulting in a linear increase in total metabolizable energy intake and milk production. Physical constraints were found not to limit grass DMI. Concentrate supplementation increased the apparent use of dietary N for milk production because of a reduction in N intake, rather than thorough improvements in N capture in the rumen.
(**Key words:** dairy cow, grass, concentrate, nutrient flow)

Abbreviation key: C0 = no concentrate supplementation, **C3** = 3 kg of concentrate, **C6** = 6 kg of concentrate, **DNDF** = potentially digestible NDF, **DOM** = digestible OM, **ECM** = energy-corrected milk, **INDF** = indigestible NDF, **LP** = large particle phase, **ME** = metabolizable energy, **MPS** = microbial protein synthesis, **RDN** = rumen-degradable N, **SP** = small particle phase, **SR** = substitution rate.

INTRODUCTION

Grass, either cut or grazed, is an important source of nutrients for dairy cows in temperate regions (Mannetje, 2000). Well-managed grass is highly digestible (Virkajärvi et al., 2003), thus representing an important source of energy for dairy cows. Grass N content is usually high and is extensively degraded in the rumen (Kolver and Muller, 1998), resulting in poor capture of total grass N to microbial N. High intakes of dietary CP are related to increased urinary N excretion. Urinary N is prone to both leaching and volatilization as ammonia (Whitehead, 2000). Supplements of low protein concentrates reduce dietary N content and thereby decrease N losses at the animal level (Jonker et al., 2002). However, to ensure high milk yields, concentrates containing RUP may be needed to complement grass-based diets (Bargo et al., 2003), which could lead to substantial N losses.

In the literature, there is a vast quantity of information reporting on supplementary feeding of dairy cows at pasture or fed on cut-grass feed (Bargo et al., 2003). However, there is a need to collect more data about the responses to concentrate feeding with respect to the supply of nutrients in grazing dairy cows. Ingested feeds are extensively degraded in the rumen to fermentation end products, which are partially recovered as microbial biomass. Thus, it is necessary to examine ruminal digestion kinetics and nutrient flow from the rumen both for supplemented and nonsupplemented diets to understand the reasons for the low DMI for grass diets as compared with the genetic potential of the modern dairy cow. Physical distension of the rumen has been proposed as the limiting factor of high fiber diet intake, whereas metabolic regulation controls intake of high-energy diet (Mertens, 1994). A highly digestible, solely grass diet has both a high fiber content and a high energy value so that physical and

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metabolic regulation work simultaneously, affecting the DMI of the cow. For optimal diet formulation, information is needed on what is the right balance among environmental needs, RUP supply, and energy content in the diet. This study is focused on determining the factors limiting production in dairy cows on a grass diet.

Feeding cows freshly cut grass enables an accurate measurement of intake, which is fundamental to assessing nutrient flows from the rumen. The results obtained from tie-stall feeding studies and grazing studies may not be totally comparable because of selective grazing behavior, which may increase the digestibility of grazed sward (Dalley et al., 1999). These errors are unlikely to be significant if high quality, homogeneous cut grass is fed. The current study was conducted to determine the effects of concentrate supplementation on intake, nutrient flow to the omasum, milk production, and nutrient use in cows fed fresh-cut grass.

MATERIALS AND METHODS

Animals, Diets, and Procedures

The study was conducted using a replicated (n = 2) 3 × 3 Latin square design with 6 rumen-cannulated Holstein-Friesian lactating cows in their second lactation (average DIM, 57 ± 12; BW, 546 ± 38 kg at the start of experiment) at MTT Agrifood Research Finland. Each of the 3 periods lasted 23 d including the first 15 d of free grazing and 8 d of indoor feeding when fresh-cut grass was offered ad libitum to cows housed in a tie-stall barn. Only the last 8 d (d 16 to 23) were used for the calculations. Treatments (**C0**, **C3**, and **C6**) consisted of 3 levels of concentrate supplementation (0, 3, or 6 kg/d, respectively) fed as 2 equal meals at 0600 and 1800 h. After each period, cows were changed over to the next diet over a period of 4 d. The concentrate consisted of barley (40.0%), oats (10.0%), molassed sugar beet pulp (25.0%), wheat bran (5.0%), rapeseed expeller (10.4%), molasses (5.5%), rapeseed oil (1.2%), and minerals (2.9%) determined on a weight basis. Cows had free access to water and a salt block, and a mineral mixture (83 g/kg DM of Ca, 44 g/kg DM of P, 62 g/kg DM of Mg, 57 g/kg DM of Na) was offered at 300 g/d. Table 1 shows the chemical composition of the feeds.

The cows grazed timothy (*Phleum pratense*)-meadow fescue (*Festuca pratensis*) pasture in an intensive rotation with an estimated herbage allowance >25 kg of DM/d from the beginning of the summer. Timothy was the predominant species in the first period, whereas meadow fescue dominated the sward during the last period. Grass for indoor feeding was harvested with a Haldrup 1500 plot harvester from a similar field to the grazed area 3 times daily at 0600, 1400, and 2200 h (stubble height 10 cm). The area harvested remained the same during the experiment. The grass was stored in the barn before being fed to the cows. Grass was offered to cows beginning on d 16 at 1500, 1900, 2300, 0300, 0700, and 1100 h. Orts were weighed before new grass was fed.

Table 1. Composition of the experimental feeds.

		Grass		
	Concentrate	Period 1	Period 2	Period 3
DM, g/kg	878	164	178	178
OM, g/kg DM	921	914	910	897
NSC,[1] g/kg DM	453			
NDF, g/kg DM	246	513	532	482
INDF,[2] g/kg DM	36	36	68	43
N, g/kg DM	26	38	38	38
ME,[3] MJ/kg DM	12.6	11.8	11.1	11.6
IVOMD,[4] g/kg		805	756	807

[1]NSC = Nonstructural carbohydrates.
[2]INDF = Indigestible NDF.
[3]ME = Metabolizable energy.
[4]IVOMD = In vitro OM digestibility.

Grass samples for chemical and DM analysis were collected after each harvest and pooled to provide 2 subsamples within each period. Samples were stored frozen at −20°C until dried at 60°C for chemical analysis. Concentrate samples were collected periodically and pooled within periods. The cows were milked and the amount of milk was recorded at 0700 and 1700 h. Milk samples were collected over 6 consecutive milkings from each cow on d 18 to 19.

The total digesta flow into the omasum was assessed by the triple-marker method (France and Siddons, 1986) using LiCoEDTA (Udén et al., 1980), Yb-acetate, and indigestible NDF (**INDF**) as markers for liquid (fluid) phase, small particle phase (**SP**), and large particle phase (**LP**), respectively. Ytterbium-acetate (5.0 g/d) and LiCoEDTA (12 g/d) were dissolved daily in 7 L of water and infused into the rumen continuously using a peristaltic pump (Watson Marlow, Falmouth, UK). Infusion of Co and Yb started on d 16 with a 7.5- and 18-g primer dose of Yb and Co, respectively, at 87 h before the first omasal sampling on d 19. The primer dose was used to reach steady-state ruminal marker concentrations more rapidly. Samples were collected from the omasum using the method described by Huhtanen et al. (1997), incorporating the modification of Ahvenjärvi et al. (2000). Briefly, a plastic tube was inserted into the omasum, and samples were collected using a compressor/vacuum pump. The sampling tube (1.2 m in length) was connected to a 200-mL sand-filled bottle in the abomasum to keep the sampling