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NEUTRAL DETERGENT FIBRE REQUIREMENTS FOR GRAZING DAIRY COWS ARE POORLY DEFINED

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SUMMARY

Currently, recommendations of fibre requirements for lactating cows grazing highly digestible pastures are based on dietary neutral detergent fibre (NDF) concentrations. Data from experiments investigating milk production responses of grazing cows to concentrate and forage supplements were examined to determine if dietary NDF concentrations reliably predicted milk fat concentrations. Within 2 pasture types, predominantly clover or ryegrass, dietary NDF concentration was related ($p<0.05$) to milk fat concentration. However, the large variation within these relationships and the differences between sward types highlighted issues with using dietary NDF concentration as a sole predictor of milk fat concentration. The effective NDF (eNDF) system has improved the precision of estimating fibre requirements of cows fed total mixed rations. However, when applied to our data, there was no relationship between dietary eNDF concentration and milk fat concentration for cows grazing either pasture type. More precise estimates of the effectiveness factors for grazed herbage may assist in defining the minimum level of NDF required to maintain milk fat concentration.

Keywords: neutral detergent fibre, effective neutral detergent fibre, dairy cows.

INTRODUCTION

In the irrigation region of northern Victoria, insufficiency of neutral detergent fibre (NDF) for grazing cows is likely to be an issue during periods of the year when highly digestible pastures are consumed in combination with cereal grain (Wales *et al.* 2001). This can be when cows are grazing annual pastures in late autumn and winter or perennial pastures in winter and early spring. Under most other circumstances, cows are consuming NDF well in excess of recommendations and issues of excess fibre associated with low energy densities of the diet become important (Wales *et al.* 1998; Wales *et al.* 2000).

There have been many attempts to describe the fibre requirements of dairy cows. Presently, the Standing Committee for Agriculture (1990) recommends that a quantity of roughage should be included in the diets for dairy cows in order to avoid low milk fat syndrome and to maintain a stable rumen fermentation. Though not definitive, they recommend an optimum level of NDF of 400 g/kg DM (based on Mertens 1983), and a range in acid detergent fibre of between 200 and 250 g/kg DM (based on Sutton 1984), below which milk fat concentration will tend to decline.

The AFRC (1993) does not specify fibre requirements. However, practical recommendations are that dairy cows require 350 to 400 g NDF/kg DM of which 0.75 should come from forage with an average particle length exceeding 1.5 cm (Chamberlain and Wilkinson 1996).

The NRC (1989) recommended a minimum of 250 to 280 g NDF/kg DM, with a minimum of 0.75 supplied by forage, for high-producing cows fed total mixed rations. This approach of recommendations based on NDF concentrations does not take into account differences in particle size of forages. Subsequently, the concept of effective NDF (eNDF) was adopted (NRC 1996) to describe the ability of a supplement to replace forage, such that milk fat concentration was maintained. More recently, the concept of physically effective fibre has been defined to relate the physical characteristics of feeds, as measured by chewing activity or particle size, to rumen fluid pH (Mertens 1997). He proposed that the physical effectiveness factor (pef) of individual feeds be based on chewing activity. However, because the assessment of chewing requires experimentation with animals, an alternative approach was developed based on the proportion of feed retained on a 1.18 mm sieve.

The Cornell Net Carbohydrate and Protein System computer model (CNCPS, 2000) has further refined eNDF to the percentage of NDF remaining on a 1.18 mm screen after dry sieving and adjusts this value to account for density, hydration and degree of lignification of the NDF within classes of feeds.

Our hypothesis was that current definitions of NDF requirements are not appropriate for cows grazing highly digestible pastures with moderate levels of supplementation.

MATERIALS AND METHODS

Experimental animals, design and diets

Data from three grazing experiments conducted at Kyabram (36°20' S, 145°04' E) and one experiment conducted at Ellinbank (38°15' S, 145°93' E) during springs from 1998 to 2000 have been analysed. Each experiment investigated the milk production responses in cows grazing highly digestible perennial pastures alone or with concentrate and forage supplements. Descriptions of the cows used and production immediately prior to each experiment and the digestibility of the pasture consumed during the experiments are given in Table 1.

Table 1. Pre experimental conditions and digestibility of pasture consumed by cows

	Experiment 1	Experiment 2	Experiment 3	Experiment 4
Site	Kyabram	Kyabram	Kyabram	Ellinbank
Experimental period (days)	21	27	27	25
Number of cows	24	63	48	60
Days lactating	44	49	43	31
Milk yield (kg milk/day)	26.2	25.2	29.9	29.6
Milk fat (g/kg milk)	39.3	40.7	40.4	39.1
Condition score (8-point scale)	-	3.6	4.0	4.4
IVDMD pasture consumed (g/kg DM)	771 - 778	833	743	830

In experiment 1, four groups of Holstein Friesian cows grazed either Persian clover (*Trifolium resupinatum* L.) or perennial ryegrass (*Lolium perenne* L.) at two herbage allowances designed to achieve similar intakes (either high or low) between pasture types (Williams *et al.* 2000). In experiment 2, similar cows grazed perennial ryegrass pastures at an allowance of 19 kg DM/cow.day (6 treatments) or 37 kg DM/cow.day (1 treatment) (see Wales *et al.* 2001). Five supplemented treatments were 5.0 kg DM pelleted cereal grain, 2.5 kg DM pasture hay as pellets or cubes and 7.5 kg DM grain plus hay, as either pellets or cubes. In experiment 3, the cows grazed subterranean clover (*Trifolium subterraneum* L.) pastures at an allowance of 19 kg DM/cow.day. The 8 treatments were: pasture-only; pasture plus 5.0 kg DM pelleted cereal grain, 0.5, 1.0 or 1.7 kg DM ryegrass straw; and pasture plus 5.0 kg DM grain plus 0.5, 1.0 or 2.0 kg DM straw. In experiment 4, similar cows grazed perennial ryegrass pastures at an allowance of 22 kg DM/cow.day. The 5 treatments were pasture-only, pasture plus 6.0 kg DM pelleted cereal grain, grain plus 300 g sodium bicarbonate, grain plus 2.2 kg DM high NDF hay and grain plus 3.9 kg DM low NDF hay. Treatments were replicated once in experiment 1, twice in experiment 3 and three times in experiments 2 and 4.

The amount of herbage eaten by each group of cows was assessed using the methods and sampling schedules described by Wales *et al.* (1998). Herbage and supplement samples were analysed for NDF in the same laboratory using a modification of the methods of Van Soest *et al.* (1991). The effective NDF was calculated by multiplying the NDF concentrations by the effectiveness factors (ef) in the feed library of CNCPS (2000). This model quotes a single ef value of 0.41 for spring and summer grazed herbage (no distinction between clover and grass-based swards), 0.98 for most hays, 0.4 for pelleted hay, 0.7 for cubed hay and 0.3 for compounded pelletised grain. In each experiment, aliquot samples of milk were collected from cows on at least 5 days/week during the experimental period and were analysed for milk fat concentration by Fossmatic 4000/5000 Combi (Foss Electric, Denmark).

Statistical analysis

Relationships between NDF or eNDF concentration in the diet and milk fat concentration were examined using regression analysis (GenStat v5). Data for each replicate was used, but they were separated into data sets on the basis of pasture type, predominantly ‘clover’ or ‘ryegrass’.

RESULTS

Differences existed at the start of experiments in milk yield and body condition of the cows, but milk fat concentrations were similar (Table 1). In experiment 1, the two swards contained 760 or 700 g/kg

DM of Persian clover or perennial ryegrass. The other pastures contained over 510 g/kg DM perennial ryegrass (experiments 2 and 4) and over 840 g/kg DM subterranean clover (experiment 3).

Average daily intakes on pasture only at low herbage allowances (<25 kg DM/cow) were 12.4 kg DM/cow for ‘clover’ (3 replicates) and 11.2 for ‘ryegrass’ (7 replicates), while at the high allowances (>25 kg DM/cow) they were 19.3 (1 replicate) and 16.5 (4 replicates) kg DM/day, respectively. The NDF concentration of the ‘clover’ and ‘ryegrass’ consumed by cows averaged 302 (range 254 to 324) g NDF/kg DM and 449 (416 to 492) g NDF/kg DM, respectively. The pelleted cereal grains contained 186 (164 to 231) g NDF/kg DM, and the hays/straws contained 678 (550 to 704) g NDF/kg DM.

In experiments 2, 3 and 4, milk fat concentrations were generally highest on pasture only or pasture + hay diets, intermediate with pastures + cereal grain + hay diets and lowest with cereal grain supplements. Across the experiments, milk fat concentration ranged from 34.3 to 42.3 g/kg milk. This considerable range in conditions provided the basis to examine relationships between NDF or eNDF and milk fat concentration, as a means of testing the robustness of recommendations for NDF in the diet of grazing cows in Victoria.

The NDF concentration of the diet consumed by groups of cows was positively ($p<0.05$) related to their milk fat concentration when grazing either ‘clover’ or ‘ryegrass’ pastures (Figure 1). However, less than 56% of the variation was explained by these relationships and the relationships were quite different for the 2 pasture types. There was no relationship between dietary eNDF concentration and milk fat concentration (Figure 2).

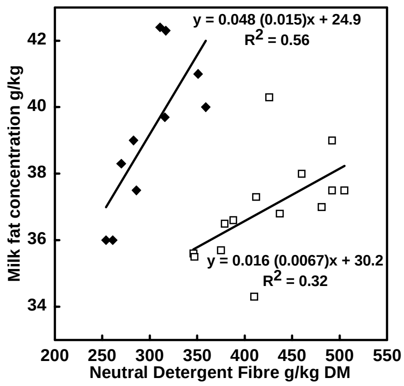

Figure 1 Relationship between neutral detergent fibre concentration of diet and milk fat concentration of groups of cows grazing either clover- (◆) or ryegrass-based pastures ( ).

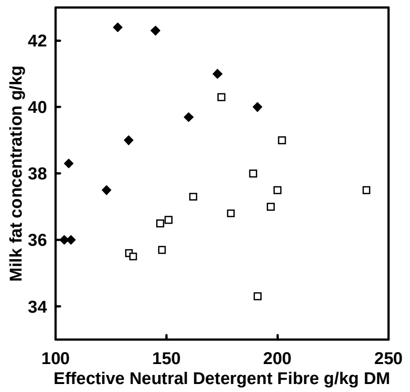

Figure 2 Effective neutral detergent fibre concentration of diet and milk fat concentration of groups of cows grazing either clover- (◆) or ryegrass-based pastures ( ).

DISCUSSION

The variation in the relationships between dietary NDF concentration and milk fat concentration on ‘clover’ and ‘ryegrass’ swards, highlights the uncertainty associated with using NDF as a sole predictor of declines in milk fat concentration. At an NDF concentration of 400 g/kg DM, the optimum suggested by SCA (1990), actual milk fat concentrations ranged from 34.3 to 40.3 g/kg milk for cows grazing ‘ryegrass’ swards. However, with ‘clover’ swards, milk fat concentrations above 40.0 g/kg occurred when dietary NDF concentrations were less than 350 g/kg DM. Many factors are likely to contribute to these differences. For example, in recent research C.R. Stockdale (pers. comm.) has shown that high milk fat concentrations in early lactation are dependent on high-energy intakes and good body condition. The moderate condition of cows prior to experiments and the restricted herbage allowance on most treatments would have influenced the relationships reported here.

Typically, clovers have higher pectin and lignin concentrations and a lower ratio of hemicellulose to cellulose compared with grasses (Leaver 1985). A simple analytical procedure, such as NDF extraction, does not fully represent the chemical make up of cell wall polysaccharides, as pectins are solubilised. In addition, considerable structural heterogeneity exists within and between plant species.

At the same DM intake, there is little difference in time spent grazing, but less rumination, in cows offered ‘clover’ compared to ‘ryegrass’ (Williams *et al.* 2000). This is presumably due to differences between the swards in chemical and structural characteristics that lead to increased rates of passage and higher intakes of clover (Moseley and Jones 1984). In experiments 3 and 4, cows on the pasture-only ('clover' and 'ryegrass') treatments consumed 12.8 and 11.3 kg DM/day, grazed for 7.4 and 7.2 hours, ruminated for 5.5 and 5.4 hours, and spent 60 and 53 min chewing/kg DM, respectively. Their milk fat concentrations were 42.4 and 40.3 g/kg, respectively. Mertens (1997) established that chewing rate (min/kg DM) = (milk fat % - 2.5869)/0.0284, whereby estimated chewing rates to achieve these milk fat concentrations were 58 and 50 min/kg DM; close to the actual rates recorded. However, estimated and actual chewing rate data for other treatments were not well matched, and there was a poor correlation between the limited number of actual data and milk fat concentrations.

The effects of physical characteristics of plant cell walls on milk fat concentrations led to the development of the eNDF system (Mertens 1997). However, using the ef values in CNCPS (2000) to calculate eNDF did not improved our ability to predict milk fat concentration in dairy cows grazing high digestibility pastures. Currently the dry sieving technique is used as a surrogate for chewing activity to determine the ef of components of rations (Mertens 1997), a technique that is not applicable for grazed herbage. With cows grazing green pasture, it may be necessary to establish relationships between chewing activity and milk fat concentration on different pasture types to improve estimates of ef or to use alternative approaches to estimating eNDF. For example, Kolver and de Veth (2002) have attempted to use rumen fluid pH as a predictor of eNDF.

To conclude, improved systems are needed for predicting insufficiency of structural carbohydrates in the diet of cows grazing highly digestible pastures. Dietary NDF concentrations were not strongly related to milk fat concentrations across the data analysed here. While the eNDF system is conceptually a better approach, dietary eNDF concentrations were poorly related to milk fat concentrations, presumably because the ef values used were not appropriate.

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