



Neutral Detergent Fibre (NDF) and Non Structural Carbohydrate (NSC) requirements in the nutrition of dairy ewes

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Paper received April 28, 2004; accepted October 15, 2004

ABSTRACT

The aim of this review was to contribute to the knowledge of neutral detergent fibre (NDF) and non structural carbohydrate (NSC) requirements in the nutrition of dairy ewes. NDF and NSC requirements were evaluated by analysing a dataset that involved 30 experimental trials carried out from 1985 to 2003. The dataset included chemical composition of the experimental diets, individual milk yield, body weight, milk protein and fat content. These selected papers regard 10 different dairy ewe breeds (Valle del Belice, Bergamasca, Comisana, Delle Langhe, Massese, Sarda, Chios, Manchega, Lacaune and Friesian) and lactating ewes in mid lactation, kept under non homogeneous environmental and feeding conditions. Results substantially confirmed that which was recently reported in literature: NDF requirements are higher in late lactation than during early lactation and they vary between 33-38% on DM, while NSC requirements are higher during early lactation than in late lactation when the energy from NSC promotes an increase in fat deposits.

Key words: NDF (Neutral Detergent Fibre), NSC (Non Structural Carbohydrates), Lactating ewes, Energy balance

RIASSUNTO

FABBISOGNI DI FIBRA NEUTRO DETERSA (NDF) E DI CARBOIDRATI NON STRUTTURALI (NSC) NELL'ALIMENTAZIONE DELLA PECORA IN LATTAZIONE.

Lo scopo di questa rassegna è quello di fornire un contributo alla conoscenza dei fabbisogni di NDF e di NSC delle pecore in lattazione attraverso l'analisi dei risultati delle ricerche eseguite sull'argomento, dalle quali sono state tratte le informazioni sulla composizione della dieta, sul peso corporeo degli individui e sulla produzione quanti-qualitativa di latte. In tal modo è stato possibile selezionare 30 differenti lavori sperimentali, effettuati dal 1985 al 2003 e pubblicati, per la maggior parte, da autori italiani. I dati, nel complesso, sono riferibili a 10 differenti tipi genetici (pecora della Valle del Belice, Bergamasca, Comisana, pecora Delle Langhe, Massese, Sarda, Chios, Manchega, Lacaune e Frisona), ad animali mantenuti in condizioni ambientali e di alimentazione eterogenee e ad uno stadio di lattazione compreso tra lo svezzamento dell'agnello (primi 30-40 giorni di lattazione) e il quarto - quinto mese di lattazione. L'analisi dei risultati di queste sperimentazioni ha consentito di confermare quanto recentemente riportato da alcuni autori italiani e francesi in merito ai fabbisogni di fibra e di NSC nel corso della lattazione. I fabbisogni di NDF, infatti, sono più elevati nell'ultima fase della lattazione, mentre nella fase iniziale il contenuto di NDF della razione sarebbe correlato negativamente con la produzione quanti-qualitativa di latte. Per questo motivo il livello ottimale di NDF nella razione durante il periodo di più elevata produzione dovrebbe aggirarsi tra il 33-38% della SS. Il livello di NSC dovrebbe essere più elevato all'inizio della lattazione, in quanto successivamente favorirebbe l'accumulo di riserve corporee senza influenzare la composizione del latte.

Parole chiave: NDF (fibra neutro deterosa), NSC (carboidrati non strutturali), Pecore in lattazione, Bilancio energetico.

Introduction

Fibre (expressed as NDF percentage on dry matter, DM) and non structural carbohydrate content in the rations of dairy ewes are strictly linked to the availability of forages throughout the year and to the utilisation of supplements in the ration. Structural and non structural carbohydrate (SC and NSC) content in the ration and their ratio affect both dry matter intake (DMI) and rumen fermentation processes and, consequently, milk yield and quality. The NDF percentage is traditionally considered positively related to milk fat content and negatively to DMI and milk yield.

An inadequate diet fibre content could cause rumen disguises that depress milk fat content and yield (Chiofalo *et al.*, 1993; Oddy, 1978; Poulton and Ashton, 1972). Pulina and Rassu (1991), reviewing the results of many experimental trials, estimated an increase in fat percentage of about 0.06% for each NDF unit added to the ration, following the equation:

$$g = 4.59 + 0.055 \text{ NDF}$$

where *g* and NDF are milk fat content and diet NDF content, respectively.

This linear relationship can be applied within a certain dietary NDF range, because over a threshold (about 30 – 32 % on DM) no additional milk fat increments were observed (Nudda *et al.*, 2001).

A positive relationship between NDF diet content and milk fat percentage has often been reported when NDF percentage increases in the diet. This behaviour may be explained with a diminution of DMI and of the diet energy content that lead to a decrease in milk yield, and, consequently, to an increase in milk fat content, because of a simple concentration effect.

Other authors, on the contrary, showed a negative correlation between the two parameters in ewes yielding more than 1.2 kg/d (Cannas and Avondo, 2002).

Recently, Bocquier and Caja (2001) showed a linear inverse relation between milk fat percentage and energy balance that led to a decrease in fat of approximately 12.2 g/l of milk for each UFL/d more in energy balance.

This relationship was established for ewes in

different stages of lactation, for a wide range of energy balance (from – 1.5 to + 1.5 UFL/d) and milk production (from 0.6 to 3.5 l/d). The authors suggested that the relationship between energy balance and milk fat percentage could explain why the diet NDF percentage is sometimes positively and sometimes negatively related to milk fat percentage.

Cannas *et al.* (2002) supposed that a positive energy balance was in correspondence to a negative correlation between diet NDF and milk lipid content, and that a negative energy balance made this correlation positive.

A large number of studies regarding NDF requirements has been aimed at dairy cows, for which many parameters have been defined and expressed either as body weight percentage or as DM percentage.

According to Mertens (1985; 1994), DMI and milk yield of dairy cows may be optimised when NDF intake reaches $1.25\% \pm 0.1$ of body weight (BW). Mertens also suggested a similar value of NDF intake for dairy ewes, however a lack of specific studies does not make it possible to extend this statement to the wide variety of sheep breeds and feeding conditions. For example, high yielding dairy breeds have different requirements than low yielding ones; total mixed rations may improve the efficiency of carbohydrates utilisation as referred to standard feeding conditions.

During the last 10-15 years, several studies were carried out on dairy sheep nutrition, but apart from a few cases, structural and non structural carbohydrate requirements were not proposed. Thus, currently there are no univocal indications about the optimal range of NDF and NSC levels in dairy ewe feeding.

Recently, Avondo and Cannas (2001) reviewed data of NDF intake, milk yield and quality regarding 10 feeding trials that involved 210 multiparous Comisana and Pinzirita ewes. The authors showed that the values of NDF intake that optimised milk yield and DMI were 1.20 and 1.46 % BW, respectively, and that these values were quite similar to those suggested by Mertens (1.25 % BW).

The main source of NSC are concentrate feeds, thus the NSC level in the ration is related to the

forage/concentrate (F/C) ratio and to the nature of the concentrate.

Very few studies are available on the NSC requirements in dairy ewe feeding.

Eyal and Folman (1978) reported that low levels of the F/C ratio (lower than 40/60) caused a decrease in milk protein and lipid content in early lactation ewes, probably because the high rumen NSC degradation rate induced a decrease in rumen pH that is unfavourable to the bacterial protein yield and SC fermentation processes.

Recently, some authors indicated that the level of NSC in the diet of dairy ewes should be higher during early lactation; in fact higher milk yield and milk protein content are reported in response to a diet with 35-38 % NSC levels (De Vincenzi *et al.*, 1999; Bovera *et al.*, 2003). Instead, during late lactation a positive relationship between diet NSC content and BW gain was observed, and no positive effects were reported on milk yield and quality (Bocquier and Caja, 2001; Scerra *et al.*, 2001; Cannas *et al.*, 2000).

Source of data

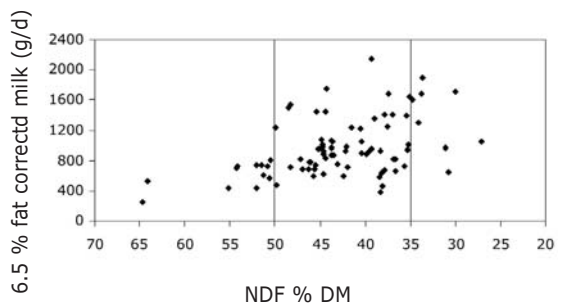
Thirty experimental trials carried out from 1985 to 2003 were selected in order to create a dataset that included the chemical composition of experimental diets, individual milk yield, body weight, milk protein and fat content. These selected papers referred to 10 different dairy ewe breeds (Valle del Belice, Bergamasca, Comisana, Delle Langhe, Massese, Sarda, Chios, Manchega, Lacaune and Friesian) and to lactating ewes in mid lactation, maintained under non homogeneous environmental and feeding condition (Manfredini *et al.*, 1987; Trimarchi *et al.*, 1989, 1991; Rossi *et al.*, 1991; Chiofalo *et al.*, 1993; Avondo *et al.*, 1994; Pennisi *et al.*, 1994; Susmel *et al.*, 1994; Battaglini *et al.*, 1995; Cannas *et al.*, 1995, 2000; Ferruzzi *et al.*, 1995; Pulina *et al.*, 1995; Lanza *et al.*, 1996; Bianchi *et al.*, 1997; Fois *et al.*, 1997; Laudadio *et al.*, 1997; Perez-Alba *et al.*, 1997; Rotunno *et al.*, 1998; Zervas *et al.*, 1998; De Vincenzi *et al.*, 1999; Hadjipanayiotou, 1999; Leto *et al.*, 2000; Witt *et al.*, 2000; Molina *et al.*, 2001; Scerra *et al.*, 2001; Antongiovanni *et al.*, 2002; Mele *et al.*, 2002; Bovera *et al.*, 2003). Linear and

quadratic regression (SAS, 1999) among milk yield, milk fat content, energy balance and NDF and NSC diet content were applied in order to discuss the results more easily.

Relationship between diet NDF and NSC content and energy balance

In spite of the wide variability caused by the heterogeneity of environmental conditions, the results of the analysis of the dataset made it possible to highlight that a large part of the data referred to a range of NDF between 35 and 50% of DMI, and that a positive relationship between the fibre content of rations (expressed as NDF content) and 6.5 % fat corrected milk yield (figure 1) may be observed, as previously reported by Avondo and Cannas (2001).

Figure 1. Relationship between NDF (% DM) and fat corrected milk (6.5%) for different dairy ewe breeds (30 experimental trials, each datum represents the mean of a treatment; n= 83).



This trend seems to confirm that the inclusion of high fibre roughage in the diet during lactation negatively affects DMI and, indirectly causes a decrease in energy intake and milk yield. However, as reported above, the NDF and NSC requirements vary during lactation. As lactation proceeds, in fact, the fibre requirements of dairy ewes seem to increase, as recently reported by Cannas (2001) and Bovera *et al.* (2003), while NSC requirements decrease, because during late lactation these kinds of carbohydrates should promote the body fat deposition instead of milk yield. However, the positive effects of fibre on milk yield

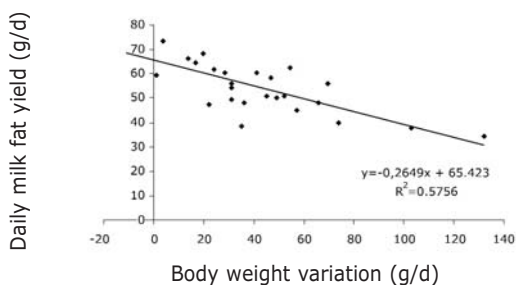
and quality during late lactation become evident only when the quality of roughage is such as to allow high levels of feed ingestion (green forages or finely chopped forages).

In order to explain the positive relationship between diet NSC content and body fat deposition during late lactation, a changing of the hormonal balance that leads to enhance the mammary gland insulin sensitivity was suggested (Cannas *et al.*, 2003). In particular, the energy from NSC should be preferably converted to body fat instead of to milk components.

This hypothesis is also supported by data of Cannas *et al.* (2001) and Bocquier and Caja (2001), who reported a negative linear relationship between the energy balance of dairy ewes and milk fat content: the effect of each milk forage unit (MFU) was quantified as -12.2 g/l of milk fat content.

Using our dataset we put in evidence a similar relationship also between daily milk fat yield and energy balance, expressed as daily variation of body weight (figure 2), although in this case we almost exclusively considered positive energetic balances.

Figure 2. Relationship between body weight variation and daily milk fat yield (n = 26).



By dividing the dataset according to 6.5% fat corrected milk classes, we demonstrated that when NDF was higher than 49% and NSC lower than 26%, daily milk yield was lower than 600 g/d. As daily milk yield increased, NSC requirements also increased, while the NDF requirements decreased (Table 1). In particular, the 6.5% fat corrected milk class with the highest frequency was the 1000-1399 g/d class that corresponded to val-

ues of NDF and NSC equal to 40% and 30%, respectively.

Although the dataset refers to heterogeneous environmental situations and to different ewe breeds, the average content of NDF and NSC in the experimental diets included in our dataset agreed with the optimal values of NDF and NSC intake reported by Cannas (2001), regarding sheep weighing 50 kg.

The last two classes refer to highly specialized dairy ewe breeds such as Manchega, Lacaune, Chios and Friesian, which seemed to have higher requirements of NSC (32-35% DM).

Relationship between diet NDF and NSC content and milk yield and quality

In order to better define the relationship between diet NDF and NSC content and milk yield and quality, we extrapolated from the entire dataset 8 experimental feeding trials homogeneous for breed (only Sarda and Comisana ewes), stage of lactation (from lamb weaning to mid lactation) and feeding regimen (dry forages and concentrate feed, no pasture; diet fat content lower than 3% DM). Therefore, we excluded all trials involving pasture, completely pelleted feed or concentrate feed with high fat content.

The analysis of this simplified dataset allowed us to find a quadratic relationship between diet NDF content and daily milk (kg/d) and milk fat yield (g/d) (Figures 3 and 4). The highest levels of milk fat yield seemed to be allowed by diet NDF content equal to 35% DM, while higher NDF content corresponded to a decrease in milk and milk fat yield. Also, when NDF content was lower than 30%, daily milk fat yield decreased, therefore, on account of this pattern we think that 35% DM represents the optimum requirement of the diet fibre for these ewe breeds, if they are confined and fed under a feeding regimen based only on dry forages and concentrate feed.

Regarding NSC, Figures 5 and 6 show that, in the range between 16 and 45% on DM, the diet NSC content and daily milk and milk fat yield were positively related and the relationship was linear. No data are available regarding the effects of higher NSC content in diet of dairy ewes.

Table 1. NDF and NSC average content extracted from 30 experimental feeding trials and related to five 6.5% fat corrected milk classes (each datum represents the mean of a treatment).

		6.5 fat corrected milk classes (g/d)				
		< 600	600-999	1000-1399	1400-1800	> 1800
NDF	% DM	49.0	42.3	39.9	38.9	39.0
NSC	"	26.3	30.2	29.8	32.3	35.6

During the first phase of lactation, therefore, diet NSC content may be the limiting factor of milk and milk fat yield.

As mentioned above, the majority of the experimental trials that compose our dataset referred to ewes that were in a positive energy balance. Therefore, when ewes are in positive energy balance, we can speculate that levels of diet NDF content higher than 35-38% DM are negatively correlated not only to milk fat content (as reported by Cannas *et al.*, 2001), but also to daily milk fat yield, probably as a result of a decrease in diet NSC content. These data, however, refer to confined ewes fed exclusively dry roughage and concentrate.

When the main dietary source is pasture, we can refer to data reported by Cannas and Avondo (2002), who created a large dataset that included the results of ten feeding trials carried out on Comisana and Pinzirita ewes during an 8-year period. The authors analysed 621 intake data indi-

vidually measured on 210 animals and found no relationship between milk fat content and diet NDF level when ewes were in the low milk yielding phase, while when ewes were in the high milk yielding phase this relationship resulted significantly negative (Figures 7 and 8).

Figure 4. Relationship between diet NDF content and daily milk fat yield (g/d) (n=21).

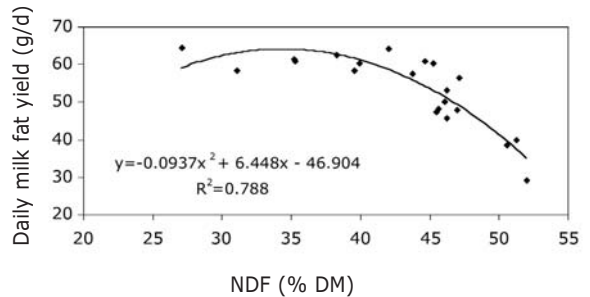


Figure 3. Relationship between diet NDF content and daily milk yield (n=21).

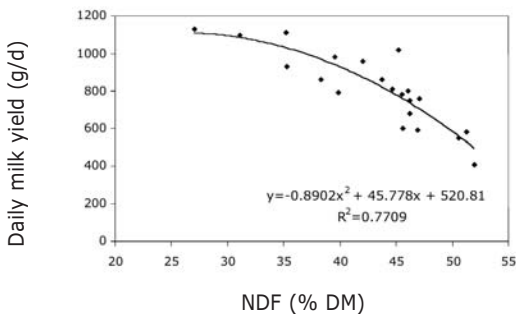


Figure 5. Relationship between diet NSC content and daily milk yield (n=21).

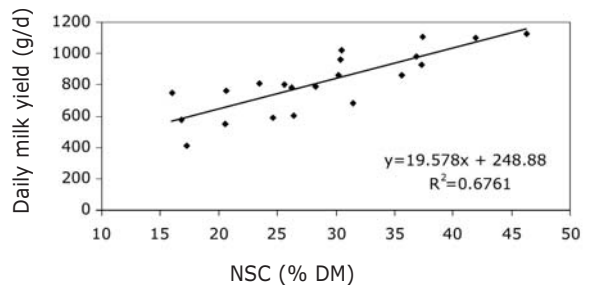


Figure 6. Relationship between diet NSC content and daily milk fat yield (g/d) (n=21).

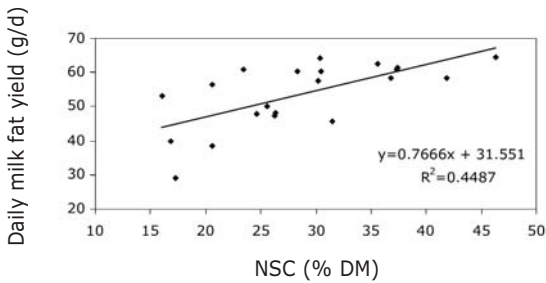


Figure 7. Relationship between diet NDF content and milk fat content. Grazing dairy sheep with milk yield > 1.2 kg/d and < 1.6 kg/d (Cannas, 2001).

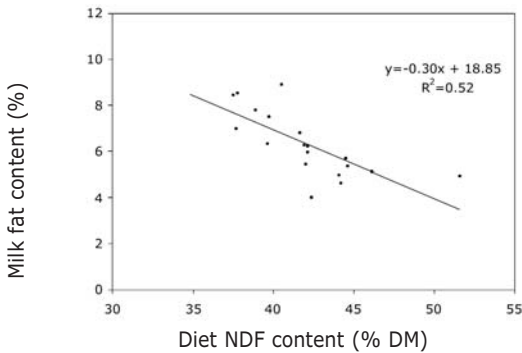
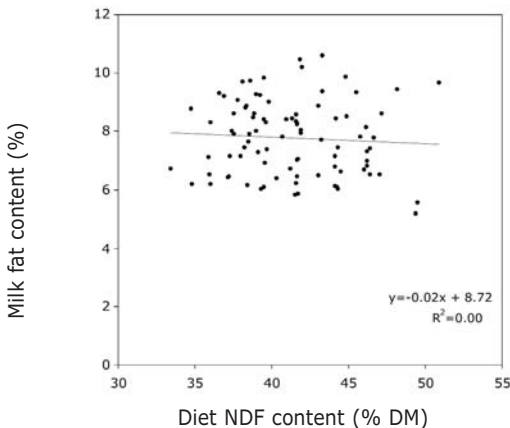


Figure 8. Relationship between diet NDF content and milk fat content. Grazing dairy sheep with milk yield < 0.6 kg/d (Cannas, 2001).



Conclusions

In conclusion, it seems evident that the role of diet NDF and NSC in affecting milk yield and quality may be mainly related to their effects on the energetic balance in ewes, which finally seems to be the major factor of variation in the milk fat content in dairy sheep. When ewes are in positive energy balance and in a free stall management system, a negative relationship between NDF intake and daily yield of milk and milk fat has been demonstrated. For grazing ewes this negative relation may be observed during the high yielding phase of lactation.

Funded by the Ministry of Agricultural and Forestry Policies, Italy, DM 535/7303/02.

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