Effect of type and level of supplement on performance of dairy cows grazing on alpine pasture

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ABSTRACT

An experiment was carried out on 32 dairy cows (average yield 21.9 ± 2.7 kg/d) grazing on summer alpine pasture, in order to examine the effect of two types of supplement - Starchy (42% of cereal) and Fibrous (41% of beet pulp) - both provided at two different levels - Low (1 kg of supplement per 5.0 kg of energy corrected milk (ECM)) and High (1 kg of supplement per 3.3 kg of ECM) - on herbage intake, milk yield and quality. The supplement was distributed twice a day, during milking, at a constant level throughout the experiment (July and August), as calculated according to the daily milk yield in a one-week preliminary period. Meteorological measurements, herbage quality and availability, herbage intake, animal body condition score (BCS), milk yield, chemical and rheological traits were determined. The herbage intake was higher (11.9 kg organic matter (OM)/d) with the Fibrous supplement at Low level. Even if the supplementation covered up to one third of the total intake of OM, none of the experimental groups increased BCS, and the Starchy-Low group showed a decrease in BCS significantly different from zero. The increase in the level of supplementation (from 3.5 to 5.0 kg OM/d in Low and High groups, respectively) improved the ECM yield by an average of 1.2 kg/d (P<0.05), without significant changes in the chemical composition of the milk, while the supplement type had no significant effects on either milk yield or composition. The mean coagulation properties were better with the Fibrous supplement as compared to the Starchy one – rennet clotting time (r): 16'24" vs 19'15" (P<0.05), time for aggregation (K_{20}): 5'03" vs 6'45" (n.s.), gel firmness (a_{30}): 26.1 mm vs 20.8 mm (P<0.05) - without significant differences derived from the level of supplementation.

Key words: Dairy cows, Alpine pasture, Supplement type, Supplement level, Animal performance.

RIASSUNTO

EFFETTO DEL TIPO E DEL LIVELLO DELL'INTEGRAZIONE SULLE PRESTAZIONI DI VACCHE DA LATTE AL PASCOLO IN ALPEGGIO

È stata condotta una prova sperimentale, nei mesi di luglio e agosto, con 32 vacche da latte (produzione media 21.9 ± 2.7 kg/d), mantenute su un pascolo alpino di alta quota, allo scopo di esaminare l'effetto del tipo e del livello d'integrazione sull'ingestione d'erba e sulla produzione quanti-qualitativa del latte. Sono stati utilizzati due tipi di concentrato, *isoenergetici ed isoproteici, Amilaceo (42% di cereali) e Fibroso (41% di polpe secche di bietola), e due livelli di integrazione, Basso (1 kg di concentrato ogni 5.0 kg di latte corretto per l'energia (ECM) e Alto (1 kg di concentrato ogni 3.3 kg di ECM). Il concentrato, distribuito due volte al giorno, durante la mungitura, veniva somministrato in quantità costante sulla base delle produzioni registrate durante un periodo di una settimana, preliminare alla prova. Sono stati rilevati i dati climatici, la quantità di erba disponibile sul pascolo e la sua composizione chimica, la quantità di erba ingerita, il punteggio di condizione corporea (BCS) degli animali, la produzione di latte, la sua qualità chimica e casearia. La temperatura media del periodo di prova è stata di 13.5°C, con una precipitazione media mensile di 145 mm. La disponibilità di erba è scesa da 0.89 t sostanza secca (SS)/ha all'inizio della prova a 0.60 t SS/ha finali, il suo valore nutritivo è passato da 0.84 a 0.65 unità foraggere latte (UFL)/kg SS. Il consumo di erba è risultato massimo con la somministrazione di concentrato Fibroso a livello Basso (11.9 kg sostanza organica (SO)/d, mediamente 1.4 kg SO/d in più rispetto agli altri gruppi). Il gruppo Amilaceo-Basso ha realizzato un'ingestione totale di SO mediamente inferiore di 1.5 kg/d rispetto agli altri gruppi. Il livello Alto di integrazione ha portato ad un'ingestione totale giornaliera mediamente maggiore di 0.8 kg/SO ($P<0.05$) e di 1.1 UFL ($P<0.001$) rispetto al livello Basso. Nonostante l'integrazione coprisse fino a un terzo del consumo totale di SO, nessuno dei gruppi sperimentali ha incrementato il BCS; in particolare il gruppo Amilaceo-Basso ha avuto una diminuzione significativamente diversa da zero (- 0.22 punti). Il livello di integrazione più elevato ha comportato un aumento medio della produzione di 1 kg/d di latte ($P<0.05$) e di 1.2 kg/d ECM ($P<0.05$), senza differenze significative per quanto riguarda la composizione chimica. Il tipo di integrazione non ha invece avuto effetti significativi sulla produzione di latte e sulla sua composizione. Le caratteristiche medie di coagulazione sono risultate migliori con il concentrato Fibroso nei confronti dell'Amilaceo – tempo di coagulazione (r): 16'24" vs 19'15" ($P<0.05$), tempo di formazione del coagulo (K_{20}): 5'03" vs 6'45" (n.s.), consistenza del coagulo (a_{30}): 26.1 mm vs 20.8 mm ($P<0.05$) - senza differenze significative tra i due livelli di somministrazione.*

Parole chiave: *Vacche da latte, Pascolo alpino, Tipo di integrazione, Livello di integrazione, Prestazioni degli animali.*

Introduction

In previous decades, the general trend of alpine livestock production led to its intensification in the most favourite areas. As a consequence, in many cases, local alpine bovine breeds, which are adaptable and less demanding, have been substituted by specialized and more productive dairy breeds, or they have been improved (Hauwuy *et al.*, 1993). This evolution may be incompatible with the maintenance of the traditional grazing activities on the alpine pasture, as demonstrated by the widespread reduction of the grazed areas. From a nutritional point of view, the requirements of the dairy cows, increased by the energy demand due to the physical activity in pastures, could not be met by grazed herbage alone, particularly on low-production, high altitude pastures (Coulon and D'Hour, 1994; Tesfa *et al.*, 1995). Moreover, especially at the beginning of the vegetative season, it is possible to observe an imbalance in the diet energy/nitrogen ratio, which is favourable to nitrogen (Valk *et al.*, 1990; Peyraud *et al.*, 1995) due to the herbage characteristics. The reduction in production, and often, the body condition loss observed under these breeding conditions (Zemp *et al.*, 1989; Malossini *et al.*, 1992; Andrighetto *et al.*, 1996), can be counterbalanced by the administration of energetic supplements.

Numerous publications and reviews have emphasised how the benefit of supplementation is offset by the animal tendency to reduce the herbage intake, so that, above certain levels, offering supplementary food at pasture becomes uneconomical (Peyraud *et al.*, 1998). Nevertheless, animal performance in response to supplementation is largely influenced by factors such as stage of lactation, herbage availability and quality, supplement type (Mayne and Wright, 1988; Spörndly, 1996).

In many experiments dairy cows fed on high levels of fibrous supplements showed higher herbage intake (Kibon and Holmes, 1987; Sayers *et al.*, 2000) and, in some cases, higher milk yield and live weight losses, than cows fed on starchy supplements (Meijs, 1986; Coulon *et al.*, 1989; Delaby and Peyraud, 1994). In others experiments, no favourable effects of fibrous supplements (Istasse *et al.*, 1986; Murphy *et al.*, 1995), or higher substitution rates with fibrous supplements compared with starchy types (Laurent and Gardeur, 1989; Spörndly, 1991) were observed.

The aim of this study was to evaluate the effect of type - Starchy vs Fibrous - and level of supplement on herbage intake, milk yield and quality on dairy cows of medium-high genetic merit, grazing on summer alpine pasture.

Material and methods

Pasture and grazing management

The experiment was carried out for 8 weeks, in July and August, on a high mountain pasture in the Italian Eastern Alpine region (Malga Juribello, Province of Trento, Italy), located in the Natural Park "Paneveggio - Pale di S. Martino". The grazable area extended over 157 ha at an altitude ranging from 1800 m to 2200 m. The characteristics of the vegetation are common to those of many high altitude pastures of the Eastern Alps: in the uppermost areas the most common floristic association is the *Nardion*, which is widespread on poorer and more acid soils. The lowest and flat areas are dominated by medium-production *Poion alpinae* pastures, characterised by the presence of species of good pasture value such us *Poa alpina, Phleum alpinum, Trifolium pratense* and *T. repens. Deschampsia cespitosa* and *Rumex alpinus* can be found only in a few areas, where manure was largely used in the past. Only organic fertilisation is allowed, as the pasture is in a protected area.

During the experimental period, a herd of 127-dairy cows utilised the first growing herbage of the pasture, starting from the lowest and ending at the highest altitude areas, following a controlled grazing system. The animals, which were kept at pasture even at night, came into the stable only during the milking time (about 4 h per day).

Animals and treatments

Thirty-two mature lactating Italian Brown cows in the herd were chosen and assigned to a 2 x 2 experimental design, according to their average performance, recorded during a preliminary period of one week preceding the beginning of the experiment (mean ± standard deviation): genetic merit 7550 ± 1050 kg, energy corrected milk (ECM) 21.2 ± 2.4 kg/d, days of lactation 194 ± 29, live weight (LW) 566 ± 38 kg and body condition score (BCS) 3.02 ± 0.29.

Table 1. Components of the supplements (g kg $^{-1}$).

	Supplement	
	Starchy	Fibrous
Maize	260	95
Wheat bran	220	-
Barley	160	-
Sugar beet pulp (dry)	73	410
Maize germ meal	85	150
Lucerne hay	-	60
Soybean flakes	30	20
Sunflower meal	60	135
Brewer yeast	10	-
Fat	-	30
Molasses	30	35
Minerals and vitamins	72	65

The experimental factors were the type of supplement - Starchy, with 42% of maize and barley, and Fibrous, with 41% of dried sugar beet pulps (Table 1) - and the level of daily administration - High, 1 kg per 3.3 kg of ECM, and Low, 1 kg per 5.0 kg of ECM - based on the preliminary milk yield and maintained constant throughout the experiment. During the preliminary period only one type of supplement, with intermediate composition, was offered at a rate of 1 kg per 4.2 kg of ECM.

The supplements were fed twice a day during milking.

Measurements, estimates and chemical analysis

Temperature and rainfall were recorded daily using an automatic weather station.

The herbage mass was assessed on two consecutive days each week, by cutting twenty 4 m x 9 cm strips of the sward actually grazed by the animals, at a height of 4 cm above ground level. Residues of supplement were individually weighed each day. Samples of herbage and supplements were dried at 65° C in a forced draught, bulked weekly, and analysed for crude protein (CP), ether extract (EE; supplements only), crude fibre (CF), neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) and starch (supplements only) content. The analysis of NDF, ADF and ADL were made according to Goering and Van Soest (1970), while the others parameters were determined according to AOAC (1990). Organic matter digestibility (OMD) of the herbage was determined *in vitro* by enzymatic method, corrected for in vivo digestibility by a regression equation (Aufrère, 1982). OMD of the supplement was estimated from the contents of the fibre components and EE (Giger-Reverdin *et al.*, 1990). The nutritive value, expressed in forage units for milk (UFL), was estimated in accordance with the INRA standards (Vermorel, 1988).

The individual intake was estimated using the n-alcane method, according to Mayes *et al.* (1986), in two periods, in mid July and mid August. For this purpose, the animals were dosed every morning, for 10 days, with 600 mg of C_{32} (dotriacontane) on paper support. In the last 3 days of each period, samples of herbage consumed were hand plucked (Minson, 1990) and grab samples of faeces were collected after each milking. The herbage samples and the individual faecal samples, dried and bulked after each period, were analysed for their n-alkanes and ash concentration. The estimate of OM herbage intake was based on the concentration of a pair of alkanes, namely the dosed C_{32} and the internal C_{31}, the dominant odd-chain alkane occurring in the herbage.

At 2-week intervals the milk yield was individually recorded and samples were collected twice daily for 2 consecutive days. Each sample was analysed for protein, fat and lactose with an infrared Milk-o-scan apparatus and for somatic cell count (SCC) with a Foss-o-matic apparatus. The milk yield (Milk) was corrected on the basis of the energetic value of its components (ECM), according to Bickel (1988). The titratable acidity (°SH/50 ml) and the rheological traits (McMahon and Brown, 1982) - rennet clotting time (r), time for aggregation (k_{20}) and gel firmness (a_{30}) - were determined for the morning milk samples.

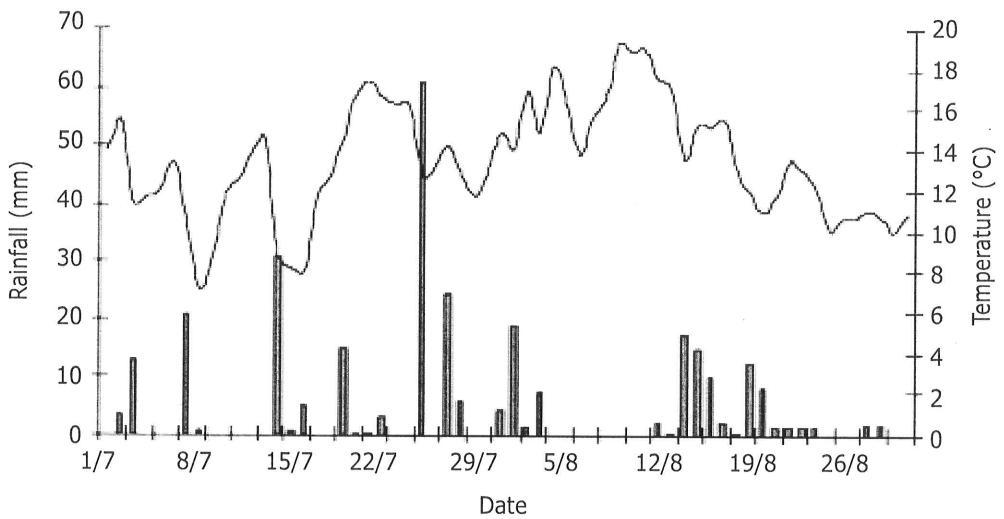
At the start and at the end of the experimental period the cows were assessed for BCS by 2 independent evaluators, according to a 5-point scale method (Edmonson *et al.*, 1989).

Statistical analysis

Intake and performance data were analysed with a 2 (supplement types) x 2 (levels of supplementation) covariance model with interaction, using the initial metabolic live weight and the preliminary-period performance as covariate, respectively.

The same model, without covariates, was used

Figure 1. Daily mean temperature (line) and rainfall (bars).



for the milk rennet coagulation properties.

The significance of the variations of BCS was evaluated within each group as a difference from 0 by the "t" test for paired comparisons.

Results

Meteorological recordings

The weather conditions during the experimental period are summarised in Figure 1. The temperature was characterised by a daily mean of 13.5°C (12.8°C in July and 14.2°C in August) and a wide daily gradient, with an absolute minimum of 2.5°C and an absolute maximum of 24.5°C.The total rainfall recorded in July and August was 186 mm and 104 mm, respectively.

Herbage allowance, feed composition and intake

The weekly evolution during the experimental period of the availability and the chemical and nutritional traits of herbage is reported in Table 2, together with the average chemical composition and nutritional value of supplements.

The mean herbage availability on the summer alpine pasture decreased progressively, from 0.89 t dry matter (DM)/ha at the beginning to 0.60 t DM/ha at the end of the experiment.

The chemical and nutritional properties of the herbage showed a tendency to get worse throughout summer, as can be seen from the opposite trends of fibre fractions, which progressively increased their content, and from CP and OMD, the percentages of which steadily decreased. As a result, the nutritive value of the herbage available declined little by little during the 8-week period, from 0.84 to 0.65 UFL/kg DM.

The supplements were characterised by comparable values of CP, OMD and UFL, but fibre fractions and starch content were different, depending on the sources of carbohydrates. In particular, the Fibrous supplement had almost twice CF and NDF and less than one third of starch compared to the Starchy one.

The average intake of supplement and herbage, the latter obtained from the two measurements made in July and August, is given in Table 3. Both supplements were almost entirely consumed, with hardly any residues; hence the values of supplement intake were practically those predicted on the basis of the ECM yield, with a difference between the Low and High of 1.5 kg OM/d.

The Fibrous-Low cows consumed an average of 1.4 kg OM/d of extra herbage compared to other groups, thus balancing the lower supplement availability and carrying their total OM intake to the level of the High supplemented groups. On the other hand, the Starchy-Low cows, which ingested an amount of herbage similar to the High supple-

Table 2. Herbage availability, chemical composition and nutritive value of feeds.

		Herbage								Supplement	
	Week	1	2	3	4	5	6	7	8	Starchy	Fibrous
Herbage availability	t DM/ha	0.89	0.85	0.83	0.78	0.70	0.63	0.64	0.60	-	-
Crude protein	% DM	16.5	15.1	14.7	15.0	14.2	14.7	13.6	11.5	15.4	15.9
Ether extract	" "	-	-	-	-	-	-	-	-	2.8	3.3
Crude fibre	" "	23.6	25.5	26.0	25.9	25.3	24.7	25.2	28.0	8.0	15.1
NDF	" "	45.6	48.0	47.8	47.7	49.5	49.0	50.0	53.0	23.5	42.1
ADF	" "	27.8	28.1	28.7	30.8	29.4	29.8	32.1	32.6	6.2	21.9
ADL	" "	8.2	9.6	9.3	9.8	9.9	9.4	10.6	11.8	1.6	1.9
Starch	" "	-	-	-	-	-	-	-	-	36.3	10.5
OMD vitro	%*	68.9	65.6	63.7	62.9	60.3	60.7	57.8	55.6	81.4	80.5
UFL	x kg DM^{-1}	0.84	0.79	0.77	0.75	0.71	0.72	0.67	0.65	1.00	0.98

* *Corrected for in vivo digestibility*

Table 3. Average individual intake of supplement and herbage.

		Starchy		Fibrous					
		Low	High	Low	High	S.E.	Level	Type	L x T
Supplement	Kg OM/d	3.5^{b}	5.0^{a}	3.5^{b}	5.0^{a}	0.52	**	ns	ns
Herbage	" "	10.5^{b}	10.6^{b}	11.9^{a}	10.5^{b}	0.76	ns	ns	*
Total intake:									
Kg OM/d		14.0^{b}	15.6^{a}	15.4^{a}	15.5^{a}	1.08	*	ns	*
UFL/d		12.3	14.0	13.4	14.0	0.93	**	ns	ns

*a,b: P<0.05; *: P<0.05; **: P<0.001; ns: not significant.*

mented cows, attained the lowest total daily OM intake, 1.5 kg/d less than other groups.

However, due to the minor nutritive value of the herbage as compared with the supplements, the High treatment allowed an energy intake higher than that of the Low one, independently of the supplement type, with an average difference equal to 1.1 UFL/d.

Animal performance and milk quality

The average cows' performance during the 8-week experimental period is reported in Table 4. The level of supplementation positively influenced milk yield, which increased as the amount of consumed concentrate grew higher. This was reflected in terms of both actual milk (+1.0 kg/d) and ECM (+1.2 kg/d) - without significant variations in composition. On the other hand, the supplement type had no statistical effects on either milk yield or milk composition.

The cows' BCS varied only in the Starchy-Low group, where animals were characterised by a diminution of body condition significantly different from zero.

The milk coagulation traits (Table 5), in particular r and a_{30}, improved with the Fibrous supplement compared with the Starchy one (16'24" vs 19'15" and 26.1 mm vs 20.8 mm, respectively), whereas they were not influenced by supplement level. Titratable acidity and SCC were not affected by either experimental factor.

Discussion

The alpine pastures of high altitude are characterised by a rapid growth of the biomass at the beginning of summer, followed by a progressive decline of the herbage yield and composition, determined by the short vegetative cycle of plants and strongly affected by meteorological conditions.

Table 4. Milk yield and composition (corrected means) and body condition score.

		Starchy		Fibrous					
		Low	High	Low	High	S.E.	Level	Type	L x T
Milk	kg/d	18.4	20.1	19.0	19.3	1.01	*	ns	ns
ECM[1]	"	18.3	20.0	18.7	19.5	1.04	*	ns	ns
Protein	%	3.31	3.24	3.40	3.46	0.27	ns	ns	ns
Fat	"	4.19	3.92	3.94	3.91	0.38	ns	ns	ns
Lactose	"	4.95	4.89	4.96	4.88	0.13	ns	ns	ns
BCS variation[2]	points	-0.22^{*0}	-0.01^{ns0}	0.01^{ns0}	0.00^{ns0}	-	-	-	-

*a,b: P<0.05; *: P<0.05; **: P<0.001; ns: not significant; 0: differences from 0.*

[1] *Energy corrected milk.*

[2] *Cumulative variation over the entire 8 week-period.*

Table 5. Rennet coagulation properties, acidity and somatic cell counts.

		Starchy		Fibrous					
		Low	High	Low	High	S.E.	Level	Type	L x T
Rennet clotting time	r, min	18'24"	20'06"	17'00"	15'48"	1'36"	ns	*	ns
Time for aggregation	k_{20}, min	6'06"	7'24"	6'24"	3'42"	2'48"	ns	ns	ns
Gel firmness	a_{30}, mm	22.2	19.4	24.4	27.9	6.05	ns	*	ns
Tritatable acidity	°SH/50 ml	3.31	3.21	3.31	3.39	0.24	ns	ns	ns
SCC[1]	,000/ml	310	395	419	450	308	ns	ns	ns

**: P<0.05; **: P<0.001; ns: not significant.*
[1] *Somatic cell count*

Despite a good water supply and warm average temperatures, the nutritive and chemical characteristics of the herbage grew noticeably worse. During the 8-week period, the herbage content of CP and NDF changed by -30% and +16% respectively, while the nutritive value changed by -23%.

The cows fed the Fibrous supplement and the Starchy-High group consumed a similar total amount of feeds (herbage + supplement), while the total intake of the Starchy-Low group was 10% less. Considering the unrestricted herbage availability, it is likely that the first three groups achieved the maximum intake allowed, in the experimental condition, by their inherent characteristics. Whereas the Fibrous-Low cows attained that level, and thus balanced the planned low supplementation in comparison with the corresponding High treatment, the Starchy-Low cows failed to achieve the same result. This could be partially explained by the fact that even at the level of 3.5 kg OM, provided in two distributions a day, the Starchy supplement would have modified the ruminal conditions, by decreasing the pH as well as the activity of cellulolytic microbes, responsible for the degradation of herbage, and consequently reducing the intake of further food, as reported by Steg *et al.* (1985), Sutton *et al.* (1987) and De Visser (1996), for higher levels of starch in the diet of indoor cows.

Although the supplementation covered up to 32% of the total OM intake, none of the experimental groups increased its adipose deposits, as assessed by the evolution of the body condition. All groups preserved their initial BCS, apart from the Starchy-Low one, which lost 0.22 BCS points as a consequence of a lesser intake that produced a state of energetic deficiency.

The greater energy intake attained with the High level of supplementation enhanced milk yield, as reported by many authors (Malossini *et al.*, 1995; Bovolenta *et al.*, 1998, 2002; Hoden *et al.*, 1991; Pulido *et al.*, 2001).

In order to verify the coherence of the experimental data, an energy balance based on the values of input (supplement + herbage), output (maintenance + ECM production) and energy provided by BCS changes (NRC, 2001) was calculated. For all groups, the balance was positive, i.e. the sum of input and energy from body condition changes was higher than output (on average + 0.42 ± 0.07 UFL/d). This difference, which averaged 9% of cows' maintenance requirements, was almost certainly due to the energy expenditure for the impact of environmental factors typical of pasture and the increased activity resulting from grazing and movement. On the basis of INRA (Hoden *et al.*, 1988) and NRC (2001) standards, the activity allowance increases the energy requirements for maintenance by 10 % for open housed cows and by over 20% for grazing cows, according to pasture characteristics and land orography.

Considering the hard pasture conditions, it is possible that the additional costs for grazing were actually higher than the estimated 9% of cows' maintenance requirements, thus the herbage intake or/and of BCS variation may have been under-evaluated.

As for the milk cheese-making traits, the Fibrous supplement provided better results, whereas the supplement level did not show any significant influence. Unlike other experiments, in which the supplement type did not affect milk technological traits (Laurent *et al.*, 1992), the positive effect observed, possibly was caused by a higher casein/protein ratio in the milk from cows fed on fibrous supplement, according to the results of Vertes and Hoden (1989).

The milk cell-count number, equal to an average of 393,000 units/ml with no differences between feeding treatments, was quite high but justified because of the lactation period and the environmental conditions.

Conclusions

The substitution of the cereal-based supplement, largely utilised for feeding dairy cows grazing on alpine pasture, with the beet pulp-based supplement provided a yield of similar amount of milk, characterised by better rheological traits.

From both economical and environmental points of view, the Fibrous supplement at Low level proved to be the best combination because it produced both a satisfactory milk yield and herbage utilisation.

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