Studies on the ruminal degradation in cows fed on alfalfa and barley-based diets

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Abstract

The paper presents a comparative study on the dynamics of readily hydrolisable sugars at ruminal level conducted on dairy cows fed on alfalfa and barley-based diets preserved as hay and silage.
The animals were assigned to four groups fed on four diets differing as structure but identical as energy and protein content. The diets were given in two meals immediately after milking. Samples of ruminal fluid were collected by average size canulae, at 2-hour intervals, for 48 hours. Ruminal nylon bags containing alfalfa and barley were incubated at intervals of 2, 4, 8, 24, 48 and 72 hours to determine the rate of fiber degradation.
Significant ($p<0.05$) differences were noticed in the ruminal dynamics of ammonia and readily hydrolisable sugars between the diets based only on silage and hay (barley+alfalfa).
Significant ($p<0.05$) differences were also noticed in fiber degradation between the silage (alfalfa+barley) and the hay, the silage displaying a higher rate of degradation.

Keywords: *sugars, fibre, alfalfa, ruminants*

Introduction

The average milk yield of dairy cows increased significantly during the past decade. This quantitative and qualitative increase was achieved due to a combination of the genetic potential of growth due to the breed and also due to the progress in animal nutrition. Feeding high quality bulk forages was the first step in increasing the milk yield.
The addition of concentrate feeds to the basal diets is required to improve the dietary energy level, which to make full use of the higher genetic potential for milk production.
One of the subjects of our cooperation with French researchers was to go in depth with the studies on dairy cows to determine the ingestibility and digestibility of different bulk forages preserved as hay (chopped) and silage, as well as the influence of diets on milk yield and quality.
The dietary energy level was increased by a change in the processing technologies, of the period of harvesting, using nitrogen fertilizers, etc. (Frame *et al.*,1991; de Visser, 1993).

There is a close relation between the dietary nutrient content and energy level and the quantity and quality of the milk, protein (given by the amino acids), fat (triglycerides) and lactose. There still are, however, questions concerning the regulation of the digestion and metabolism processes in dairy cows.
Glucose is the main nutrient in milk secretion since it s the primary precursor of lactose synthesis, the most important milk constituent. About 85% of lactose carbon comes from the blood glucose, its availability depending on the propionate produced during the ruminal fermentation.
At the same time, 97% of milk fat consists of triglycerides, which are formed of fatty acids with 4-18 carbon atoms. Most fatty acids are synthesized in the udder from lactic and butyric acid, which are produced by the ruminal fermentation (Didley, 1988; de Visser, 1993).
The literature does not mention studies on the dietary carbohydrate level. There are studies on the hydrolysis and fermentation of sucrose, lactose and glucose conducted on cows fitted with ruminal fistulae where sucrose is hydrolyzed immediately in the rumen, while lactose seems to be limited by the ruminal fermentation, particularly if the ruminal microsymbionts are not adapted to lactose (Weisbjerg *et al.*,1996).
Investigations were also conducted on starch digestion in dairy cows fed on barley and oats-based diets administered pelleted or expanded (Harstad *et al.*,1996) and it was observed that even if the starch content is lower in oats (45-50%) than in barley (55-60%), the amount of digestible starch is higher in the pelleted oats.
The concentrate feeds based on expanded barley increase the ruminal pH and change VFA production towards a decrease of $(C_2+C_4)/C_3$ ratio.
The concentrate feeds based on oats did not induce significant changes in the ruminal fermentation.
NDF and ADF digestion is not influenced significantly by the heat treatment of either barley or oats.
Other studies monitored the effect of sugar beet pulp-based diets on the production of ruminal VFA (Gallo *et al.*,1996) or the effect of replacing the barley-based concentrate feeds with oats or oats/rape seed-based concentrate feeds on milk yield and quality, which resulted in a significant increase of milk yield, of milk protein and lactose with a low fat content (Ekern *et al.*,1996).

Material and methods

Dairy cows fitted with ruminal fistulae and average size canulae were assigned to 4 groups fed on 4 diets differing as structure but with identical energy and protein levels (Table 1).

Table 1 *Diet formulation*

Feeds	D1	D2	D3	D4
Silage (60% + 40%)	10.5	7.15	4.0	-
Hay (60% + 40%)	-	3.68	7.16	11.5
Corn	2	2.68	3.32	4.0
Peas	1	0.66	0.34	-
Wheat ran	1	0.66	0.34	-
Dicalcium phosphate	0.026	0.034	0.034	0.051
TOTAL DM	14.526	14.864	15.200	15.551
Milk FU	14.90	14.92	14.97	14.92
IDPN	1.280	1.261	1.255	1.247
IPDE	959	987	1.013	1.039
Ca	97	100	103	106
P	54	54	54	54
Premix	1% of ingested DM			

Both the silage and the hay consisted on alfalfa and barley and the diets were supplemented with concentrate feeds. The diets were formulated using the new system of nutritive value assessment applied to dairy cows. The diets were given in two meals, immediately after milking.

Samples of ruminal fluid were collected at 2-hour intervals throughout 48 hours and assayed for the dynamics of ammonia and total sugar concentration. Ruminal nylon bags containing alfalfa and barley hay and silage were incubated at intervals of 2, 4, 8, 24, 48 and 72 hours to determine the rate of NDF and ADF degradation. The following methods were used for chemical analyses: Weende method for organic matter, protein, fat, fiber and ash; Petrescu method for the ammonia; Bertrand method for the total sugars; van Soest method for NDF and ADF.

Results and discussion

Table 2 shows the chemical composition of the feeds. It can be observed that the barley hay has the highest starch level (43.10 g/kg DM), the barley and alfalfa silage has the highest sugar level (87.26 g/kg DM) and crude fiber level (471 g/kg DM).

Figure 1 shows the dynamics of ruminal ammonia. The peak values were observed 3 hours after meal administration in all four diets. Ammonia concentration was higher in diets D1, D2 and D3 containing barley+alfalfa silage than in D4 based on barley+alfalfa hay, as follows: 26.2 mg NH_3/100 ml ruminal fluid (D1), 24.4 mg NH_3/100 ml ruminal fluid (D2) and 18.8 mg NH_3/100 ml ruminal

fluid (D3), compared to 13.68 mg NH_3/100 ml ruminal fluid (D4). The differences are significant ($p<0.05$).
Differences were also noticed between the two diets containing silage and hay (D2 and D3) due to their different proportion in the diet. Thus, significantly ($p<0.05$) higher ammonia levels were noticed in diet 2 with a higher content of silage than in diet 3.
Ammonia concentration during the night peaked at an interval of 15 hours, but at much lower values than in the samples collected during the day.
Figure 2 shows the ruminal dynamics of total sugars. The peaks were observed 5 to 7 hours after meal administration in all four diets.
Significant ($p<0.05$) differences were noticed between the four diets, the formulations with silage and silage+hay having higher sugar levels than the diet of hay only, as follows: 127 mg glucose (D1), 122.6 mg glucose (D2) and 115.6 mg glucose (D3) compared to 96 mg glucose/100 ml ruminal fluid (D4).
Figures 3 and 4 show the rate of cell wall (ADF and NDF) degradation. As it can be seen it has a linear shape both for ADF and NDF in both cases: silage and (alfalfa+barley) hay.
NDF degradation in the silage was computed with a linear equation of the type $y=0.6632x$, with $R^2=0.9905$, being higher than in the hay, which degraded according to a linear equation of the type $y=0.5371x$, with $R^2=0.9817$.
ADF degradation in the silage was computed also with a linear equation of the type $y=0.5581x$, with $R^2=0.9941$, also being higher than in the hay, which degraded according to a linear equation of the type $y=0.4726x$, with $R^2=0.9818$.

Conclusions

Ammonia ruminal concentration peaked 3 hours post prandially.
Total sugar concentration peaked later, after 5 to 7 hours post prandially due to the ruminal degradation of both dietary starch and fiber.
Significant ($p<0.05$) differences were notices between the diets with silage (alfalfa+barley) and the diet based on hay (alfalfa+barley) only.
The rate of ADF and NDF degradation was higher in the silage than in the hay.

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Table 2 *Feed chemical composition (g; kJ/kg feed as such: kg DM)*

Feeds	DM	OM	CP	EE	CF	NFE	Ash	Starch	Sugar	GE
Compound feed D1	867	824	140	25	49	647	43	261	196	3761
	1000	951	120	28	56	747	49	300	220	4337
Compound feed D2	875	836	107	23	54	652	39	308	151	3809
	1000	954	123	26	61	745	45	352	173	4355
Compound feed D3	873	838	99	24	42	674	35	333	196	3777
	1000	960	113	26	47	772	41	381	225	4329
Compound feed D4	865	829	83	26	38	683	34	279	191	3725
	1000	958	96	30	43	790	39	323	221	4309
Silage (barley+alfalfa)	260	235	24	9	82	119	26	7	15	1129
	1000	904	92	35	315	458	100	26	58	4342
Barley hay	797	729	66	12	263	390	67	34	60	3351
	1000	915	83	15	331	488	84	43	75	4208
Alfalfa hay	774	707	117	14	244	334	67	28	25	3392
	1000	915	151	17	315	431	86	37	33	4386

Figure 1

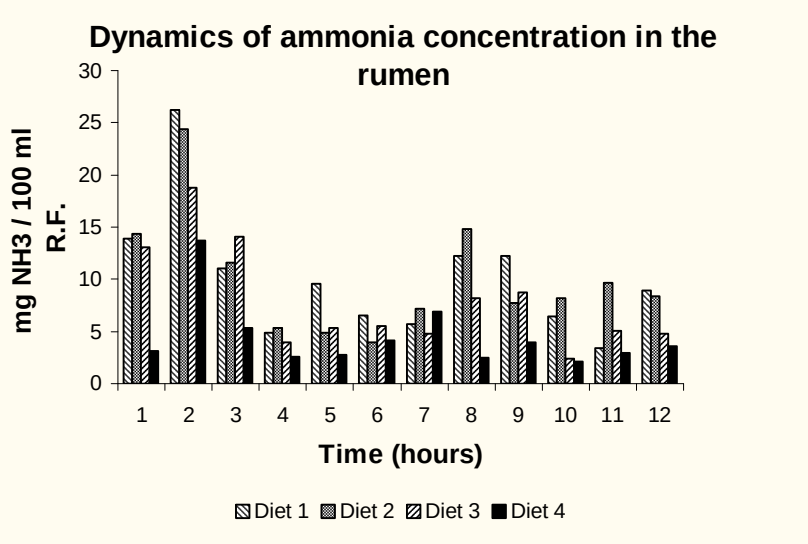

Figure 2

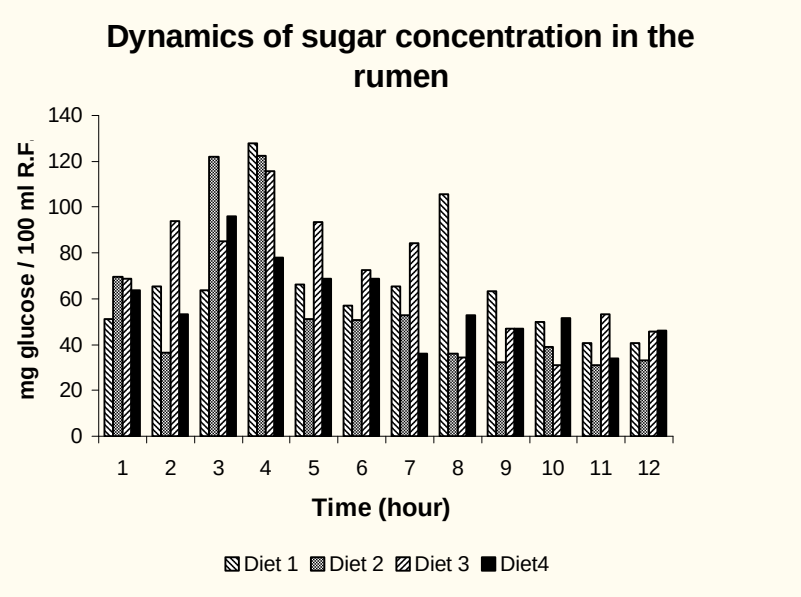

Fig. 2. Ruminal degradation of NDF in the alfalfa+barley silage and hay

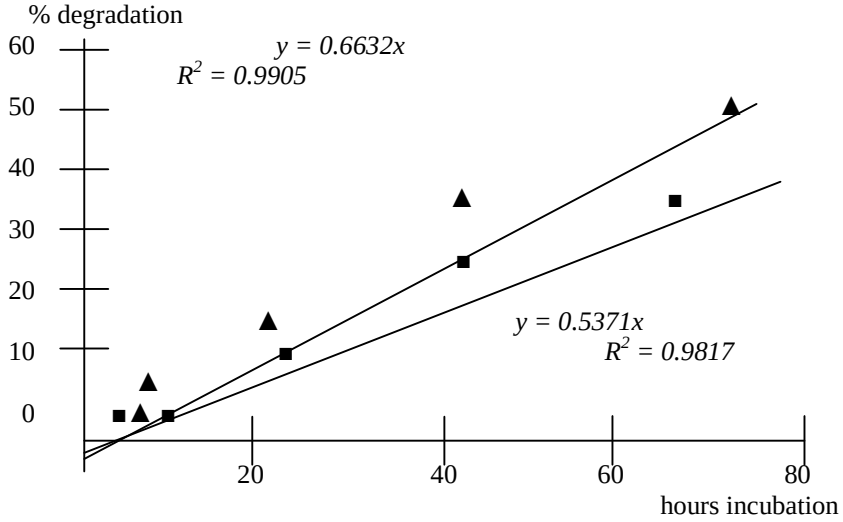

Fig. 3. Ruminal degradation of NDF in the alfalfa+barley silage and hay