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Mixed ration or separate feeding in automatic milking systems – does it matter in free cow traffic?

M. Patel & E. Spörndly
Swedish University of Agricultural Sciences (SLU), Department of Animal Nutrition & Management, P.O. Box 7024, 750 07 Uppsala.
Correspondence: Mikaela.Patel@slu.se

Introduction

The number of farms with automatic milking (AM) has steadily increased in Sweden and other Scandinavian countries over the last years and approximately one third of the milk produced in Sweden is produced from cows in AM systems (Landin & Gyllensvärd, 2012). A prerequisite for successful AM is a well-functioning cow traffic. The most important factor that drives cow traffic in an AM barn is the feed, both the concentrates that is supplied in the milking unit and the feed supplied at the feed table and in some cases also the feed offered in the concentrate stations (Rodenburg, 2011). The feed can be distributed as a mixed ration or else, forage and concentrates can be fed separately. Offering the feed as a mix (total mixed ration; TMR or partial mixed ration; PMR) has proved to be a rational way of achieving a high feed intake. The benefits of feeding a mix, compared to separate feeding, are: *a* more even intake of fibre and starch over a 24-hour period, it facilitates the transition between feed batches, it provides an increased feed intake and cheap by-products can be used in the mixture (Rodenburg & Wheeler, 2002; Spörndly, 2003). However, mixed feed with a high nutrient density, combined with AM is claimed to lead to low milking frequencies with low milk yields as a result, often termed "lazy cow syndrome". In total mixed rations with high quality grass/clover silage, it is not unusual to mix in straw to reduce the concentration of nutrients in the feed mix (Lundborg, 2014). This must be regarded as counterproductive when farmers are striving for early harvests of herbage to obtain a high nutritional value of the silage.

The relationship between milking frequency and milk yield is uncertain in dairy farms with AM. In several studies, no difference in milk yield has been shown between systems with free or controlled cow traffic even though the number of milkings per cow per day were less in the free system (Melin *et al.*, 2007; Forsberg, 2008; Bach *et al.*, 2009). Although the low milking frequencies associated with the provision of mixed feed in AM barns is regarded as a problem, controlled experiments comparing mixed feed with separate feeding of silage and concentrates are scarce in the literature (Rodenburg & Wheeler, 2002). These studies, also, do not cover AM systems or the feeds and cow traffic systems that are common in Scandinavia. Hence, the aim of this experiment was to investigate how mixed silage and concentrates affects feed intake and milk production compared with separate feeding, in an AM barn with free cow traffic.

Materials and Methods

The experiment was conducted at the experimental farm Lövsta at the Swedish University of Agricultural Sciences in Uppsala. Thirty-eight cows, 10 primiparous and 28 multiparous, of the Swedish Red Breed and Holstein with an average of 70 ± 30 days in lactation, were randomly allotted to either a mix of grass/clover silage with crushed concentrates (MIX) or a ration of silage and pelleted concentrates (SR) fed separately. The concentrates used in the MIX and SR treatments contained the same ingredient proportions and, thus, had the same nutrient content as well. The experiment consisted of an adaptation period of four weeks and a measurement period of six weeks in a free cow traffic system with AM (DeLaval, Tumba, Sweden). The experimental feeds and feeding rations were determined according to the regulations of organic production (KRAV, 2015), i.e., the proportions of concentrate were limited to 50% (on DM basis) during the first 90 days of lactation and to 40% during the remaining part of the lactation. The feeds originated from the same silos/batches and the mix and silage were fed *ad libitum.* The chemical composition of the silage and concentrates is presented in Table 1. The mix contained 35% concentrates and 65% silage on dry matter (DM) basis and the concentrates ration in the SR treatment was continuously adjusted in relation to silage intake to ensure that the silage/concentrates ratio was the same for both treatments. All cows received pelleted concentrates in the milking unit and the allotted daily ration was calculated according to silage intake in order to ensure the predetermined silage/concentrates ratios. The cows had permission to visit the milking unit five hours after previous milking and they were fetched and brought to the milking unit if 13 hours had passed since the last milking. Daily feed intake, milk yield and milking frequencies were recorded automatically and the milk constituents analysed fortnightly.

The statistical model (PROC MIXED, SAS 9.3) included treatment, parity, breed and days in milk using a mixed model with repeated measurements and 'Cow' as random variable. All interactions were included in the model, but were excluded when not significant ($P > 0.05$).

Table 1 Chemical composition of the grass/clover silage and concentrate, means ± standard deviation

Item	Silage, n = 3	Concentrate, n=3
Dry matter (DM), %	32.1 ± 0.23	88.2 ± 0.8
Metabolizable energy, MJ/kg DM	11.4 ± 0.1	13.4[1]
NDF, g/kg DM	444 ± 26	169.5 ± 8.7[2]
Ash, g/kg DM	84.0 ± 3.5	58.1 ± 2.1
Crude protein g/kg DM	138 ± 5.6	192 ± 6.5
Starch, g/kg DM	NA	398.9 ± 17.1
OMD, %[3]	78.5 ± 0.4	NA
pH	4.07 ± 0.1	-
Am-N, % of total N	7.1 ± 0.2	-

[1]Determined from manufacturer
[2]analyzed as aNDFom
[3]OMD, organic matter digestibility
NA, not analyzed

Results and Discussion

The average daily feed intake was higher in the MIX group compared with the SR group, 26.8 kg and 24.0 kg DM, respectively (P = 0.005). This difference was shown both in intake of silage and of concentrates (Table 2). Feed intake was also higher in multiparous cows compared to primiparous cows, kg 28.7 and 22.1 kg, respectively (P < 0.001). There was no difference in total DM intake in cows < 90 DIM and cows > 90 DIM, although there were differences both in intake of silage and concentrates. This was an effect of the experimental plan since the concentrate ration was adjusted from 50% to 40% of total DM intake at this time point. However, when the concentrate ration was decreased, the cows compensated by increased intake of silage so the sum of the two feeds remained equal regardless of the proportion of concentrate.

The results revealed no differences in milk production or milk constituents, with 35.0 and 35.4 kg ECM/cow and day in the MIX and SR groups, respectively (Table 3). Milking frequency was higher in the MIX, compared with the SR group with 2.6 and 2.3 milkings per day, respectively. This was unexpected since nutrient dense mixed feeds are often claimed to lower milking frequency (“lazy cow syndrome”). The same pattern remained when fetched visits were excluded from the analyses, giving 2.0 and 2.4 voluntary milkings per day in the SR and MIX group, respectively. The reason for the higher milking frequency in the MIX group may have been that the milking unit was the only place where cows received concentrates, whereas for the SR group concentrates was also available in the concentrate stations. However, the higher milking frequency in the MIX group did not result in a higher milk yield, which may have been expected since earlier studies have shown increased yield with increased milk frequency (Svennersten-Sjaunja & Pettersson, 2008). The higher feed intake in the MIX group may have resulted in an increased deposition of adipose tissues. These data are still not completely analysed, but will add valuable information to the final conclusions of the experiment. The differences in milking frequency did not result in differences in somatic cell count (SCC) and overall, the SCC was low during the experiment.

Table 2 Feed intake (kg dry matter; DM) by cow and day during the measurement period of six weeks. Figures presented as Least square means and standard error of the means (SEM) by treatment, lactation and days in milk (DIM) in dairy cows fed either grass/clover silage and concentrate separate (SR) or mixed (MIX)

	Treatment				Lactation				DIM			
	SR	MIX	SEM	Sign.[1]	1	≥2	SEM	Sign.[1]	0-90	>91	SEM	Sign[1]
Silage	13.9	15.5	0.47	*	12.7	16.7	0.36	***	13.9	15.5	0.35	***
Concentrate, milkning unit	2.9	3.4	0.13	**	2.8	3.5	0.10	***	4.5	1.9	0.09	***
Total concentrate	10.1	11.3	0.31	**	9.4	12.0	0.24	***	11.5	9.9	0.23	***
Total DM intake	24.0	26.8	0.74	**	22.1	28.7	0.57	***	25.4	25.4	-	ND

[1]Sign., level of significance: NS = $P > 0.05$, * = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$
ND, not determined

Table 3 Average daily milk production during the measurement period of six weeks in dairy cows fed either grass/clover silage and concentrate separate (SR) or mixed (MIX). Energy corrected milk yield (ECM) and figures for fat, protein, lactose and somatic cell count (SCC) are means of four sampling days (fortnightly sampling). Figures presented as Least square means and standard error of the means (SEM)

	Treatment			
Item	SR	MIX	SEM	Sign[1].
Milk, kg	35.7	34.6	1.37	NS
ECM, kg	35.4	35.0	1.24	NS
Fat, kg	1.39	1.39	0.06	NS
Protein, kg	1.20	1.17	0.04	NS
Lactose, kg	1.68	1.66	0.07	NS
Fat, %	4.05	4.12	0.10	NS
Protein, %	3.47	3.44	0.05	NS
Lactose, %	4.78	4.82	0.21	NS
SCC, $\times 10^3$/ml	31.28	50.43	0.09	NS

[1]Sign., level of significance: NS = $P > 0.05$, * = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$

Conclusions

This study showed increased feed intake and increased milking frequencies when dairy cows were fed a nutrient dense mixed ration in a free cow traffic system compared with cows fed the same proportions silage and concentrates separately. Nevertheless, no difference in milk yield was shown between the treatments.

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