

Milk production, feed sorting behaviour and social interactions in the feeding area in cows fed TMR or compact TMR

M. Lindberg, U. Robertsson & C. Kronqvist

Swedish University of Agricultural Sciences (SLU), Department of Animal Nutrition & Management, BOX 7024, 750 07 Uppsala, Sweden.

Correspondence: Mikaela.Lindberg@slu.se

Introduction

Swedish dairy cows are to an increasing extent fed concentrates and roughage mixed together, in a total mixed ration (TMR). Total mixed rations may be beneficial especially for organic herds, as it facilitates the use of homegrown protein feeds, which often are rich in starch and thereby can cause rumen disturbances when fed separately to the roughage. When the diet is mixed, the risk of rumen acidosis is decreased due to the more even intake of fibre and starch. However, it has been shown that animals tend to sort the diet if it is possible, leading to differences in composition over time, commonly resulting in higher fibre concentration the longer the feed has been available to the animals (Khan *et al.*, 2014). In other words, low ranked cows, that may be pushed away from the feed and get to eat last, are offered a less nutrient dense feed compared with high ranked cows. Since sorting of the diet will result in a variable diet composition over the day, it may result in problems like sub-acute rumen acidosis (Shaver, 2002).

This sorting behaviour has been suggested to decrease when providing the cows with a so-called compact TMR (CTMR; Kristensen, 2015), where the concentrate ingredients are soaked before adding forage and mixing the diet for a longer time. Soaking of the concentrates makes small, starchy particles stick better in the mix and a prolonged mixing time decreases the proportion of long particles. A more finely chopped feed results in fewer particles that are rejected (Leonardi & Armentano, 2003) and the addition of water to a TMR can decrease sorting behaviour (Fish & DeVries, 2012). However, water addition has in some cases been shown to increase rather than decrease sorting (Felton & DeVries, 2010). Shorter particle size of forage-based diets has been shown to increase feed intake and milk production, as well as protein concentration of the milk (Nasrollahi *et al.*, 2015). Other effects may be reduced eating and ruminating times (Storm & Kristensen, 2010) or shortened total eating time (Nasrollahi *et al.*, 2014) which will give the cow more time to rest.

The aim of the study was to evaluate the effects of a CTMR, achieved by decreased dry matter (DM) content and increased mixing of the diet, on milk production and dairy cow behaviour at the feed bunk. It was hypothesized that feeding a CTMR diet would result in equal or increased milk production and less sorting behaviours and fewer aggressive interactions at the feed bunk compared with a traditional TMR diet.

Materials and methods

Two dietary treatments were tested in 40 mid-lactation dairy cows in a change-over experiment with randomized block-design. The cows were blocked according to parity and stage of lactation and, within block, they were randomly allocated to one of two groups of 20 animals each. The experimental periods consisted of two weeks for adaptation and one week for measurements and the experiment lasted six weeks in total. The cows were housed in a free-stall barn in two separate units. The feed bunk was shared between the units, but divided in length so that cows did not reach the feed supplied on the opposite side of the feed bunk. In

addition to the experimental animals, non-experimental cows were housed in the barn to achieve a realistic traffic around the feed table. In total, 59-61 cows were housed in each unit, having access to 32 feeding spaces with headlocks per unit during the measurement period.

Feed was available *ad libitum* and was mixed and distributed twice daily with the aim of approximately 10% feed residues. The same second harvest grass/clover silage (precision chopped before ensiling) and concentrate (pelleted and crushed) was used for the diets with the difference that the forage in the CTMR was mixed for 60 minutes in a mixer with knives (SiloKing, Tittmoning, Germany). Then concentrate and approximately 30% water was added during an additional mixing for 10 minutes in a mixer without knives (DeLaval, Tumba, Sweden). The TMR consisted of forage from the bunker silo and concentrates mixed without knives for 10 minutes. The increased mixing time and addition of water in the CTMR was aiming to decrease particle size and lower the DM content of the feed. The silage:concentrate ratio was 60:40 on DM basis according to organic standards for milk production (KRAV, 2017). Average DM content of the silage was 42% and the diet contained (/kg DM) 12.5 MJ metabolizable energy (ME), 187 g crude protein (CP) and 367 g neutral detergent fibre (NDF). Particle size was evaluated using the Penn State particle separator (Lammers *et al.*, 1996) with two sieves and a bottom pan. The cows were milked twice a day at 6 AM and 5 PM in an automatic milking rotary (DeLaval, Tumba, Sweden). Milk yield was automatically recorded at each milking and test milking was performed at morning and evening milking two consecutive days during the measurement periods. Milk samples were analysed with a Delta Combiscope (Combiscope FTIR 300, Delta instruments, the Netherlands) for fat, protein and lactose content. Energy corrected milk yield (ECM) was calculated according to the formula determined by Sjaunja *et al.* (1990).

Behavioural studies were performed during the measurement periods. Continuous observations to study sorting behaviour and aggressive interactions between cows at 0 to 1 h after feeding and 2 to 3 h post feeding.

Data on feed sorting behaviour and aggressive interactions were analysed with mixed models including period, treatment and hour as fixed effects. Data on milk yield were analysed with PROC MIXED (SAS 9.4), a mixed model including block, period and treatment as fixed effects and cow as random. Interactions between the fixed effects were tested but found non-significant and excluded from the models. Effects were considered significant when $P < 0.05$.

Results and discussion

Mean distribution of particle sizes in fresh weight of the feeds at feeding were in percentage: 6, 64 and 30 vs. 31, 34 and 34 of >19 mm, 8 to 19 mm and <8 mm in CTMR and TMR, respectively (data not shown). Feed sorting behaviours were more frequent in the group fed TMR compared with CTMR, which supported our hypothesis. Cows showed more digging and eating from underneath in this group, while eating from the side and throwing feed did not differ between treatments (Table 1). Digging and eating from underneath are typical sorting behaviours in cattle (Leonardi & Armentano, 2003). Hypothetically, the decrease in sorting behaviour could have resulted in less difference between the feed residuals and the newly mixed diet, and the results regarding aggressive interactions (Table 2) indicated that there were fewer aggressive interactions in the CTMR treatment compared to the TMR treatment. It could be speculated that the cows were less prone to compete for new feed in the CTMR treatment. Total number of aggressive interactions was higher around feeding compared with two to three hours after feeding ($P = 0.005$; SEM = 1.25; data not shown).

Table 1 Feed sorting behaviours in lactating dairy cows fed a total mixed ration (TMR) or a compact TMR (CTMR) at a feed bunk. Presented as LSmeans and standard error of the mean (SEM)

Number of sorting behaviours/h	Treatment		SEM	P-value
	TMR	CTMR		
Total	42.6	16.9	4.74	0.002
Digging	23.4	6.8	3.13	0.003
Eating from underneath	10.1	1.0	1.13	< 0.001
Eating from the side	7.0	8.6	1.20	0.36
Throwing	2.1	0.5	0.67	0.11

Table 2 Number of aggressive interactions in lactating dairy cows fed a total mixed ration (TMR) or compact TMR (CTMR) at a feed bunk. Presented as LSmeans and standard error of the mean (SEM)

Number of aggressive interactions/h	Treatment		SEM	P-value
	TMR	CTMR		
Total	14.8	8.5	1.25	0.004
Lower head	3.9	2.0	0.58	0.041
Head butting	5.6	2.5	0.60	0.003
Push	1.5	1.5	0.65	1.0
Squeeze	3.4	2.3	0.65	0.25

There were no differences in milk yield or composition between treatments (Table 3). Thus, the hypothesis that feeding CTMR would result in equal or increased milk production compared to feeding TMR was supported.

Table 3 Daily milk yield and composition from cows fed total mixed ration (TMR) or compact TMR (CTMR). Presented as LSmeans and standard error of the mean (SEM)

	TMR	CTMR	SEM	P-value
Milk yield, kg	33.4	32.9	0.78	0.10
ECM¹, kg	31.8	31.4	0.82	0.47
Fat (%)	3.66	3.69	0.08	0.72
Protein (%)	3.39	3.36	0.04	0.56
Lactose (%)	4.50	4.44	0.04	0.24

¹ECM, energy corrected milk

Conclusions

Increased mixing time and addition of water to a diet with 60% grass silage resulted in fewer aggressive interactions among dairy cows. This may have been the result of a more homogenous diet, also supported by a decrease in sorting behavior. However, there were no differences in milk yield or milk composition between the two dietary treatments.

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