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Allocation of feed based on individual dairy cow live weight changes II: Effect on milk production

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ABSTRACT

Based on individual cow live weight gain, feeding strategies were designed for individual feeding of dairy cows in loose-housing systems, and examined in a four-year production trial including 115 Danish Red (DR), 91 Danish Holstein (DH), and 93 Danish Jersey (DJ). The objective of the present paper was to examine the milk yield obtained in response to three feeding strategies. The interrelationship between feed intake and live weight changes is presented in a companion paper.

Cows were stalled in a loose-housing system based on automatic milking, automatic recording of feed intake and automatic weighing of the cows. All cows had 3 kg of individually separately offered concentrate (ISC) in addition to a mixed ration (MR). Cows were either allowed a medium energy MR during whole lactation (strategy MR1) or a high energy MR during early lactation, which was reduced to a low energy MR either early or late (strategy MR2-E and MR2-L). The early and late changes were defined as a live weight gain after live weight minimum at 15 and 35 kg, respectively, for DR/DH and 11 and 25 kg, respectively, for DJ. When MR energy concentration was changed, cows on the MR2 strategies were offered 3 kg per day of extra concentrate. The total allowance of 6 kg ISC was stepwise reduced to 3 kg per day as live weight continued to increase until 50 and 35 kg for DR/DH and DJ, respectively.

Compared to feeding the MR1 strategy, the analysis showed that feeding the MR2 strategies did not significantly affect milk yield within primiparous DR and DH or within any DJ, as total lactation feed energy intake within these groups of cows was not significantly affected by the feeding strategy. Results obtained for multiparous DH showed that it is possible to increase milk yield without reducing the milk:feed ratio, when MR2 strategies were applied compared to the MR1 strategy. Feeding high energy rations during early lactation caused a higher peak feed energy intake within multiparous cows of DH and DR, but only multiparous DH obtained higher peak ECM yield in response to higher feed energy intake in early lactation. Across breed the results suggested that cows offered the MR2-E strategy might obtain higher lactation ECM yield compared to cows offered the MR2-L strategy due to a higher ECM yield persistency obtained by cows offered the MR2-E strategy. Results on feed intake and live weight changes presented in a companion paper indicated, that cows offered the MR2 strategies obtained a lower extent of mobilization compared to cows offered the MR1 strategy, and feeding the MR2-E strategy significantly increased duration of the mobilization period, which might have increased MR2-E cows' ability to maintain a high milk production during mid lactation.

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1. Introduction

Feeding strategies based on group feeding of dairy cows and in particular the total mixed ration (TMR) feeding strategy have become the most widespread feeding strategies in Denmark as

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herd sizes have increased and loose-housing systems have become the most common way of stalling dairy cows (Skjødt and Mortensen, 2004). Within dairy herd variation in daily milk yield between individual cows can amount 10–20% (Broster, 1972; Østergaard, 1979; Konggaard et al., 1982). Therefore, application of group feeding strategies implies a risk that the high yielding cows' ability to express their milk yield potential is limited in order to avoid too fat and low yielding cows at the end of lactation. As dairy herd size is continuously increasing, increasing nutritional and economical advantages of the individual cow concern in feed allocation during lactation are expected on dairy herd level. Therefore, development of systems to manage individual cow feeding in dairy herds with loose-housing systems is highly relevant, especially in systems using automatic milking systems (AMS) where TMR cannot be used as separate concentrate feeding in the AMS is necessary.

Examples of using on-line recording of real-time parameters as milk yield and live weight as basis for feed management have been presented (Maltz et al., 1991; Maltz et al., 1992). Live weight changes can be used to identify individual cow's energy balance and divide individual lactations in the physiological stages of mobilization and deposition (Maltz et al., 1997) and large variation in duration of the mobilization period of cows offered the same ration are demonstrated (Akinyele and Spahr, 1975; Bossen and Weisbjerg, 2005).

Experiments of different types have shown that increasing ration energy concentration during early lactation in general can improve peak yield (e.g. Everson et al., 1976; Oldenbroek, 1988; Friggens et al., 1998), but results on the correlation between initial lactation yield or peak yield and milk yield persistency are diverging (Akinyele and Spahr, 1975; Broster et al., 1975; Østergaard, 1979). The milk response to increased energy allowance is much higher in early compared to late lactation (Broster, 1972) due to changes in energy partitioning between individual life functions as lactation advances (Kirkland and Gordon, 2001). A recent study has shown, that the physiological stages of mobilization and deposition reflect two different stages of energy partitioning (van Knegsel et al., 2007a). These results indicate that milk yield might be improved without compromising feed energy utilization and animal health if ration energy concentration during lactation is individually adjusted dependent on the physiological stage of lactation.

Therefore an experiment was performed to investigate feeding strategies for individual cow feeding according to energy balance based on automatic live weight recordings. Two feeding strategies with a stepwise reduction of ration energy concentration from high to low level during lactation using live weight changes as management parameter were designed. In the experiment these strategies were compared to a feeding strategy with a constant medium ration energy concentration during the whole lactation. The objective of the present paper was to examine milk production obtained by cows of three different breeds in response to these feeding strategies. In the companion paper (Bossen et al., 2009) the interrelationship between feed energy intake and live weight changes of dairy cows are discussed.

2. Materials and methods

This section includes a detailed description on procedures for data recording and initial data validation regarding milk yield and milk quality. Experimental facilities, animals, procedures for automatic recording of feed intake and live weight, the corresponding initial data validation, and definitions of the feed and live weight variables for statistical analysis for the present experiment are described in detail by Bossen et al. (2009), and are only summarized in this section.

2.1. Experimental facilities and animals

Data for the present experiment were obtained from a 4 year production trial carried out at the Danish Cattle Research Centre from November 2002 until September 2006. Cows were kept in a loose-housing system with slatted floor and cubicles with mattresses. A free cow-traffic system for access to the automatic milking system (AMS) (DeLaval AB, Tumba, Sweden) was used. Within the dairy unit, cows were organized in 3 groups (AMS-groups), and each group had access to one automatic milking unit (AMU) equipped with a device for automatic measurement of milk yield and milk sampling. Additionally the AMUs were equipped with a device for concentrate feeding and weighing of concentrate refusals at the end of each cow visit. Below each AMU a platform scale (Danvaegt, Hinnerup, Denmark) for automatic recording of cow live weight was installed. For automatic recording of mixed ration feed intake the Insentec RIC system (Insentec, Marknesse, the Netherlands) was used.

2.2. Experimental design

Cows of the three breeds Danish Red (DR), Danish Holstein (DH) and Danish Jersey (DJ) were used for the experiment. Within breed cows were divided on two genetic lines Y and HR, selected primarily for milk yield and health/reproduction, respectively. Within breed and genetic line cows and heifers, respectively, were randomly assigned to one of the 3 experimental treatments, representing 3 different whole lactation feeding strategies. The three strategies were all based on the allocation of a mixed ration (MR) in combination with separate individual concentrate (ISC) allowance. The experiment included a total of 445 lactations. Data from the 299 lactations used in the statistical analysis were distributed on breeds, parities and feeding strategies as shown in Table 1.

Lactating cows were allowed 3 kg of basis concentrate daily in the AMU during the whole lactation. Cows offered the strategy MR1 had ad libitum access to a MR with medium energy concentration during the whole lactation. Cows offered the MR2 strategies had ad libitum access to a high energy MR in the first part of lactation and a low energy MR in later lactation. Changing MR energy concentration from high to low on the MR2 strategies was either carried out at an early (MR2-E) or a late (MR2-L) stage of lactation. The early and late stages of lactation were defined as a live weight gain after live weight minimum at 15 and 35 kg, respectively, for DR/DH and at 11 and 25 kg, respectively for DJ. Reduction of ration energy concentration was never introduced before lactation week 8. Reduction of MR energy concentration was introduced from day to day, and cows were simultaneously allowed 3 kg of extra concentrate in the AMU. The extra concentrate was stepwise reduced by 1 kg as the individual cow live weight further increased.

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