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paper

ENHANCING ANIMAL WELFARE AND FARMER INCOME THROUGH STRATEGIC ANIMAL FEEDING

Some case studies

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Some case studies

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Preface

Good nutrition is the fundamental requirement for all farm animals and it is considered as one of the biggest contributors to animal welfare. Improper nutrition not only affects productivity but also the health, behaviour and welfare of an animal. At the same time, the safety and quality of the food chain is indirectly affected by the welfare of farm animals due to the close links among animal welfare, animal health and food-borne diseases such as *Escherichia coli, Salmonella, Campylobacter,* etc. Stress factors, poor welfare and imbalanced nutrition can increase susceptibility to diseases among animals, thus increasing the need for veterinary treatment, posing risks to food consumers, decreasing profitability and endangering environmental sustainability of the livestock production systems and of the associated animal food chains.

Increasing worldwide demand for animal products is imposing a huge strain not only on the natural resources but also on farm animals. In intensive production systems, animals are being pushed towards maximizing productivity, while in the extensive and smallholder systems in developing countries animal productivity and welfare are compromised by inadequate nutrition. Even in intensive production systems where animals receive abundant nutritious diets, animal welfare could be impaired due to excessive or inappropriate feeding. An array of management-related factors – such as housing and bedding, restraining systems, space and crowding, transport conditions, stunning and slaughter methods, castration of males and tail docking – affect welfare.

A large body of literature exists on how these factors impact on animal welfare, health, productivity and product quality, but little attention has been paid to understanding the linkages between animal nutrition and animal welfare. This knowledge is a pre-requisite for drawing up policy options and guidelines for establishing livestock production systems that are humane, socially acceptable, efficient and environmentally friendly.

Farmers find it difficult to adopt practices that promote animal welfare without having sound information on the impact of such practices on animal productivity and their income. Any such practice that does not increase farmers' incomes is unlikely to be followed, especially in developing countries.

At the Expert Consultation held at FAO headquarters in Rome in September 2011, participants called for a series of case studies to document existing practices that enhance animal welfare as well as farmers' incomes; currently, such studies are few and far between.

This document presents a number of such studies and it is hoped that the information they contain will encourage researchers and agencies working in the area of animal welfare to initiate studies to capture the impact of any intervention on farmers' incomes – an area that has been neglected to date. It is also envisaged that these studies could pave the way for developing guidelines and policy options to promote sustainable animal feeding that enhances animal welfare, animal productivity, animal product quality and profitability.

Contents

Reducing variability in nutrient consumption: Improving health, welfare and profitability of dairy cows fed total mixed rations

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MAIN MESSAGES

- Selective consumption, or sorting, of lactating dairy cow diets leads to increased variability in nutrient intakes. Specifically, cows consume less long forage particles than expected, leading to depressions in rumen pH, and greater risk of subacute ruminal acidosis (SARA).
- Dairy cattle with SARA face poor feed efficiency, reduced feed digestibility and microbial protein synthesis, reduced milk fat, inconsistent dry matter intake, as well as increased incidence of other diseases, including diarrhoea, ruminal ulcers, parakeratosis, liver abscesses and laminitis.
- These negative consequences of SARA on dairy cow welfare and producer profitability, combined with the high prevalence of this condition, constitute a significant concern for the dairy cattle industry.
- To reduce the risk of SARA and its resultant impacts on dairy cow welfare and profitability, producers can implement several dietary and non-dietary nutritional measures to reduce the degree of feed sorting, including: increasing the proportion of dietary forage content, reducing forage particle length, adding water to dry diets, adding molasses-based liquid feeds to wet diets, and providing fresh feed more often throughout the day.

ACRONYMS

DMI dry matter intake
NDF neutral detergent fibre
peNDF physically effective (neutral detergent) fibre
TMR total mixed ration
SARA subacute ruminal acidosis

INTRODUCTION

Maintaining healthy animals is a key component of animal welfare. Ensuring good rumen health in dairy cattle is key for the maintenance of efficiency and productivity, and thus herd profitability. In dairy cattle, the rumen environment is designed to function optimally within a pH range of 6.2–7.2. To maintain healthy rumen function, dairy cows require diets that contain adequate amounts of physically effective fibre (peNDF). Ensuring adequate intake of peNDF can be difficult because most commercial dairy rations, designed to maximize milk production, contain high levels of concentrate and high-quality forages, often limiting in peNDF (Beauchemin and Yang, 2005). When ruminants consume excessive amounts of rapidly fermentable (non-fibre) carbohydrates, combined with low intake of peNDF, they are not able to maximize their rumination time and salivary buffer flow to the rumen, and thus ruminal pH drops below normal physiological levels. Sub-optimal ruminal pH (e.g. pH 5.2–5.8) is often referred to as subacute ruminal acidosis (SARA) (Owens *et al.*, 1998).

SARA is a major concern in terms of both productivity and animal welfare. Rumen pH<5.8 is harmful to ruminal cellulolytic bacteria (Russell & Wilson, 1996) and SARA is thus detrimental to fibre digestibility. As result, dairy cattle with SARA are less profitable because of poor feed efficiency, reduced feed digestibility and microbial protein synthesis, reduced milk fat, and inconsistent dry matter intake (DMI). They also face increased incidence of other diseases, including diarrhoea, ruminal ulcers, parakeratosis, liver abscesses and laminitis (Krause & Oetzel, 2006; Plaizier *et al.*, 2008).

Despite our vast knowledge of the etiology of SARA and its consequences, the prevalence of this digestive condition, which is estimated to range from 19 to 29 percent in dairy cows in early- and mid-lactation, remains very high because we try to maximize milk production through encouragement of maximum intake of diets containing high proportions of highly-fermentable carbohydrates (Krause and Oetzel, 2006).

This case study focuses on how dietary selection (sorting) of dairy rations may lead to depressed rumen pH, thus increasing the risk of SARA. Through a series of research studies, we have established evidence indicating that excessive sorting of certain ration components by dairy cattle can lead to SARA and also promote variability in nutrient intake. We have also investigated the impact of this resultant health condition on cow productivity and, thus, also profitability. Finally, a discussion of means to reduce this behaviour is outlined.

FEED SORTING AND INTAKE CONSISTENCY

Dairy cattle are commonly fed their feed components in the form of a total mixed ration (TMR). Total mixed rations are designed as a homogenous mixture with the goals of helping to minimize the selective consumption of individual feed components by dairy cattle, promoting a steady-state condition conducive to continuous rumen function and ingesta flow, and ensuring adequate intakes of fibre (Coppock *et al.*, 1981). It is not surprising that providing feed as a TMR is standard on most commercial dairies, particularly for lactating animals. Unfortunately, even when providing feed as a TMR, cows have been shown to preferentially select (sort) for the grain component of the TMR and discriminate against the longer forage components (Leonardi and Armentano, 2003). To date, our collective research has demonstrated that, on average, when dairy cows are fed TMR they selectively consume approximately five to ten percent more of the smallest ration particles and ten to

20 percent less of the longest ration particles than that which we would predict they would consume based on the original ration formulation.

IMPACT OF FEED SORTING ON RUMEN HEALTH AND PRODUCTIVITY

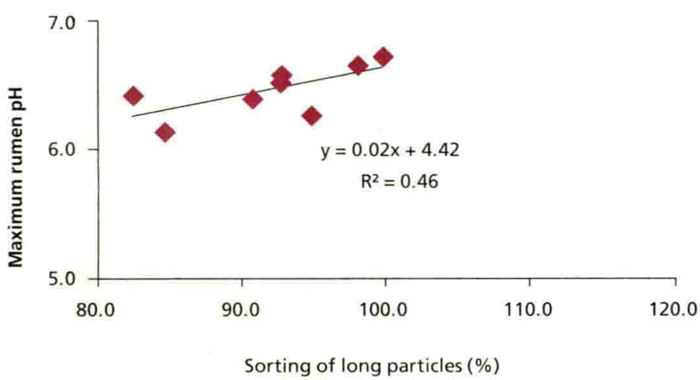
The result of sorting of TMR by dairy cows can, therefore, be that the ration actually consumed by cows is higher in fermentable carbohydrates than intended and lower in effective fibre. Such nutrient consumption patterns lead to excessive acid production and reduced buffering capacity in the rumen. Not surprisingly, therefore, we have demonstrated that such consumption patterns are related to depressions in rumen pH (Figure 1; DeVries *et al.*, 2008) and, thereby, increase the risk of SARA. In fact, we have been able to explain between 45 and 97 percent of the variability in measures of rumen pH (minimum, maximum, mean and range) based on the feed sorting patterns of lactating dairy cows (DeVries *et al.*, 2008).

Given the relationship between sorting and rumen pH, and the fact that depressed rumen pH may lead to milk fat depression, it is not surprising that we have recently demonstrated a clear association between sorting against long ration particle and producing milk of lower fat percentage. In two recent separate studies, we observed that milk fat decreased by 0.15 percent for every 10 percent refusal of long forage particles in the ration (DeVries *et al.*, 2011; Fish *et al.*, 2012). Sorting of a TMR can also reduce the nutritive value of the TMR remaining in the feed bunk, particularly in the later hours past the time of feed delivery (DeVries *et al.*, 2005) after the greatest amount of sorting has already occurred (Hosseinkhani *et al.*, 2008).

Figure 2 illustrates how feed sorting deteriorates nutritional value, as indicated by the quadratic increase in fibre content in the feed remaining in the feed bunk throughout the course of the day. For group-fed cows, this may be detrimental for those cows that do not have access to feed, at the time when it is delivered, for example when there is high competition at the feed bunk or when lameness incidence is high. In such cases, cows that are forced to return to the feed bunk at later time points during the day may end up

FIGURE 1

Association between sorting (% of actual intake relative to predicted intake) of long ration particles (>19 mm screen) and maximum rumen pH



Source: Adapted from DeVries *et al.* (2008).

consuming a ration very different from that originally formulated for them and may, thus, not be able to maintain adequate nutrient intake to maintain high levels of milk production (Krause and Oetzel, 2006); whereas those accessing the feed bunk for a greater period earlier in the day are more likely to experience SARA because of selective intake of highly-fermentable feed particles.

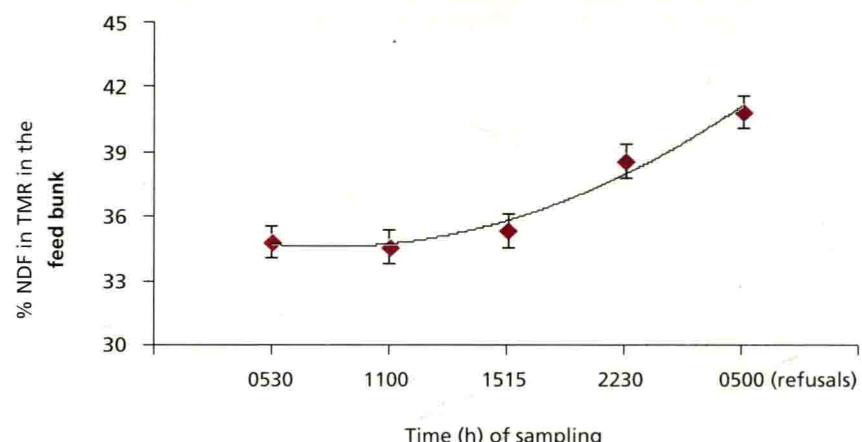
ECONOMIC COST OF FEED SORTING AND SUBACUTE RUMINAL ACIDOSIS

Reduced profitability associated with feed sorting and any resultant SARA is related to both direct and indirect costs. As noted above, our research has indicated that milk fat decreases by 0.15 percent for every ten percent refusal of long forage particles in the ration (DeVries *et al.*, 2011; Fish and DeVries, 2012). The financial impact of such a drop in milk fat is substantial, particularly in areas where milk value is related to component prices. For example, a ten percent refusal of long ration particles in a 500-cow Canadian dairy herd may result in approximately 90 000 Canadian dollars in annual lost revenue due to production of less milk fat. Indirect costs of sorting, including greater within-herd variability of nutrient intakes, would add to this decrease in profitability.

The direct financial impact of SARA was demonstrated by a field study on a large dairy farm in New York State where it was found that SARA reduced milk yield by 2.7 kg/day, milk fat production by 0.3 percent and milk protein production by 0.1 percent (Stone, 1999). These production losses associated with SARA alone were estimated to be US$1.12/day/cow (Stone, 1999). To place that cost in further context, if a 1 000-cow dairy herd had a 25 percent prevalence rate of SARA, the production losses associated with SARA would be approximately US$102 200 annually. These costs exclude the indirect financial impact of associated disorders and risks (such as lameness, reduced reproductive efficiency and increased culling) and veterinary treatment, which would be in addition to the cost of lost milk production.

FIGURE 2

Change in neutral detergent fibre (NDF) content of the ration remaining in the feed bunk over the course of the day as the ration is being sorted



Source: Adapted from DeVries *et al.* (2005).

REDUCING THE DEGREE OF SORTING OF TOTAL MIXED RATIONS

As described above, the high-energy diets, which are low in neutral detergent fibre (NDF) and high in starch, that are typically fed to lactating dairy cows can put the cows at risk of SARA. Interestingly, our research indicates that lactating dairy cows demonstrate higher degrees of sorting against longer forage particles and for smaller grain concentrate particles when fed lower forage diets (DeVries *et al.*, 2007; 2008). Thus, in situations where rations are being heavily sorted, it is recommended that a greater proportion of forage be included in the ration. Besides the quantity of forage, the type and particle size of forages will also affect feed sorting (Leonardi and Armentano, 2003). A greater proportion of dry forage (hay) in the ration will increase the amount of sorting against longer fibrous particles. Greater particle size of forages, including alfalfa hay and corn silage, also results in increased sorting against long forage particles in the TMR. Thus, sorting can be reduced by chopping forages into smaller lengths; however, care must be taken in those situations not to reduce particle size to the extent that the forage loses its physical effectiveness for stimulating rumination and rumen buffering.

Beyond changing forage characteristics or content, sorting can be influenced by other dietary measures. It is commonly believed that adding water to a dry TMR will help bind particles together and make it harder for dairy cattle to sort out smaller particles. Research has shown that the amount of feed sorting (against long particles) can be reduced when water is added to a dry TMR (>60 percent dry matter), particularly those rations containing a high proportion of dry forage (Leonardi *et al.*, 2005; Fish and DeVries, 2012). Recent research has also indicated that for wetter rations, other liquids (for example, a molasses-based liquid feed) may be more effective at reducing feed sorting (DeVries and Gill, 2012). It is recommended that in situations where sorting of mixed rations is evident, producers try adding water or liquid feed to their TMR, and carefully monitor the effects that these may have.

There are also feeding management practices which influence the degree of feed sorting. Increasing the frequency of TMR delivery from once per day to twice (or more often) per day has been shown to reduce feed sorting (DeVries *et al.*, 2005; Endres and Espejo, 2010). Given this, and the fact that more frequent feeding also promotes more equal access to freshly delivered feed and a more even distribution of feeding time over the course of the day, feeding cows more often has the potential to reduce the variation in composition of ration consumed.

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Improving the welfare of dairy goats: Feeding behaviour identifies goats at risk of subacute rumen acidosis

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MAIN MESSAGES

- Feeding behaviour is highly variable between animals.
- Feeding behaviour modifies rumen pH pattern and occurrence of subacute ruminal acidosis (SARA).
- Avoiding SARA increases animal welfare, milk production and therefore farm profitability.

ACRONYMS

CP crude protein
DMI dry matter intake
NDF neutral detergent fibre
PCA Principal Component Analysis
SARA subacute ruminal acidosis
SD standard deviation

INTRODUCTION

High-concentrate, low-forage, energy-dense diets are often fed to ruminants in intensive systems as a means of achieving high growth rates and high levels of milk production. These highly fermentable diets are associated with reduced chewing, decreased rumination and decreased saliva production which can limit the buffering capacity of the rumen, and thus often causes rumen acidosis (extended periods where rumen pH falls below 6.0).

To date, the majority of work in this area has focused on dairy and beef cattle, specifically in terms of rumen function and the negative effects of this disease on animal health and production, including prolonged periods of feed refusal, decreased performance, metabolic acidosis, dehydration, laminitis, polioencephalomalacia and liver abscesses (Owens *et al.*, 1998). Although acute acidosis is easily diagnosed, subacute ruminal acidosis (SARA) often goes undetected because subclinical signs are less pronounced. The tremendous individual differences between animals within a herd and the fact that not all animals succumb to this disease at the same time make this a particularly challenging disease for farmers to manage.

Clearly, the welfare of animals succumbing to acidosis or SARA is reduced. A recent study on dairy goats by Desnoyers *et al.* (2011) provides compelling evidence that individual differences in feeding behaviour between lactating goats can impact the severity of this disease and thus impact animal welfare. The aim of this paper is to expand on the original work of Desnoyers *et al.* (2011) by first describing the relationship between feeding behaviour and rumen pH and then estimating the potential animal welfare and possible economic costs resulting from SARA by describing the impact of SARA on milk production in dairy goats.

CASE STUDY

The study of Desnoyers *et al.* (2011) used 12 rumen cannulated dairy goats (eight Alpine and four Saanen) in mid lactation (6^{th} to 17^{th} week of lactation) that were housed in individual pens. It was carried out according to French legislation on animal experimentation in line with the *European Convention for the Protection of Vertebrates used for Experimental and other Scientific Purposes* (European Directive 86/609).

At the start of the experiment, the average body weight of the goats was 65 ± 7.4 kg (Mean ± SD) and the milk yield per day was 3.5 ± 0.58 kg. Animals had free access to water and were fed a total mixed ration *ad libitum* (ten percent refusals). The percentages of the different components of the diet were, on a dry matter basis: 50 percent concentrate blend (25 percent wheat, 25 percent barley, 30 percent maize, 15 percent soybean meal, three percent molasses and two percent mineral premix), 35 percent grass hay and 15 percent pressed sugar beet pulp. On a dry matter basis, the neutral detergent fibre (NDF) content was 34.7 percent and the CP content was 12.7 percent. Goats were fed two-thirds of their daily ration at 16:00 and the remaining one-third at 08:00. They were milked twice daily at 15:30 in the afternoon and 7:30 in the morning.

Each goat was fitted with a leather halter that measured feeding behaviour (time spent eating, ruminating or jaw resting) and a self-cleaning indwelling rumen pH probe that provided continuous pH measurements every minute. The pH probe was introduced into the rumen through the cannula and linked to a portable device placed in one of the pockets of a coat covering the back of the animal. All goats had previous experience with the halter device. Given that two-thirds of the total daily feed was offered in the afternoon, the data used for this case study was limited to the time between the afternoon delivery and the morning milking time (15 hours and 20 minutes). There was no human activity during this time period minimizing any external influences on the feeding behaviour measurements.

Outcome measures (rumen pH, eating, ruminating and jaw resting durations) were summarized in forty-six 20-minute intervals, when available, for the 11-week experimental period. Some data were lost due to technical issues resulting in only 333 feeding patterns measures for the 12 goats. A feeding pattern corresponded to data from one goat and one day.

Principal Component Analysis (PCA) was performed on the cumulative time spent eating and the cumulative time spent ruminating within each of the forty-six 20-minute intervals; these were treated as 92 potentially independent variables (with 46 measures per variable) in the PCA. The first two components of the PCA explained 11.3 percent of the total variance, which is a reasonable proportion given the high number of variables involved (92). We also observed an inverse relationship between eating and ruminating on the first component, particularly during the first three hours following the afternoon feeding. To describe the individual variation observed in feeding patterns between animals, the 33 patterns (representing 10 percent of the total number of patterns), that were to the extreme left and the other 33 patterns that were to the extreme right of the first principal component were selected.

The mean value for the 33 feeding patterns that were to the extreme left (Group 1A in the paper of Desnoyers *et al.*, 2011) represented the goats that had a large first period of feed intake immediately after feeding, followed by a period of increased rumination during the night and another period of intake in the early morning hours. In the second set (Group 1B), the 33 patterns at the extreme right, the goats had a relatively short first period of intake after feeding, followed by a period of rumination and then a second major period of intake about t to five hours after feeding (Figure 1).

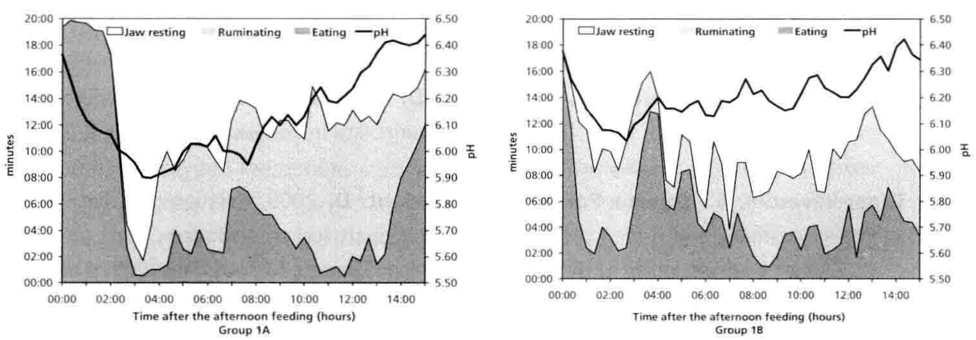
Unlike the first group, this latter group alternated eating and ruminating periods during the night and in the early morning hours.

The dry matter intake expressed on a body weight basis (38.8 ± 9.54 g/kg BW; Mean ± SD), the time spent eating (124 min ± 53 min/kg DMI), and the time spent ruminating (103 min ± 42 min/kg DMI) were all similar for both groups. However, given that the goats in group 1A were heavier (62.9 ± 6.32 - Mean ± SE) than those in group 1B (54.9 ± 9.60 kg), they consumed more feed on a daily basis than the goats in Group 1B (2.57 ± 0.558 vs 1.97 ± 0.647 kg DMI/day).

Although there were no differences in the daily mean rumen pH values (Group A: 6.07 ± 0.352 vs Group B: 6.21 ± 0.227) between the two groups, we did observe large differ-

FIGURE 1*

Time spent eating, ruminating or jaw resting, and rumen pH



Note: Measurements were taken at 20 minute intervals during the 15 hours and 20 minutes following the afternoon feeding for the 10 percent of patterns at the extreme left and the extreme right (Groups 1A and 1B) on the first axis of the Principal Component Analysis based on the time spent eating and the time spent ruminating during each of the 46 intervals of 20 minutes following the afternoon feeding that also had measurements of rumen pH (22 and 13 patterns, for Groups 1A and 1B, respectively).

* Reprinted from Desnoyers M., Giger-Reverdin S., Sauvant D. & Duvaux-Ponter C. 2011. The use of a multivariate analysis to study between-goat variability in feeding behavior and associated rumen pH patterns. Journal of Dairy Science 94(2): 842-852, Copyright (2011), with permission from the publisher.

ences between the groups in the rumen pH patterns. The rumen pH in the goats that had a pronounced first period of intake followed by a period of night rumination (Group 1A) decreased pH quickly and remained below the threshold of 6.0 for approximately five of the 15 hours and 20 minutes, compared with the pH of the goats from the other group which was slightly below 6.0 for only one hour (Figure 1). Given that extended periods where rumen pH is below 6.0 is a known risk factor for SARA, we are confident that these goats were suffering from SARA.

The milk production for Group 1A was 1.33 kg milk/kg DMI and for Group 1B was 1.50 milk/kg DMI. Although this study was not intended to determine the effects on milk production, the fact that the goats that produced 0.170 kg more milk/kg DMI also had feeding behaviour patterns that resulted in improved rumen pH patterns is of interest and warrants further investigation.

From a practical point of view the results in the current study, together with those of Giger-Reverdin *et al.* (2009) suggest that the amount of feed consumed in the 90 minutes after feeding may be a useful indicator identifying which goats within a herd are at risk of SARA. We strongly encourage further research to determine the effects of improved feeding behaviour patterns on farm income over feed costs.

CONCLUSION

All goats in the present study were provided the same diet but differences in their individual feeding behaviour patterns determined whether they were more or less at risk of succumbing to SARA. Although all goats consumed approximately the same amount of dry matter intake (expressed on a body weight basis) and had similar chewing durations (expressed on a dry matter intake basis), those animals which alternated eating and ruminating periods minimized the amount of time their rumen pH fell below the threshold value of 6.0. It follows that these goats were less likely to suffer from SARA and thus had improved welfare. Moreover they produced about 170 g more milk per kg DMI and thus were likely to contribute more to total farm income over feed costs arising from milk sales.

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