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Effects on post-fresh period milk production and fertility as a result of prior niacin supplementation of dairy cows during their fresh period

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ABSTRACT

If cows successfully transition the immediate post-partum (i.e., fresh) period, then it is likely they had a limited negative energy balance and avoided metabolic disease. Our objective was to determine if modulating fat metabolism during the fresh period, by feeding ruminally protected niacin (RPNi), had carry-over effects after cessation of its feeding on subsequent milk production and fertility of high producing Holstein cows. Multiparous Holstein cows (701) which had been fed one of four RPNi levels (i.e., 0, 3.5, 7, 14 g/d of nicotinic acid (NA) through 21 ± 3.9 days in milk (DIM), were followed through 150 DIM after they moved from their RPNi treatment fresh pen to common 'high cow' pens (i.e., early lactation high producing multiparity cows) where they were not fed RPNi. At their first milk sampling in the high pen (i.e., 48 ± 8.0 DIM), milk and milk fat yields of cows previously fed RPNi 3.5, which had been the highest of all treatment groups while in the fresh pen, slumped to become the lowest yields ($P = 0.04$ and 0.05, respectively). In contrast, milk and milk fat yields of cows previously fed RPNi 14, which had been lowest of all treatment groups while in the fresh period, increased ($P = 0.04$, 0.05, respectively) to become the highest yields. Over the next ~60 DIM, milk and milk component yields of cows from all fresh period treatments converged. Body condition score (BCS) of cows fed 3.5 and 7 g/d NA in the fresh period decreased to the greatest extent ($P = 0.01$) in early lactation but, by 138 DIM, fresh period RPNi 3.5 cows had gained 0.18 BCS units, while cows previously fed 14 g/d of RPNi had lost 0.23 BCS units. No fresh period RPNi treatment impacted any measure of reproductive performance through 150 DIM, but cessation of RPNi feeding when cows moved to high pens caused immediate changes in performance which differed relative to previous RPNi treatment.

1. Introduction

Immediate post-partum (i.e., fresh) dairy cows are often in negative energy balance (NEB) due to increasing energy demands to support rising milk output at a time of low dry matter (DM) intake. Excessive NEB makes cows more susceptible to ketosis, fatty liver and metritis, all of which can lead to decreased milk production and an increased chance culling (Ospina et al., 2010). If cows successfully transition the fresh period, it is likely that they had more severe NEB (Butler et al., 1981), which makes mitigating NEB of fresh cows crucial to a successful lactation.

A potential strategy to reduce the NEB of fresh dairy cows is to feed the B-vitamin niacin in the form of nicotinic acid (NA) since it is known for its anti-lipolysis properties (Gille et al., 2008). Indeed feeding RPNi to early lactation dairy cows decreased (Wrinkle et al., 2012), or tended to decrease (Morey et al., 2011), milk fat yield, likely by limiting release of long-chain fatty acids (FA) from adipose tissues, thereby decreasing availability of FA for importation into the mammary gland. Thus its supplementation to fresh cows could reduce the amount of non-esterified FA (NEFA) available for ketogenesis by limiting lipolysis, thereby helping cows maintain body condition score (BCS), but at the cost of a concurrent short term decrease in milk fat production. While feeding NA to fresh cows has not been consistent among studies, supplementation of ruminally unprotected NA has reduced plasma β-hydroxybutyrate and NEFA levels (Jaster et al., 1983), and rumen-protected niacin (RPNi) feeding has decreased plasma NEFA levels (Morey et al., 2011).

If NA feeding to fresh cows reduces lipolysis to help them maintain BCS, while decreasing accumulation of metabolites associated with ketosis, the extent of NEB would be mitigated and cows should be less

Abbreviations: BCS, body condition score; DIM, days in milk; DM, dry matter; FA, fatty acid; NA, nicotinic acid; NEB, negative energy balance; NEFA, non-esterified FA; RPNi, ruminally protected niacin; TMR, total mixed ration

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likely to experience common fresh cow ailments long known to decrease full lactation performance. For example Butler and Smith (1989) concluded that NEB was the primary factor regulating the reproductive system of early lactation dairy cows, and that cows in NEB have lower fertility, while Staples et al. (1998) found that more severe NEB resulted in cows returning to estrus earlier. Thus reducing the extent of early lactation NEB should improve fertility, which was shown by Kashfi et al. (2011) in response to NA feeding during the transition period. If RPNi feeding to fresh cows helps reduce loss of BCS, thereby reducing the extent of NEB while maintaining adipose stores, it has the potential to improve fertility.

Our objective was to determine if modulating fat metabolism during the fresh period by feeding RPNi had a carry-over effect, after cessation of its feeding in the post-fresh period, on milk production and fertility of commercially managed high producing Holstein cows.

2. Materials and methods

This experiment reports post-fresh period performance of lactating dairy cows (which had previously been fed no RPNi, or one of three increasing levels of RPNi, during the fresh period) through 150 days in milk (DIM). The fresh period experiment study is described by Havlin et al. (2017). However, in brief, Havlin et al. (2017) assigned multiparous Holstein dairy cows at calving to 1 of 4 RPNi feeding levels designed to deliver an average of 0, 3.5, 7 or 14 g NA/cow/d, which they received for their full time in the fresh pen. To facilitate feeding 4 treatments with 3 pens, the 3 treatments in Periods 1 and 2 were RPNi treatments 0, 3.5 and 7, whereas in Periods 3, 4 and 5 they were RPNi treatments 0, 7 and 14. The extra period while feeding treatments 0, 7 and 14 was because calving rates declined as the study progressed. To avoid confounding treatment with pen, cows and their diets were simultaneously rotated among the fresh pens every 4 or 5 weeks to create 5 periods, where periods 1 and 5 were 5 wks and periods 2, 3 and 4 were 4 wks.

This experiment addresses productive, reproductive and BCS characteristics from when cows were moved from tha fresh pen to comingled high pens, where no RPNi was fed, to 150 DIM.

2.1. Animals and management

Multiparous Holstein cows from Havlin et al. (2017) were physically and electronically tracked after their move from their RPNi treatment fresh pen to a 'high cow' pen (i.e., early lactation multiparous cows) through 150 DIM. To be included, cows must have been in their fresh pen for > 13 d, have been milk sampled therein at least once, moved from their fresh to a high pen by < 30 DIM, and remained there through 150 DIM. All cows that had BCS scored in their close-up dry period and in their fresh pen continued to be BCS scored monthly. To be included in the BCS subgroup, cows had to have had their BCS scored for 4 consecutive months in their high pen.

Cows were bred at standing estrous by artificial insemination based on removal of coloured chalk (All-weather Paintstick, LACO Industries, Chicago, IL, USA) from the tail head with a 40 d voluntary post-calving waiting period. Pregnancy was diagnosed by manual rectal palpation 34–41 d after breeding, and diagnoses were entered into Dairy Comp 305 software (Valley Agricultural Software, Tulare, CA, USA). Fertility data, collected from all cows, included services/cow, 1st service conception rate, DIM at first breeding, pregnancy rate, days open and services/conception were calculated from the Dairy Comp 305 herd records.

Cows were milked three times daily in a double 40 parallel parlor. Daily, while cows were out of the pen during morning milking, feed refusals were removed and total mixed ration (TMR) was delivered. The amount of TMR delivered was calculated daily based on the number of cows/pen, and previous days refusals, to obtain orts of ~10 g/kg of TMR. All cows were fed the same ration, with no RPNi added. When cows returned from morning milking, they were locked in head gates for health checks and breeding. Cows were housed in pens containing ~355 cows in covered barns, stocked on average to 111% of headlocks and 118% of freestalls, and bedded with dried manure solids which was groomed daily and renewed weekly. Cows had *ad libitum* access to drinking water in the pens at all times.

2.2. Experimental design

Cows were moved from their RPNi fresh pen between 14 and 28 DIM, inclusive, when dairy staff judged them healthy, to a high pen. Cows were moved from all fresh pens, with different RPNi treatments, to one high pen weekly, with no RPNi treatment, and each of these weekly moves were defined as a 'group' for statistical analysis. Over a 4 wk period, corresponding to the period lengths in Havlin et al. (2017), the efflux of cows (~90/wk) was sufficient to fill one high pen. At this time fresh cows were moved to a 2nd high pen, and so on, resulting in 5 high pens.

2.3. TMR sampling and analysis

The TMR was sampled every 2 weeks from the feed bunk of each high cow pen prior to cows returning from milking according to collection and sub sampling methods in Havlin et al. (2017). The TMR samples were dried, processed and analyzed as described in Havlin et al. (2017).

2.4. Body condition scoring

Body condition was scored monthly for all cows in the BCS subgroup, as defined above, according to the same procedure as used in Havlin et al. (2017).

2.5. Milk sampling and analysis

Kings County Dairy Herd Improvement Association personnel (Hanford, CA, USA) conducted a milk test using Tru-test milk meters (Tru-test Ltd. Auckland, New Zealand) on all cows monthly according to Havlin et al. (2017), which also describes the analytical procedures used for milk component analysis. Milk sample collection took place ± 24 h of BCS sampling. Milk energy (MJ/kg) was calculated using the equation of Tyrrell and Reid (1965) using milk fat, crude protein (i.e., analyzed true protein divided by 0.93) and lactose.

2.6. Statistical analysis

Milk production, fertility, and BCS parameters were analyzed using the MIXED option of SAS (2014). The statistical model included fixed effects of pen and treatment (i.e., prior RPNi fresh pen treatment), time (i.e., DIM) as a repeated effect, with cows nested within group (described above in the 'Experimental Design') as a random effect. Cows determined sick due to high SCC (i.e., SCC > 4500 cells/μl; $n = 7$ cows) or with milk yield or component values judged to be biological outliers (i.e., obvious analytical errors; $n = 7$ cows) at any milk test, were removed in a treatment blind process in order to avoid bias. This process left 672 cows in the statistical data set (i.e., 244, 103, 206, 119 cows for treatments 0, 3.5, 7, 14 g/d NA). All cows for BCS analysis ($n = 110$) fit the inclusion criteria of cows used for milk production. Contrasts were used to identify linear and quadratic contrasts of fresh pen RPNi treatment on response parameters as planned *a priori*. Treatment differences were accepted if $P \leq 0.05$, and tendencies if $0.05 < P \leq 0.10$.