

Choline's Impact on Milk Production

Multi-Study Research Summary

Meta-analysis of the effects of supplemental rumen-protected choline during the transition period on performance and health of dairy cows

Arshad, U., M. G. Zenobi, C. R. Staples, and J. E. P. Santos. 2020. *J. Dairy Sci.* 103:282–300.

Trial 1: Effects of supplementation with ruminally protected choline on performance of multiparous Holstein cows did not depend upon prepartum intake of calories

Zenobi, M. G., R. Gardinal, J. E. Zuniga, A. L. G. Dias, C. D. Nelson, J. P. Driver, B. A. Barton, J. E. P. Santos, and C. R. Staples. 2018a. *J. Dairy Sci.* 101:1088–1110.

Trial 2: Timing of initiation and duration of feeding rumen-protected choline affects performance of lactating Holstein cows

Bollatti, J. M., M. G. Zenobi, N. A. Artusso, G. F. Alfaro, A. M. Lopez, B. A. Barton, C. R. Staples, and J. E. P. Santos. 2020b. *J. Dairy Sci.* 103:4174–4191.

Trial 3: Increasing the prepartum dose of rumen-protected choline: Effects on milk production and metabolism in high-producing Holstein dairy cows

Holdorf, H. T., S. J. Kendall, K. E. Ruh, M. J. Caputo, G. J. Combs, S. J. Henisz, W. E. Brown, T. Bresolin, R. E. P. Ferreira, J. R. R. Dorea, and H. M. White. 2023. *J. Dairy Sci.* 106:5988-6004.

Trial 4: Effects of dietary rumen-protected choline supplementation to periparturient dairy cattle on inflammation, metabolism, and performance during an intramammary lipopolysaccharide challenge

Swartz, T. H., B. J. Bradford, L. K. Mamedova, and K. A. Estes. 2023. *J. Dairy Sci.* In Press.

Choline's Role in Increasing Yields of Milk and Components

A question frequently asked by nutritionists and producers alike is, "Where is that next 5 pounds of milk going to come from?" As in the past, the answer lies somewhere in the combination of improved genetics, better management, and enhanced nutrition. In recent times, genetic advancements challenge our ability to meet the nutritional needs of the modern dairy cow, but scientists around the globe are hustling to keep pace. Some of the most recent nutritional research has focused on understanding the role choline plays in helping cows express their genetic potential for milk production.

ReaShure® *Precision Release Choline* (Balchem Corp., Montvale, NJ) was first introduced over 25 years ago. It was designed to address the high incidence rates (40-60%) of fatty liver in transition dairy cows. Fatty liver is a classic symptom of choline deficiency. Over the past 25 years, ongoing research has shown that supplementing ReaShure during the transition period can consistently improve milk production and cow health. More recent research illustrates that feeding ReaShure prepartum can improve the health and growth of their calves after they are born and progress into adulthood. This document will summarize the newest research that shows choline's consistent impact on milk production.

Methodologies

Meta-Analysis. Arshad et al. (2020) published the results of a meta-analysis of research that examined the effects of peripartum supplementation of rumen-protected choline (RPC) on multiparous cow performance. There were 21 total studies in the analysis, with 66 different treatments and over 1,300 cows. All studies used in the analysis fed RPC prepartum and for some length of time postpartum. Individual trial ECM yield responses were plotted against grams of choline ion provided by the RPC products at the recommended feeding levels. ECM response was reported over the duration of each study, which varied from 15 to 140 DIM (57.5 ± 42.2 d).

Trial 1. Zenobi et al. (2018a) conducted a 2x2 factorial study using 109 parous cows with either 0 or 60 g/d ReaShure (12.9 g choline ion) fed during transition (21 d pre- to 21 d postpartum). Selection criteria included healthy cows with no history of chronic disease before enrollment. The study monitored ECM yield and DMI for 15 weeks into lactation. Cows were then placed in the general milking herd and ECM yield was monitored out to 40 weeks (280 d) of lactation. This was the first study to look at the benefit of short-term (transition) RPC supplementation on full lactation performance.

Trial 2. Bollatti et al. (2020b) also looked at the effect of transition (21 d prepartum to 21 d postpartum) supplementation of ReaShure (60 g/d) on ECM yield over

15 weeks and on milk yield over 25 weeks postpartum. There were 113 parous, healthy, pregnant cows with no recent history of disease in the 90 d preceding enrollment.

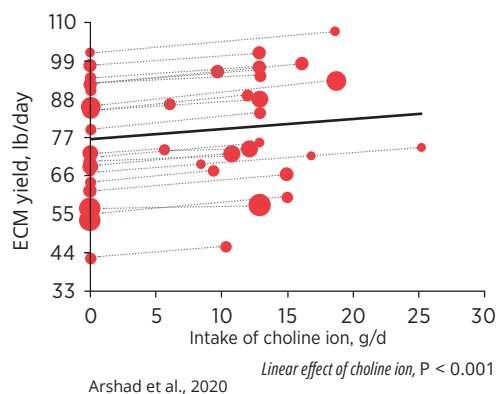
Trial 3. Holdorf et al. (2023) looked at the effects of peripartum RPC supplementation and prepartum (21 d) dose effects on lactation performance in 116 parous cows. Treatments were control, 15 g/d choline ion from ReaShure (21 d pre- to 21 d postpartum), 15 g/d choline ion from a concentrated prototype (21 d pre- to 21 d postpartum), and 22 g/d of choline ion from the prototype prepartum (21 d) followed by 15 g/d postpartum (21 d). Performance was monitored during the 21 d postpartum supplementation period and through 100 d postpartum.

Trial 4. Swartz et al. (2023) evaluated the effects of choline ion dose on lactation performance in 67 parous cows. Treatments were: 1) control (0 g/d choline ion), 2) ReaShure – regular dose (13.6 g/d choline ion) or 3) ReaShure – high dose (20.4 g/d choline ion) fed through transition (21 d pre- to 21 d postpartum). Cow performance was monitored over the first 16 d of lactation. At d 17 postpartum, 50% of the cows per treatment were challenged with an intramammary LPS challenge. Performance was measured during the LPS period (d 17 to d 22). From d 22 through d 84 of lactation, all cows were fed a common diet and performance was measured.

Results

Responses in ECM yield to supplementation of RPC during transition as reported by the Arshad et al. meta-analysis (2020) are shown in Figure 1. The x-axis shows the level of choline ion fed. The y-axis shows the ECM yield of the control cows (no choline) for each trial. The average increase in ECM across all studies was 4.8 lbs (2.2 kg) per day compared to control cows, and ECM yield increased linearly with increasing level of RPC fed (solid line). The analysis showed that while the ECM response varied by study, the responses were consistently positive. It should also be noted that increased ECM production occurred, regardless of initial milk production, and that positive responses occurred across a wide range of management and nutrition practices.

Figure 1 Effect of supplemental choline on energy-corrected milk yield



Many of the earlier studies cited in the Arshad et al. (2020) summary only followed lactation responses for a few weeks postpartum. Zenobi et al. (2018a) was the first study to follow performance into late lactation (40 weeks). Choline-supplemented cows (60 g/d of ReaShure peripartum) produced 4.63 lbs (2.1 kg) more milk per day than control cows over the entire 40 weeks of lactation (Figure 2). If extrapolated to a complete 305 d lactation, these cows on average would have produced approximately 1,400 lbs (641 kg) of additional milk. Fat and protein content were not affected by ReaShure supplementation, but yields of both were significantly increased.

Bollatti et al. (2020b) showed a very similar response to ReaShure as seen in Zenobi et al. (2018a). In the first 21 d postpartum, ReaShure-supplemented cows produced 6.83 lbs (3.1 kg) more ECM per day than control cows. ECM continued to be higher (5.29 lbs/2.4 kg) for the following 12 weeks once ReaShure supplementation had ended (Figure 3). Milk yield was monitored out to 25 weeks, and ReaShure-supplemented cows averaged 94.6 lbs (42.9 kg) compared to 90.2 lbs (40.9 kg) for control cows. Based on the post-supplementation 9-week response, these cows would have produced an additional 1,345 lbs (610 kg) of milk over 305 days. During the 21 d supplemental period, ReaShure-supplemented cows tended to have higher percent milk fat ($P = 0.08$) and significantly higher milk fat yield ($P = 0.02$). Milk protein yield was not affected by treatment during the supplementation period. In the 12-week carryover period, milk fat yield but not concentration tended to increase ($P = 0.07$), and protein percent and yield were unaffected by choline.

More recently, the University of Wisconsin (Holdorf et al., 2023) reported ECM yield out to 100 d postpartum. During the 21-d postpartum supplementation period, milk and component yields were not affected by choline. However, during the post-supplementation period (d 22 to d 100 of lactation), ECM yield tended to increase ($P = 0.06$) in cows supplemented with the recommended ReaShure dose during the peripartum period (5.2 lbs [2.4 kg]) compared to control cows. If the higher production were sustained throughout a 305 d lactation as suggested by the work of Zenobi et al. (2018a) and Bollatti et al. (2020b), on average these cows would have produced an additional 1,471 lbs (667 kg) of ECM.

Figure 2 Effect of feeding ReaShure during the transition period on milk production over the full lactation

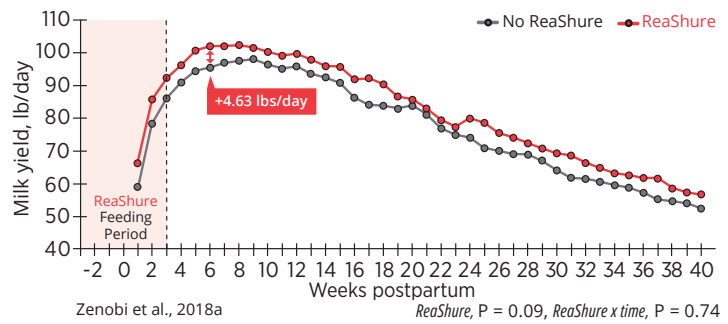


Figure 3 Effect of feeding ReaShure during the transition period on energy-corrected milk over the first 15 weeks of lactation

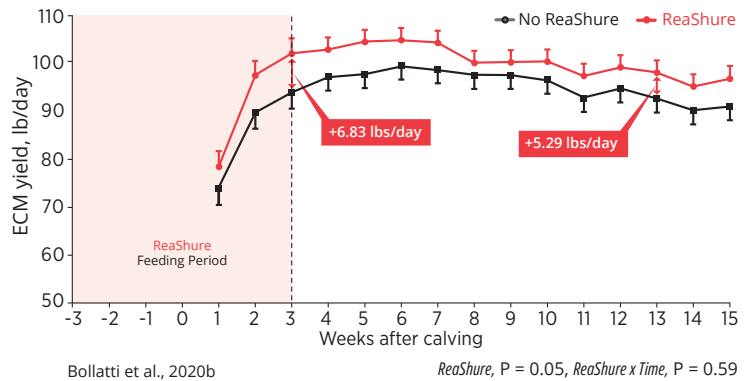


Figure 4 Effect of feeding ReaShure during the transition period on milk yield through 12 weeks of lactation

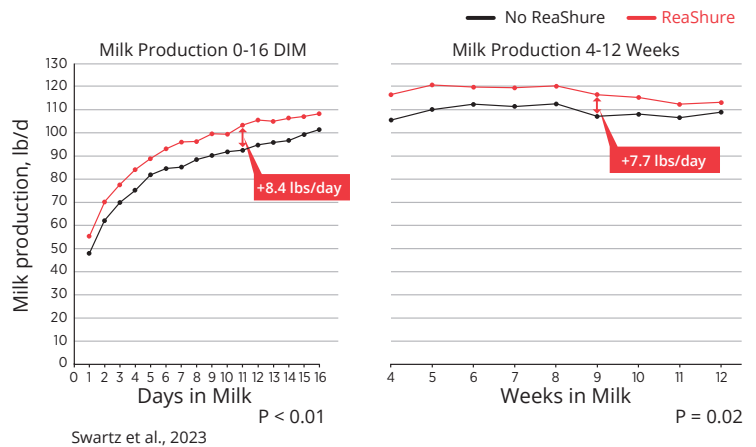
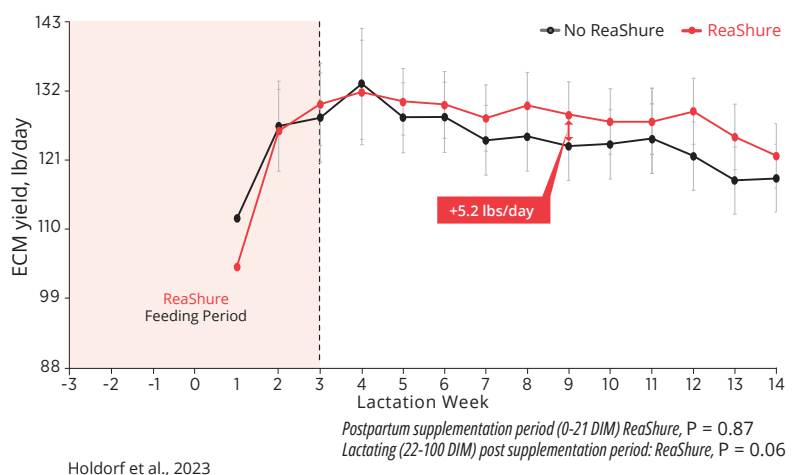


Figure 5 Effect of feeding ReaShure during transition on energy-corrected milk yield through 14 weeks of lactation



Work by Swartz et al. (2023) further substantiates the production benefits associated with peripartum ReaShure supplementation. Cows fed ReaShure peripartum produced on average 8.4 lbs (3.8 kg) more milk than control cows from calving to d 16 of lactation. During an intramammary LPS challenge (d 17 to d 21), cows saw significant decreases in milk yield, but cows supplemented with ReaShure maintained their advantage in milk yield. In the subsequent carry over period (d 22 to d 84), cows supplemented with ReaShure on average produced 7.7 lbs (3.5 kg) more milk per day than control cows. The projected advantage in milk yield over an entire 305 d lactation would be 2,364 lbs (1,072 kg) more milk per cow.

Discussion

The meta-analysis was already highly significant for increased milk and ECM yields due to RPC supplementation. If the more recent studies by Holdorf et al. (2023) and Swartz et al. (2023) are added to the 21 studies summarized by Arshad et al. (2020), it further strengthens this conclusion. While the exact modes by which choline does this are still debated, increased milk yield is a great barometer of improved cow health and wellness. Improvements in lipid and carbohydrate metabolism, particularly by the liver, are most likely involved. However, considering the role of choline in methyl donation (epigenetics, protein expression), cellular structure, function and integrity (intestinal, mammary), and immunity (functionality, inflammation), there are certainly other possible contributing factors to enhanced performance. While there may be undiscovered benefits to feeding cows RPC in other phases of the lactation cycle, it is clearly beneficial to do so in the peripartum period. The long-term impacts on lactation performance discussed are derived from the targeted application during a very short window: just 21 days pre- to 21 days postpartum.

Summary

More than 25 university studies have consistently shown improved lactation performance from RPC supplementation during the transition period. In the

specific studies cited above, the average increased milk/ECM yield improvement was an approximated 1,500 lbs (700 kg) per cow over a 305 d lactation. If the average response of the 21 studies reported in the Arshad et al. (2020) analysis was extrapolated to a 305 d lactation, the increased ECM yield would have been 1,465 lbs (665 kg). Virtually all cows have a need for supplemental choline during transition to achieve optimal performance. The relatively small investment to provide this required nutrient during a well-defined short, and critical time period can pay tremendous dividends for the current lactation and well into the future.*

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