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ReaShure®-XC
Precision Release Choline

Choline's Impact on Transition Cow Health
Multi-Study Research Summary

Multi-Study Research Summary: Transition Cow Health

Trial 1: Effects of feeding rumen-protected choline on incidence of diseases and reproduction of dairy cows

F. S. Lima, M. F. Sá Filho, L. F. Greco and J.E. P. Santos. 2012. The Veterinary Journal. 193:140-145.

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 2: Hepatic triacylglycerol associations with production and health in dairy cows

Arshad, U. and J. E. P. Santos. 2022. J. Dairy Sci. 105:5393-5409.

Trial 3: Feeding increasing amounts of ruminally protected choline decreased fatty liver in nonlactating, pregnant Holstein cows in negative energy status

Zenobi, M. G., T. L. Scheffler, J. E. Zuniga, M. B. Poindexter, S. R. Campagna, H. F. Castro Gonzalez, A. T. Farmer, B. A. Barton, J. E. P. Santos, and C. R. Staples. 2018b. J. Dairy Sci. 101:5902-5923.

Trial 4: Effects of prepartum choline supplementation on health, performance, and reproduction in Holstein cows

Poindexter, M. B., G. Negro, M. J. Granados, P. G. Loesia Lima, D. C. Ramos, D. M. Burgos, K. Estes, M. G. Zenobi, C. Zimmerman, J. E. P. Santos, and C. D. Nelson. 2023. J. Dairy Sci. In Review.

Balchem manufactures two versions of their rumen-protected choline product. ReaShure and a more concentrated form called ReaShure-XC. Both are designed to provide approximately 13 g/d choline ion when fed at the recommended feeding levels (ReaShure = 60/g/h/d, ReaShure-XC = 30 g/h/d). One or both of these products were used in the following trials.

Choline's Role in Easing the Transition from the Dry Period into Lactation

High producing cows are healthy cows. This has been said many different ways by many different researchers. It is a recognition that sick and stressed cows simply do not perform as well as healthy cows with similar genetics when fed the same nutrition. When producers improve cow comfort, health, and nutrition (collectively cow wellness), milk production inevitably increases. Choline is a powerful nutrient that plays critical roles within the body that contribute to the improved wellness of cows, particularly during the transition period when this nutrient is deficient.

If improved milk production is a biomarker for improved wellness, then choline's position as a required nutrient for cow health is well established in the literature through its repeated and consistent ability to enhance milk production in peer-reviewed university research. The exact mode(s) by which choline enhances cow performance are still being researched and debated. Research has pointed toward a number of possibilities including reduction in liver fat, better management of mobilized lipids, reductions in metabolic diseases, reduced inflammation, improved immune function, and improved cellular integrity and/or cellular proliferation.

Demand for choline and choline metabolites increases as cows approach parturition (calf growth, colostrum synthesis, and mammary gland development all require choline). At the same time, dry matter intake (and concurrently choline intake) declines, resulting in increased fat mobilization to meet the cow's energy requirement. Effective utilization of the increased mobilized NEFA (fat) absolutely requires choline. Evidence of this choline need is seen through increased milk yields, reduced incidences of metabolic diseases and the costs associated with treating them, as well as reduced involuntary culling related to cow health.

Current research has shown that one critical timeframe for feeding supplemental choline (as rumen-protected choline, RPC) is a very narrow window of approximately 42 days (21 d prepartum to 21 d postpartum) during the peripartum period. As dry matter intake increases and energy balance improves, resulting in decreasing fat mobilization, the need for supplemental choline declines. However, the benefits in terms of improved milk production have been shown to continue throughout the entire lactation due to higher peak milk yields and sustained yields through the entire lactation.*

Methodologies

Trial 1. Lima et al. (2012) conducted a 362-cow study on a large commercial dairy farm. The objective was to evaluate the impact of ReaShure® *Precision Release Choline* (Balchem Corp., Montvale, NJ) fed for 25 days prepartum through 80 days postpartum on the incidence of early lactation disease and reproductive performance. Treatments were Control (no ReaShure, 68 primiparous and 115 multiparous cows) or ReaShure (60 g/cow/d (12,9 g/d choline ion), 64 primiparous and 115 multiparous cows).

Meta-Analysis. Arshad et al. (2020) conducted a meta-analysis of 21 peer-reviewed research trials. Health data reported in the trials were compiled and analyzed (retained placenta, metritis, mastitis, milk fever, displaced abomasum, and ketosis). Not all trials reported all disease incidences.

Trial 2. Arshad and Santos, (2022) reviewed the collective data from 4 trials (329 cows) that had measured liver triacylglycerol (TAG; fat) levels at 6 to 11 days post-calving. Intakes of dry matter (DMI), energy balance, body weight (BW), body condition (BCS), milk production, and incidence of diseases were evaluated for the first 105 d postpartum. Blood metabolites were also measured in the first 21 d postpartum. The objective was to evaluate the associations between hepatic TAG content with production, blood metabolites, disease incidence and survival in Holstein cows.

Trial 3. Zenobi et al. (2018b) conducted a restricted intake dry cow study with Holstein cows looking at the impact of feeding ReaShure on the accumulation of fat and glycogen in the liver. Pregnant, nonlactating multiparous Holstein cows (77) were assigned to one of five treatments: 0; 6,5; 12,9; 19,4; 25,8 g/d choline ion from ReaShure. Cows were fed ad libitum for 5 days and then restricted to 32% of their energy and protein requirement for 9 days. Liver and blood samples were taken on days 5 and 14.

Trial 4. Poindexter et al. (In Review) performed a large herd study in 2020 involving 2.172 Holstein cows. Treatments were Control with no ReaShure (11 pens, 1.103 cows) or 60 g/cow/d (12,9 g/d choline ion) ReaShure (10 pens, 1.068 cows) fed for the last 3 weeks of gestation. At calving, all cows were fed a common fresh cow ration containing 60 g/cow/d (12,9 g/d choline ion) ReaShure. Disease incidences were monitored for 60 days postpartum and the percent of cows leaving the herd by 300 DIM was reported.

Results

Research investigating treatment effects on diseases in transition cows can be difficult because of the relatively low incidence rate of any one disease and the significant variation that can exist between treatments. Lima et al. (2012) was the first study completed with a relatively large number of animals (approximately 180 cows per

treatment). Results of this study are shown in Table 1. Significant reductions (P < 0,10) were observed in the incidences of clinical ketosis, mastitis and morbidity. However, metritis (25,4%), clinical ketosis (65,4%), DAs (37,2%), mastitis (30,6%), morbidity (31,6%) and mortality (46,6%) were all reduced by more than 25% in ReaShure-fed cows which can have important economic consequences.

In the work by Arshad et al. (2020), reductions in incidence rates of early lactation metabolic diseases in cows fed RPC were noted. However, only retained placenta and mastitis were significantly (P < 0,10) reduced.

One potential mode of action by which RPC can increase herd health and milk yield is

Table 1 **The effects of feeding ReaShure during transition on health disorders**

	Control Average, %	ReaShure Average, %	%, Reduction	*P* Value
Retained Placenta	10,8	10,0	7,4	0,72
Fever	31,7	33,0	-3,9	0,77
Puerperal Metritis	3,7	4,4	-19,2	0,69
Metritis	12,8	9,6	25,4	0,33
Clinical Ketosis	11,9	4,1	65,4	**0,01**
Displaced Abomasum	3,9	2,5	37,2	0,77
Mastitis	22,1	15,3	30,6	**0,06**
Morbidity	57,4	39,3	31,6	**0,001**
Mortality	6,6	3,5	46,6	0,27
Left Study	9,6	7,2	25,5	0,63

Lima et al., 2012

Table 2 **Impact of liver triacylglycerol accumulation on cow health events**

	Hepatic Triacylglycerol, % Wet Basis			*P*-Value
Clinical Disease, %	2,5	5,0	7,5	Linear
Retained Placenta	9,3 ± 2,7	11,9 ± 3,2	15,1 ± 4,7	0,12
Metritis	12,5 ± 3,4	18,2 ± 4,5	25,7 ± 6,8	0,01
Puerperal metritis	6,9 ± 2,3	10,2 ± 3,4	14,7 ± 6,0	0,07
Displaced Abomasum	1,0 ± 0,9	1,0 ± 0,8	1,0 ± 0,9	0,99
Mastitis	14,2 ± 3,2	16,9 ± 3,3	19,9 ± 4,5	0,15
Morbidity[1]	36,2 ± 5.0	41,3 ± 5,4	46,7 ± 6,9	0,10
Multiple Diseases[2]	8,7 ± 2,9	13,7 ± 4,1	21,2 ± 6,6	0,01

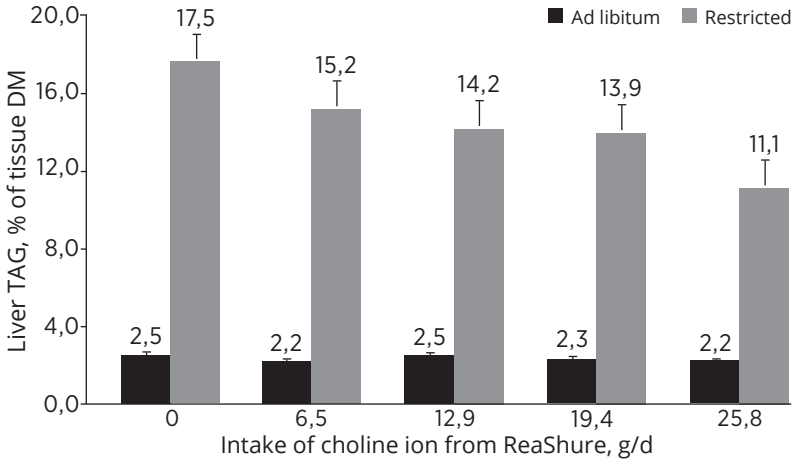
[1]Morbidity included retained placenta, metritis, displaced abomasum, milk fever, pneumonia, and mastitis.
[2]Multiple diseases included cows diagnosed with more than one type of disease listed in morbidity.

Arshad and Santos et al., 2022

by reducing accumulation of lipid in the liver during transition. The work completed by Arshad and Santos (2022) gave some new insight into the impact of liver lipid accumulation on animal performance. Table 2 shows the effect of relatively small increases in liver triglyceride accumulation on the incidences of various metabolic diseases. In most cases, as liver fat accumulation increases, the incidence rates of metabolic diseases also increases.

While lactation studies show variable results on the effect of RPC on liver fat accumulation, these studies are confounded by changes in DMI and increases in milk yield (energy balance and fat mobilization). The study by Zenobi et al. (2018) looked specifically at the impact of the addition of ReaShure on liver fat accumulation independent of milk yield using the feed restricted dry cow model. The results of that study are shown in Figure 1. Clearly, supplementation of ReaShure at increasing doses linearly decreased the accumulation of fat in the liver. ReaShure enhances the ability of the liver to manage the export of

Figure 1 **Effect of increasing intake of choline ion from ReaShure on liver concentration of triacylglycerol**



Linear decrease in liver TAG with increasing intake of choline ions, P < 0,001
CTL vs all choline ion intakes, P = 0,003

Zenobi et al., 2018b

accumulating fat during transition, thus reducing the negative effects of fatty liver on cow health.

Poindexter et al. (In Review) investigated the health benefits from ReaShure in a large commercial dairy, encompassing an extensive number of cows. It is important to keep in mind that all cows were fed a common diet which included ReaShure postpartum. Any differences would be associated with prepartum effects of ReaShure. Table 3 reports the health results from the study. Prepartum ReaShure supplementation did reduce milk fever incidence (P < 0,08). Additionally, the percent of cows involuntarily leaving the herd by 300 DIM was significantly (P < 0,05) reduced in cows fed ReaShure pre and postpartum (29,2% for control vs. 24,7% in ReaShure fed cows). This was primarily due to a reduction in cows sold.

Discussion

Cows fed ReaShure, particularly both pre- and postpartum, were seen to produce more milk and be healthier. There are several theories that have been put forth to explain how ReaShure benefits the cow during transition. One theory is that choline, a structural component of phosphatidylcholine (PC), is deficient during the peripartum period. This occurs as a result of increased demand for choline and choline metabolites needed for fetal and uterine growth, colostrum synthesis and mammary cell proliferation. In addition, as the cow enters negative energy balance, she mobilizes body fat and much of this is metabolized by the liver. Very low density lipoprotein (VLDL) is required to transport fat out of the liver and its synthesis requires PC. If PC supply is inadequate, VLDL synthesis is inhibited, resulting in fat accumulation in the liver. Eventually, fat levels begin to negatively affect liver function and is associated with increasing negative health effects.

Table 3 **Effect of feeding ReaShure prepartum on health**

	Control Average, %	ReaShure Average, %	%, Reduction	*P* Value
Retained Placenta	4,4	4,5	-3,4	0,9
Metritis	21,8	23,2	-6,4	0,62
Milk Fever	1,9	0,8	60,5	**0,08**
Mastitis	4,6	5,0	-7,6	0,47
Morbidity	31,9	33,4	-4,5	0,62
Multiple Diseases	7,1	5,4	24,6	0,12
Subclinical Disease				
Hypocalcemia	51,4	54,3	-5,6	0,49
Hyperketonemia	18,8	19,9	-0,05	0,96
Left Herd by 300 DIM	29,2	24,7	15,4	**0,05**
Sold	26,2	22,6	13,7	**0,08**
Mortality	3,0	2,1	30,0	0,92

Poindexter et al., In Review

Summary

ReaShure has a 25-year track record of helping cows make a sound transition from the dry period into a healthy and prosperous lactation. Choline is shown to support metabolic health through enabling VLDL synthesis to transport fat out of the liver. However, it is unlikely that this is choline's one and only mode of action to positively impact cow health. Ongoing research continues to explore this essential and required nutrient's role in helping cows achieve their genetic potential.

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