



CholiGEM™ improved lactation performance and demonstrates a positive impact on metabolism of Holstein cows

Abstract

In this study, dry Holstein cows ($n = 48$) at 245 ± 3 d of gestation were blocked by parity and assigned to Control or CholiGEM™ treatment within each block. Cows enrolled in the CholiGEM treatment received 15 g/d of CholiGEM from 21 d prepartum and 30 g/d of CholiGEM from calving to 21 d postpartum. There were no differences in DMI in the pre- and postpartum periods. Cows fed CholiGEM increased the 3.5% fat-corrected milk yield in both primiparous (Control = 37.7 ± 0.2 vs. CholiGEM = 38.8 ± 0.2 , $P < 0.001$) and multiparous (Control = 50.6 ± 0.2 vs. CholiGEM = 52.9 ± 0.2 , $P < 0.001$) cows up to 150 days in milk (DIM), as well as milk fat yield. Glucose, NEFA (non-esterified fatty acids), and BHBA (beta-hydroxy-butyric acid) had no differences between the treatments. However, CholiGEM decreased numerically BHBA (Control = 1.07 ± 0.13 vs. CholiGEM = 0.63 ± 0.13) in multiparous on the third week postpartum and tended to reduce the incidence of subclinical ketosis (12.7% vs. 4.2%). In summary, CholiGEM supplemented during the transition period improved lactation performance and had a positive impact on metabolism of Holstein cows.

KEYWORDS

Transition period, energy-related metabolites, lactation performance

Introduction

Recent findings from meta-analysis (Arshad et al., 2020) reinforced the importance of rumen-protected choline (RPC) supplementation during the transition period for dairy cows. This supplementation has been shown to enhance pre- and postpartum dry matter intake (DMI), milk yield, milk composition, and metabolic processes. However, the effectiveness of RPC feeding hinges on various factors, including the timing of supplementation both before and after calving (Lima et al., 2012; Arshad et al., 2020; Bollatti et al., 2020), as well as the choline's bioavailability, which is influenced by the type of encapsulation utilized and the choline core content and characteristics (Humer et al., 2019). CholiGEM™ is the next generation of rumen-protected choline chloride, developed by Kemin Animal Nutrition and Health that features high choline chloride content (60%) and high bioavailability. The objective of this study was to determine the effects of CholiGEM on lactation performance and markers of metabolism in Holstein cows.

Materials and Methods

This study was conducted at the dairy farm of Teaching and Research Facilities at the University of California, Davis. The study followed a complete randomized block with dry Holstein cows at 245 ± 3 d of gestation blocked by parity (Primiparous vs. Multiparous) and within each block assigned to Control or CholiGEM treatment. Cows enrolled in the

CholiGEM treatment received 15 g/d of CholiGEM from 21 d prepartum, and 30 g/d of CholiGEM from calving to 21 d postpartum. Cows in both treatments were assigned to an individual feeding gate (American Calan Inc., Northwood, NH) for a one-week adaptation period before initiating intake measurements, which were conducted from 21 d prepartum to 21 d postpartum. From 22 to 150 DIM, cows were moved to a free-stall barn equipped with headlock stations. Cows were milked twice daily, and milk yield was recorded automatically (DeLaval, Tumba, SE) from 0 to 150 DIM. Blood was sampled weekly from 21 d pre- to 21 d postpartum to evaluate energy-related metabolites (glucose, NEFA, and BHBA). Data were analyzed by the MIXED or GLIMMIX procedures of SAS (version 9.4, SAS Institute Inc., Cary, NC).

Table 1: Formulation and composition of the diets for pre- and postpartum period

Item	Prepartum ¹	Postpartum ²
Ingredient, % of DM		
Grain mix ³	24.3	41.5
Alfalfa hay	27.1	30.8
Wheat hay	23.3	9.6
Whole cottonseed	-	7.7
Almond hull	17.4	7.7
Strata ^{®4}	-	0.1
Milk mineral	-	1.2
Saturated free fatty acids	-	1.2
Salt	-	0.2
Acidogenic supplement ⁵	1.1	-
Dry cow pellet ⁶	4.7	-
Prequel ^{TM7}	0.9	-
Dry cow mineral	1.2	-
Nutrient composition		
Crude Protein, %	15.9 ± 1.5	17.9 ± 0.8
Neutral detergent fiber (NDF), %	33.8 ± 3.4	31.3 ± 3.3
Ether extract, %	3.7 ± 0.9	5.7 ± 0.4
Neutral fiber carbohydrate (NFC), %	41.9 ± 3.2	39.7 ± 2.5
NE _L , Mcal/kg	1.4 ± 0.03	1.5 ± 0.03
DCAD, mEq/kg	-46.1 ± 2.2	200 ± 101

¹Diet fed for an average (±SD) of 19.0 ± 0.7 d for multiparous and 17.0 ± 0.7 d for primiparous.

²Diet fed from calving to 150 d postpartum.

³Mixture of 39.2% rolled corn, 22.4% WMR, 14.6% DDG, 14.1% beet pulp, 6.5% SBM, 1.9% ground wheat, and 1.3% molasses.

⁴Strata[®] (fat supplement containing 80% total fat, 9.3–11.1% calcium, and 16% EPA/DHA Omega-3 fatty acids, Virtus Nutrition LLC, Corcoran, CA).

⁵NutriCABTM: acidogenic feed supplement (Kemin Industries Inc., Des Moines, IA).

⁶Dry cow pellet (24.0% crude protein, 3.0% crude fat, 9% crude fiber, 0.3–0.8% calcium, 1% phosphorus, 0.8% sodium, 2.0–3.9 ppm selenium, Western Milling LLC, Goshen, CA).

⁷Prequel™ (fat supplement with omega-6s containing 80% total fat, and 9.3–11.1% calcium, Virtus Nutrition LLC, Corcoran, CA).

Results

Dry matter intake and milk production up to 21 DIM

As shown in Table 2, supplementation of CholiGEM during the transition period had no effect on DMI pre- ($P = 0.13$; Table 2) and postpartum ($P = 0.30$, Table 2). CholiGEM had no effect on lactose ($P = 0.96$, Table 2) during the first 21 DIM. However, cows fed CholiGEM increased ECM ($P = 0.05$), 3.5% FCM ($P = 0.004$), milk fat percent ($P < 0.001$), and fat yield ($P < 0.001$) compared with the cows in the Control group. There were effects of treatment ($P < 0.001$), parity ($P < 0.001$), and an interaction treatment by parity ($P < 0.001$) for protein percentage with primiparous CholiGEM having lower protein percentage than primiparous Control cows. There were effects of treatment ($P < 0.001$), parity ($P < 0.001$), and an interaction treatment by parity ($P < 0.001$) for lactose percentage with primiparous CholiGEM having higher lactose percentage than primiparous Control cows.

Lactation performance

When evaluated up to 150 DIM between treatments, multiparous and primiparous cows supplemented with CholiGEM during the transition period had greater ECM, 3.5% FCM, milk fat percent, and milk fat yield ($P < 0.001$, Table 2), with the interaction between treatment and parity ($P < 0.001$, Table 2). Over time, there were noticeable changes in ECM, 3.5% FCM, fat, protein, and lactose yields ($P < 0.001$), but there were no interactions between treatment and time ($P > 0.05$).

Table 2. Production performance responses for Control and CholiGEM groups in the transition period

Item	Multiparous		Primiparous		P-value		
	Control	CholiGEM	Control	CholiGEM	Treatment	Parity	T x P ²
Dry matter intake ¹ , kg/d							
Prepartum	22.5 ± 0.3	21.5 ± 0.2	14.0 ± 0.2	13.4 ± 0.2	0.13	<0.001	0.75
Postpartum	26.9 ± 0.3	25.7 ± 0.3	17.0 ± 0.2	15.8 ± 0.2	0.30	<0.001	0.88
Milk and milk components until 21 DIM ³							
ECM ⁴ , kg	44.7 ± 0.4	45.8 ± 0.4	28.9 ± 0.4	29.2 ± 0.4	0.05	<0.001	0.31
3.5% FCM ⁵ , kg	44.7 ± 0.	46.3 ± 0.4	29.1 ± 0.4	29.8 ± 0.4	0.004	<0.001	0.27
Fat							
%	3.87 ± 0.02	4.19 ± 0.02	4.07 ± 0.02	4.19 ± 0.02	<0.001	<0.001	<0.001
kg/d	1.63 ± 0.01	1.74 ± 0.01	1.08 ± 0.01	1.12 ± 0.01	<0.001	<0.001	0.03
Protein							
%	3.34 ± 0.01	3.35 ± 0.01	3.36 ± 0.01	3.29 ± 0.01	<0.001	<0.001	<0.001
kg/d	1.41 ± 0.04	1.39 ± 0.04	0.90 ± 0.04	0.88 ± 0.04	0.61	<0.001	0.98
Lactose							

%	4.82 ± 0.01	4.82 ± 0.01	4.90 ± 0.01	4.93 ± 0.01	<0.001	<0.001	0.02
kg/d	2.04 ± 0.02	2.03 ± 0.02	1.33 ± 0.02	1.35 ± 0.02	0.96	<0.001	<0.001
Milk and milk components until 150 DIM ³							
ECM, kg	50.6 ± 0.2	52.3 ± 0.2	37.4 ± 0.1	38.1 ± 0.2	<0.001	<0.001	<0.001
3.5% FCM, kg	50.6 ± 0.6	52.9 ± 0.6	37.7 ± 0.5	38.8 ± 0.5	<0.001	<0.001	<0.001
Fat							
%	3.89 ± 0.0	4.19 ± 0.01	4.06 ± 0.01	4.19 ± 0.01	<0.001	<0.001	<0.001
kg/d	1.85 ± 0.01	1.99 ± 0.01	1.40 ± 0.01	1.46 ± 0.01	<0.001	<0.001	<0.001
Protein							
%	3.34 ± 0.01	3.36 ± 0.01	3.36 ± 0.01	3.29 ± 0.01	<0.001	<0.001	<0.001
kg/d	1.58 ± 0.04	1.57 ± 0.04	1.17 ± 0.04	1.15 ± 0.04	0.70	<0.001	0.87
Lactose							
%	4.82 ± 0.01	4.82 ± 0.01	4.90 ± 0.01	4.93 ± 0.01	<0.001	<0.001	<0.001
kg/d	2.26 ± 0.08	2.25 ± 0.08	1.73 ± 0.04	1.71 ± 0.04	0.81	<0.001	0.86

¹Prepartum = measurements in the last 21 d of gestation. Postpartum = measurements in the first 21 d postpartum.

²Interaction between treatment and parity (T x P)

³There was an effect of time ($P < 0.001$) for ECM, 3.5% FCM, fat, protein, and lactose but no interaction between time and treatment were found ($P > 0.05$)

⁴ECM (energy corrected milk) yield = [(0.3246 × milk yield) + (12.86 × fat yield) + (7.04 × protein yield)]

⁵3.5% FCM (fat-protein corrected milk) = (0.4324 × milk yield) + (16.218 × milk fat yield)

Energy-related metabolites and disease incidence

There were no effects of CholiGEM on glucose ($P = 0.54$) or NEFA ($P = 0.69$), regardless of parity (Figure 1A and 1B). No interaction was found between the treatment and week for NEFA in multiparous ($P = 0.55$, Figure 1C). However, an interaction between the treatment and week was detected in primiparous ($P = 0.03$, Figure 1D), with plasma concentration of NEFA increasing up to 2 weeks postpartum in cows fed CholiGEM, while in Control cows after week one postpartum NEFA decreased.

Even though there were no overall differences in BHBA between treatments for multiparous (Figure 2A) and primiparous (Figure 2B), multiparous cows in the CholiGEM treatment tended to have a lower incidence of subclinical ketosis cases by 3 weeks postpartum ($12.7 \pm 3.3\%$ vs. $4.2 \pm 2.0\%$, $P = 0.06$). Considering all cows enrolled in the study, the incidence of health disorders was not statistically different between treatments for milk fever (Control = 8.3% vs. CholiGEM = 4.2%), metritis (Control = 12.5% vs. CholiGEM = 12.5%), subclinical ketosis (Control = 8.4% vs. CholiGEM = 4.2%), and displaced abomasum (Control = 4.2% vs. CholiGEM = 0%).

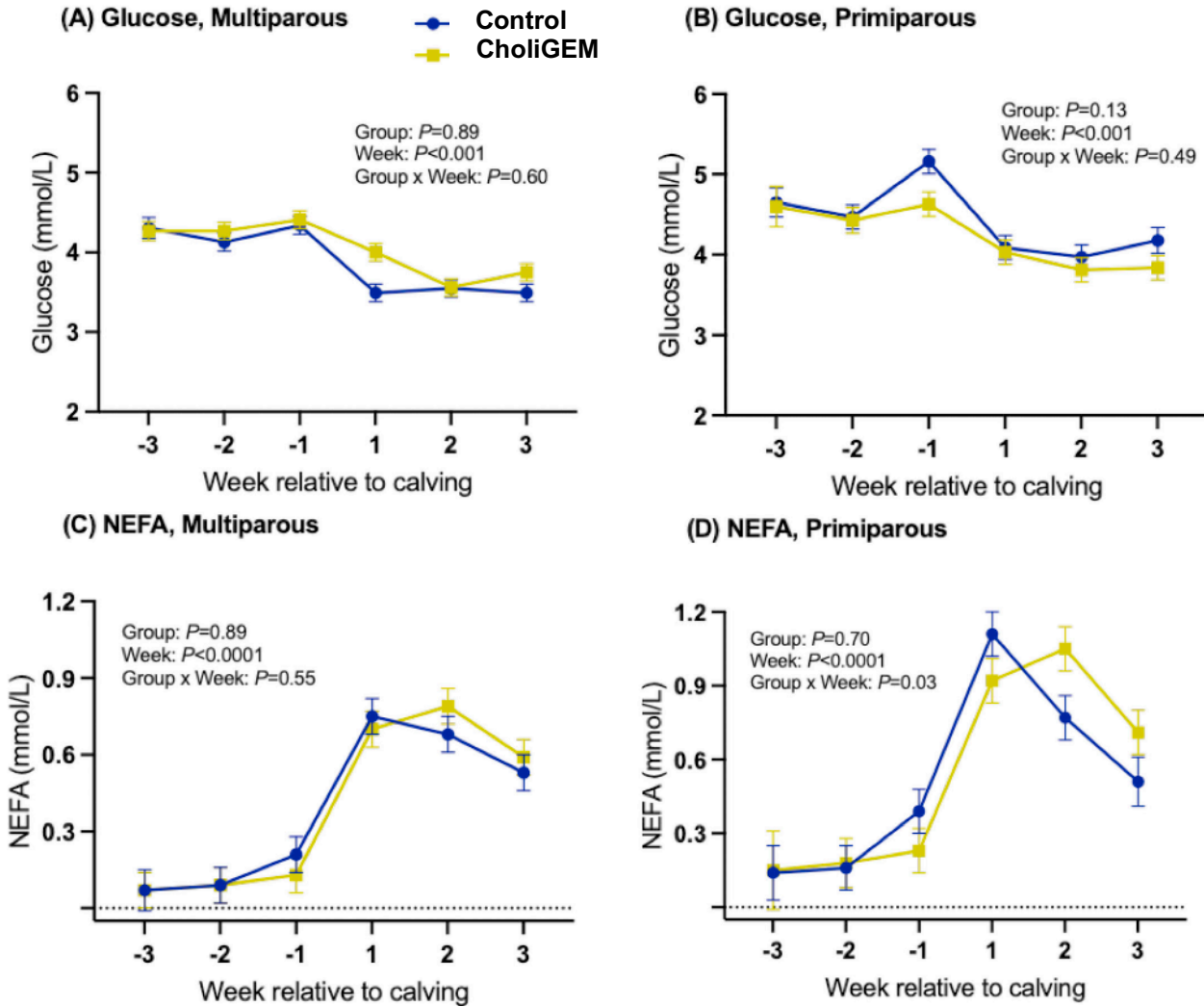


Figure 1. Plasma concentration of glucose and NEFA in multiparous (A, C) and primiparous (B, D) in Control (n = 24), and CholiGEM (n = 24, 15 g/d of CholiGEM from 21 d prepartum and 30 g/d of CholiGEM from calving to 21 d postpartum) treatments.

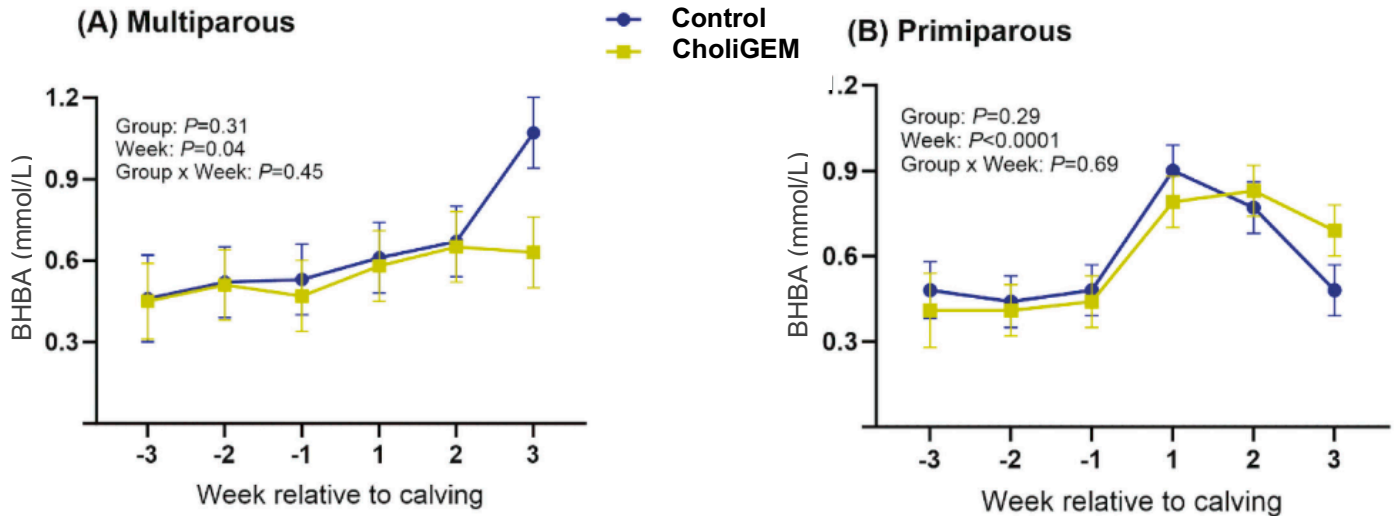


Figure 2. Plasma concentration of BHBA in multiparous (A) and primiparous (B) in Control (n = 24), and CholiGEM (n = 24, 15 g/d of CholiGEM from 21 d prepartum and 30 g/d of CholiGEM from calving to 21 d postpartum) treatments.

Conclusion

CholiGEM supplemented during the transition period positively affected dairy cows' lactation performance and health through 150 DIM. These results underscore CholiGEM as a helpful tool in supporting metabolic adaptations to lactation and health in dairy cows.

References

1. Arshad, U., Zenobi, M.G., Staples, C.R. and Santos, J.E.P. 2020. Meta-analysis of the effects of supplemental rumen-protected choline during the transition period on performance and health of parous dairy cows. *J. Dairy Sci.* 103: 282-300.
2. Lima, F. S., M. F. Sa Filho, L. F. Greco, and J. E. P. Santos. 2012. Effects of feeding rumen-protected choline on incidence of diseases and reproduction of dairy cows. *Vet. J.* 193:140–145.
3. Bollatti, J. M., M. G. Zenobi, N. A. Artusso, G. F. Alfaro, A. M. Lopez, B. A. Barton, C. D. Nelson, C. R. Staples, and J. E. P. Santos. 2020. Timing of initiation and duration of feeding rumen protected choline affects performance of lactating Holstein cows. *J. Dairy Sci.* 103:4174–4191.
4. Humer, E., G. Bruggeman, and Q. Zebeli. 2019. A Meta-Analysis on the Impact of the Supplementation of Rumen-Protected Choline on the Metabolic Health and Performance of Dairy Cattle. *Animals (Basel)* 9:566.