

Effects of feeding calcareous marine algae to Holstein cows beginning prepartum on postpartum performance and serum metabolites

Z. Wu and J. K. Bernard

University of Georgia, Tifton, GA

ABSTRACT

Thirty-six multiparous Holstein cows and 12 springing heifers were used in a 9 wk randomized design trial to determine the effect of feeding calcareous marine algae (Acid Buf, Celtic Sea, Ireland) from 3 wk prepartum through 6 wk postpartum on dry matter intake (DMI), milk yield and composition, and blood and urine metabolites. Within parity, animals were assigned randomly to one of four treatments with a 2×2 factorial arrangement. Prepartum diets were supplemented with 0 (CON) or 50 g/d calcareous marine algae (CMA) resulting in a DCAD of -3 and -5 meq/100g, respectively. Postpartum diets were supplemented with either 317 g/d sodium bicarbonate (NBC) or 100 g/d CMA to achieve a DCAD of 35 and 17 meq/100g, respectively. No differences ($P = 0.6142$) were observed in prepartum DMI which averaged 11.9 and 12.2 kg/d for CON and CMA, respectively. Postpartum DMI, milk yield, percentage of milk fat, protein, lactose, and SNF were not different ($P > 0.10$) among treatments and averaged 18.0, 38.1, 4.02, 2.71, 4.75, and 8.37; 19.8, 39.0, 3.96, 2.85, 4.74, and 8.38; 19.4, 37.3, 4.01, 2.71, 4.75, and 8.41; and 20.0 kg/d, 38.1 kg/d, 4.24%, 2.81%, 4.72%, and 8.37% for CON-NBC, CMA-NBC, CON-CMA, and CMA-CMA, respectively. Milk protein yield was higher ($P = 0.0453$) for cows fed CMA prepartum compared with CON; 1.09 and 1.02 kg/d, respectively. Interactions of prepartum treatment and wk were observed for yield of milk fat ($P = 0.0222$), energy-corrected milk (ECM, $P = 0.0395$) and 3.5% fat-corrected milk (FCM, $P = 0.0290$) because of higher yields for cows fed CMA during wk 2 and 6 compared with CON. An interaction of prepartum treatment and wk ($P < 0.05$) was also observed for milk efficiency (ECM/DMI, FCM/DMI) because of lower efficiencies for cows fed CMA during wk 1 and 4 compared with CON; however, efficiencies tended to reverse and were numerically higher for CMA compared with CON during wk 6. Serum Na concentrations were greater ($P < 0.05$) for cows fed CON prepartum or NBC postpartum compared with CMA. Postpartum urinary concentrations of Na exhibited an interaction among treatments ($P = 0.0353$) and were higher for

CON-NBC and CMA-NBC compared with CON-CMA and CMA-CMA; 121.21, 105.43, 41.24 and 59.55 mmol/L, respectively. Similar interactions of treatments ($P < 0.05$) were also observed for serum urea N and creatinine postpartum. Postpartum urinary K concentrations were higher ($P = 0.003$) for cows fed CMA postpartum compared with NBC; 155.60 and 118.40 mmol/L, respectively. Results of this trial indicate that cows feeding CMA prepartum does not affect DMI or serum metabolites prepartum, but supported higher milk protein yields and increases in ECM and FCM postpartum. Efficiency of milk production was higher for CON during wk 1 and 4, but was not different afterwards. Performance and serum metabolite concentrations of cows fed CMA postpartum were comparable with that of cows fed NBC except for changes in serum and urinary concentration of Na related to dietary intake of Na.

Key words: DCAD, milk yield, milk composition

INTRODUCTION

Transition cows are highly susceptible to periparturient diseases due to tremendous physiological adaptation during that period. Milk fever, hypocalcaemia, is a metabolic disease occurring at parturition resulting from low blood Ca concentration and is economically important due to lower milk yield. According to Curtis et al. (1985) reported that cows that have clinical milk fever are at greater risk for developing other disorders, such as dystocia, retained fetal placenta, ketosis or coliform mastitis. Feeding anionic diets prepartum has been one of the successful strategies to reduce clinical and subclinical hypocalcaemia (Oetzel et al., 1988; Goff et al., 1991). Incidence rate of milk fever was significantly reduced by feeding anionic diets prepartum compared with feeding cationic diets (Block, 1984). However, feeding cationic diets is recommended postpartum to prevent rumen acidosis and further improve animal performance postpartum (West et al., 1991, 1992; Hu and Murphy, 2004).

Calcareous marine algae (CMA, Calmin, Celtic Sea Minerals, Ireland.) is a natural product containing high concentrations of soluble Ca (30%) and Mg (6%) along with trace minerals and has been reported to be an effective rumen buffer (Caliz, 2009). Limited data are available on effects of feeding this buffer to dairy cattle, either before or during lactation. The objective of this study was to determine the effect of feeding calcareous marine algae from 3 wk

prepartum through 6 wk postpartum on DMI, milk yield and composition, blood and urine metabolites.

MATERIALS AND METHODS

Thirty-six Holstein cows and 12 springing heifers were selected for use in a randomized block trial with a 2×2 factorial arrangement of treatments beginning 3 wk prepartum through 6 wk postpartum. Cows were blocked by parity and expected calving date. All protocols were approved by the University of Georgia Institute of Animal Care and Use Committee.

Animals were trained to eat behind Calan doors (American Calan, Inc., Northwood, NH) before beginning the trial. Cows were housed in a 4-row free stall barn with supplemental evaporative cooling provided by fans and misters and were allowed free access to a grassed exercise lot. At calving, cows were moved to grassed lot or a box stall and returned to the free stall area after calving. Cows were fed once daily in amounts to provide a minimum of 5% refusal and had free access to water. The amount of feed offered and refused was recorded daily.

Experimental diets were formulated to meet NRC requirements for late gestation and early lactation, respectively (Table 1). Supplemental CMA was included in diets according to the manufactures recommendations. Each day a basal diet was mixed for either prepartum or postpartum treatments (Model 3120 Reel Mixer, Kuhn North America, Brodhead, WI). Treatment premixes (Table 1) were prepared and included with the other ingredients prior to final mixing and feeding using a DataRanger (American Calan, Inc.). Samples of dietary ingredients and TMR were collected three times each week and DM determined by drying in a forced air oven 50 °C for 48 h. Samples were ground to pass through a 6-mm screen, composited by week, and a subsample ground to pass through a 1-mm screen. Samples were analyzed for concentrations of ash (AOAC, 2000), N (Leco FP-528 Nitrogen Analyzer, St. Joseph, MO), ether extract, ADF, (AOAC, 200), NDF (Van Soest et al., 1991), starch, (Hall, 2009), and minerals (AOAC, 2000).

After calving, cows were milked three times daily beginning at 0000, 0800 and 1600. Milk weights were recorded electronically at each milking (Alpro, DeLaval, Kansas City, MO), totaled each day, and a weekly average calculated. Milk samples were collected from three consecutive milkings each week. Samples were shipped for next day delivery to Dairy One Cooperative (Ithaca, NY) for analysis of fat, protein, lactose, SNF, MUN and SCC

concentrations by mid-infrared spectrophotometric analysis with a Foss 4000 instrument (Foss North America, Eden Prairie, MN).

Body weight of cows was recorded on three consecutive days at the beginning of the preliminary period and during wk 3 and 6 postpartum and once immediately after parturition. Access to water and feed was restricted until measurements were recorded immediately after the 0800 milking. Body condition scores were assigned by two individuals when BW was recorded as described by Wildman et al. (1982).

Two whole blood samples were collected from the coccygeal vein at 0900 once during wk -3, -2, -1 prepartum, at calving, and wk 1, 2, 3 and 6 postpartum. One sample was used for determination of serum glucose, urea N, total protein, albumin, creatinine, total bilirubin, aspartate aminotransferase (AST), creatine kinase, gamma-glutamyltransferase (GGT), Ca, P, Mg, Na, K, Cl, bicarbonate, and anion gap using a Bodhringer Mannheim/Hitachi 912 automated chemistry analyzer (Roche Laboratory Systems, Indianapolis, IN). Serum was separated from the second sample and analyzed for non-esterified fatty acids (NEFA) concentrations using an enzymatic procedure (Waco Chemicals USA, Inc., Richmond, VA). The NEFA method involved acylation of coenzyme A (CoA) by the fatty acids in the presence of added acyl-CoA synthetase. The acyl-CoA is oxidized by the addition of acyl-CoA oxidase to generate hydrogen peroxide, which in the presence of peroxidase permits the oxidative condensation of 3-methyl-N-ethyl-N(β -hydroxyethyl)-aniline (MEFA) with 4-aminoantipyrine to form a purple colored adduct, which can be measured colorimetrically at 550 nm. Blood ketone concentrations were determined using a Nova Max Ketone Strips and a Nova Max Plus reader (Nova Biomedical, Waltham, MA). Urine samples were collected at the same times for analyses for pH and electrolyte concentrations.

Data was analyzed using PROC MIXED procedures of SAS. The model included block, prepartum and postpartum treatment, week, and the appropriate interactions. Genetic merit (PTA of multiparous cows and ETA of springing heifers) was included as a covariate for production variables. Cow within treatment and block was included as a random effect and week as a repeated measure.

RESULTS AND DISCUSSION

The chemical composition of the experimental diets is presented in Table 2. Nutrient concentrations were similar for prepartum diets and postpartum diets except that Na concentrations were greater for NBC than CMA postpartum as expected. The DCAD [(Na + K) - (Cl + S)] of the diets was -4.54, -2.74, 35.49 and 14.96 meq/100g for CON, CMA prepartum, NBC, CMA postpartum, respectively.

Prepartum DMI was not different among treatments ($P = 0.6142$, $SE = 0.6$) for CON and CMA and averaged 11.9 and 12.2 kg/d, respectively. Postpartum DMI, milk yield, and composition are presented in Table 3. No differences among treatments were observed in DMI, milk yield, percentage of milk fat, protein and lactose. Milk protein yield ($P = 0.0453$) was higher for the cows fed CMA prepartum compared with CON, 1.09 and 1.02 kg/d respectively. Interactions of prepartum treatment and wk were observed for milk fat yield ($P = 0.0222$, Figure 1), ECM ($P = 0.0395$, Figure 2) and FCM ($P = 0.0290$, Figure 3) because of higher yields for cows fed CMA during wk 2 and 6 compared with CON. An interaction of prepartum treatment and wk ($P < 0.05$) was also observed for milk efficiency (ECM/DMI [Figure 4], FCM/DMI [Figure 5]) because of lower efficiencies for cows fed CMA during wk 1 and 4 compared with CON; however efficiencies tended to reverse and be slightly higher for CMA compared with CON during wk 6. Daily milk yield exhibited an interaction of postpartum treatment and DIM ($P = 0.0093$) as milk yield was higher for NBC compared with CMA during 28-31 DIM but was not different during 1-27 or 32-42 DIM (Figure 6). No differences were observed among treatments in BW throughout the trial (Figure 7).

Concentrations of select metabolites and minerals in serum and urine prepartum are presented in Table 4. Prepartum serum Na ($P = 0.0461$) increased from 142.55 to 143.32 meq/L, when fed with CON compared with CMA. Also prepartum urine pH ($P = 0.0910$) was higher for the cows fed CON compared with CMA, 7.35 and 7.00, respectively. No differences were observed in the other metabolites and minerals.

Concentrations of select metabolites and minerals in serum and urine of cows postpartum are presented in Table 5. Postpartum serum urea N ($P = 0.0148$) exhibited an interaction between prepartum and postpartum treatments, and was highest for CON-NBC, CMA-CMA, intermediate for CON-CMA, and lowest for CMA-NBC, 12.18, 11.70, 11.20 and 10.31 mg/dl, respectively. An interaction of prepartum and postpartum treatments ($P = 0.0005$) was also observed in

postpartum serum creatinine which was highest for CON-NBC, intermediate for CMA-CMA, and lowest for CMA-NBC and CON-CMA, 0.77, 0.77, 0.70 and 0.65 mg/dl, respectively. Postpartum serum Na ($P = 0.0154$) increased from 139.81 to 140.60 when fed NBC postpartum compared with CMA. An interaction of prepartum and postpartum treatments ($P = 0.0353$) was observed for urine Na concentration which was higher for CON-NBC and CMA-NBC, and lower for CON-CMA, CMA-CMA, 121.21, 105.43, 41.24 and 59.55 mmol/L, respectively. Postpartum urine K ($P = 0.0030$) was higher for the cows fed CMA postpartum compared with NBC, 155.60 and 118.40 mmol/L, respectively.

In the current trial, cows fed CMA prepartum had higher milk protein yield during 6 wk and higher yields of milk fat, ECM, FCM during wk 2 and 6 compared with CON. These improvements could be related to improved Ca status of cows fed CMA although total Ca concentrations were not different among treatments. It has been suggested that ionized Ca is a more reliable indicator than total blood calcium (Ballantine and Herbein, 1991; Dauth et al., 1984; Saccon et al., 1995). The availability of Ca in CMA is greater than other Ca supplements available (Taylor, personnel communication). The DMI of cows fed supplemental CMA prepartum was approximately 6% greater compared with CON. While not different, this small improvement would have provided additional nutrients which would have maintained a more positive energy balance prepartum. Additional research is needed to verify this.

Hu and Murphy (2004) conducted a meta-analysis of trials examining the response to increasing dietary DCAD concentrations and concluded that maximum DMI and milk yield occurred when DCAD (Na+K-Cl) increased to 34 and 40 meq/100 g DMI, respectively. Similar results were also reported by Wildman et al. (2007) when postpartum DCAD was increased from 14.2 to 38.7 meq/100g. In current trial, the inclusion of CMA postpartum was as effective as NBC for maintaining milk yield and composition even though diets containing CMA had lower DCAD compared with NBC, 15 and 35 meq/100g, respectively. Cruywagen et al. (2007) reported greater milk yield for cows fed CMA compared with sodium bicarbonate. Calitz (2009) also observed higher milk yield without any negative effects on milk composition for cows fed CMA. These authors attributed the improvements to the slow-release buffer effect and higher bio-availability of the Ca, which may explain the similar performance from CMA at lower DCAD level compared with NBC in our study.

Blood bicarbonate and mineral concentrations were not different among treatments except that Na was higher for cows fed CON prepartum and for cows fed NBC postpartum compared with those fed CMA. The reason for higher Na concentrations prepartum is not clear as dietary concentrations of Na were similar for both CON and CMA. The increased concentration of blood Na postpartum is related to the higher dietary concentration of Na for cows fed NBC compared with CMA, 0.78 and 0.33 % of DM, respectively. Urinary concentrations of Na were higher, however concentration of K postpartum were lower for cows fed NBC compared with CMA. Dietary concentrations of K were slightly higher for NBC compared with CMA, 1.46 and 1.38 % of DM, respectively. The increased concentration of K observed with CMA is not related to dietary concentrations or intake. As the kidneys work to maintain homeostatic conditions, it would appear that greater amounts of K were excreted than Na for CMA to maintain electrostatic balance. Urinary pH tended to be higher prepartum for cows fed CON compared with CMA, but no differences were observed postpartum. Hu and Murphy (2004) reported a linear increase in blood bicarbonate concentrations as DCAD increased although concentrations of Na and K were not altered. These authors also reported increased urinary excretion of Na and K as DCAD increased and proposed that the increased excretion prevented any increase in blood concentrations.

CONCLUSIONS

Feeding CMA prepartum did not alter prepartum DMI, but supported higher milk protein yield postpartum and supported higher yields of milk fat, ECM, and FCM during wk 2 and 6. Overall efficiency (ECM/DMI or FCM/DMI) was not different among treatments, but was greater for CON during wk 1 and 4 but tended to reverse trends after wk 4. Feeding CMA postpartum maintained similar intake, milk yield and composition as NBC. Blood and urine metabolite concentrations primarily reflected dietary mineral supplementation. The results of this trial indicate that feeding CMA prepartum has positive effects on postpartum performance. Based on the results from this trial and our previous research, CMA supports performance similar to that of NBC which suggest it provides adequate buffering.

REFERENCES

- AOAC. 2000. Official Methods of Analysis. 17th ed. Association of Official Analytical Chemists, Arlington, Va.
- Ballantine, H. T., and J. H. Herbein. 1991. Potentiometric determination of ionized and total calcium in blood plasma of Holstein and Jersey cows. *J. Dairy Sci.* 74:446-449.
- Block, E. 1984. Manipulating dietary anions and cations for prepartum dairy cows to reduce incidence of milk fever. *J. Dairy Sci.* 67:2939-2948.
- Calitz, T. 2009. The effect of acid Buf and combinations of Acid Buf and sodium bicarbonate in dairy cow diets on production response and rumen parameters. M. S. Thesis. Stellenbosch Univ., Matieland, South Africa.
- Cruywagen, C. W., S. J. Taylor, and M. M. Beya. 2007. The effect of buffering dairy cow diets with limestone, Acid Buf or sodium bicarbonate + limestone on production response and rumen parameters. *J. Dairy Sci.* 90 (Suppl. 1):561. (Abstr.)
- Curtis, C. R., H. N. Erb, C. J. Sniffen, R. D. Smith, P. A. Powers, M. C. Smith, M. E. White, R. B. Hillman, and E. J. Pearson. 1983. Association of parturient hypocalcemia with eight periparturient disorders in Holstein cows. *J. Am Vet Med Assoc.* 183:559-61.
- Curtis, C. R., H. N. Erb, C. J. Sniffen, R. D. Smith, and D. S. Kronfeld. 1985. Path analysis of dry period nutrition, postpartum metabolic and reproductive disorders, and mastitis in holstein cows¹. *J. Dairy Sci.* 68:2347-2360.
- Dauth, J., M. J. Dreyer, and J. P. de Coning. 1984. Ionized calcium versus total calcium in dairy cows. *J. S Afr Vet Assoc.* 55:71-2.
- Goff, J. P., R. L. Horst, F. J. Mueller, J. K. Miller, G. A. Kiess, and H. H. Dowlen. 1991. Addition of chloride to a prepartal diet high in cations increases 1, 25-dihydroxyvitamin D response to hypocalcemia preventing milk fever. *J. Dairy Sci.* 74:3863-3871.
- Hall, M. B. 2009. Analysis of starch, including maltooligosaccharides, in animal feeds: a comparison of methods and a recommended method for AOAC collaborative study. *JAOAC* 92: 42-49.
- Hu, W., and M. R. Murphy. 2004. Dietary cation-anion difference effects on performance and acid-base status of lactating dairy cows: a meta-analysis. *J. Dairy Sci.* 87:2222-2229.

- Oetzel, G. R., J. D. Olson, C. R. Curtis, and M. J. Fettman. 1988. Ammonium chloride and ammonium sulfate for prevention of parturient paresis in dairy cows. *J. Dairy Sci.* 71:3302-3309.
- Saccon, N., F. Agnes., S. Dominoni., and P. Camussone. 1995. Metabolic profile of dairy cows from the first fecundation to the peak of the second lactation. *Archivio-Veterinario-Italiano (Italy)*. 46: 49-56.
- Van Soest, P.J., J.B. Robertson, and B.A. Lewis. 1991. Methods for dietary Fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *J. Dairy Science* 74:3583-3597.
- West, J. W., B. G. Mullinix, and T. G. Sandifer. 1991. Changing dietary electrolyte balance for dairy cows in cool and hot environments. *J. Dairy Sci.* 74:1662-1674.
- West, J. W., K. D. Haydon, B. G. Mullinix, and T. G. Sandifer. 1992. Dietary cation-anion balance and cation source effects on production and acid-base status of heat-stressed cows¹. *J. Dairy Sci.* 75:2776-2786.
- Wildman, C. D., J. W. West, and J. K. Bernard. 2007. Effect of dietary cation-anion difference and dietary crude protein on milk yield, acid-base chemistry, and rumen fermentation. *J. Dairy Sci.* 90:4693-4700.

Table 1. Ingredient composition of experimental diets (% of DM).

Ingredient	Prepartum		Postpartum	
	CON ¹	CMA	NBC	CMA
Corn silage	39.32	39.32	41.25	41.25
Alfalfa hay	6.21	6.21		
Ryegrass baleage			5.38	5.38
Bermudagrass baleage	5.17	5.17	1.79	1.79
Ground corn	10.35	10.35	14.89	14.89
Cottonseed hulls ²	0.46	0.41		1.26
Citrus pulp	7.24	7.24	5.38	5.38
Soybean hulls	7.24	7.24	4.48	4.48
Brewers grains, wet	8.28	8.28	11.66	11.66
Megalac ³			1.35	1.35
Biochlor ⁴	5.59	5.59		
Soybean meal, 47.5% CP	6.21	6.21	4.93	4.93
AminoPlus ⁵			1.79	1.79
ProLak ⁶			3.14	3.14
Urea			0.18	0.18
Sodium bicarbonate ¹			1.26	
Magnesium oxide ¹	0.29	0.21	0.18	0.18
CMA ^{1,7}		0.46		0.39
Calcium carbonate ²	1.32	0.99	0.32	
Calcium monophosphate	0.21	0.21	0.18	0.18
Salt			0.63	0.63
Potassium carbonate ²			0.22	0.18
Potassium magnesium sulfate	0.21	0.21	0.09	0.09
Zinpro Availa-4 ⁸	0.08	0.08	0.04	0.04
Yeast culture	0.52	0.52	0.22	0.22
OmniGen-AF ⁹	0.52	0.52	0.22	0.22
Vitamin E, 20,000 IU/454 g	0.04	0.04	0.02	0.02
Monensin, 3 g/454g ¹⁰	0.54	0.54	0.23	0.23
Trace mineral – vitamin premix ¹¹	0.20	0.20	0.14	0.14

¹CON = control diet, CMA = supplemental calcareous marine algae, and NBC = supplemental sodium bicarbonate

²Ingredients were blended into a premix and added to mixer prior to feeding.

³Calcium salts of long chain fatty acids, Arm Hammer Animal Nutrition, Church & Dwight Co., Inc. Princeton, NY

⁴Feed supplement providing a source of dietary anions, Arm Hammer Animal Nutrition, Church & Dwight Co., Inc. Princeton, NY

⁵Ruminally protected soybean meal, Ag Processing, Inc. Omaha, NE

⁶Marine and animal rumen undegradable protein supplement, H. J. Baker & Bros., Inc. Westport, CT

⁷Calcareous marine algae, Calmin, Celtic Sea Minerals, Cork, Ireland

⁸Organic zinc, manganese, copper, and cobalt, Zinpro Corporation, Eden Prairie, MN.

⁹Immune stimulant, Prince Agri Products, Inc., Quincy, IL

¹⁰Rumensin, Elanco Animal Health, Indianapolis, IN.

¹¹Mineral-vitamin premix contained (DM basis):): 26.1% Ca; 0.38% Mg; 1.76% S; 144 ppm Co; 9,523 ppm Cu; 1,465 ppm Fe; 842 ppm I; 28,617 ppm Mn; 220 ppm Se; 25,343 ppm Zn; 4,210,830 IU/kg Vitamin A; 1,684,330 IU/kg Vitamin D; 21,045 IU/kg Vitamin E.

Table 2. Chemical composition of experimental diets fed prepartum and postpartum.

Ingredient	Prepartum		Postpartum	
	CON ¹	CMA	NBC	CMA
DM, %	43.8 ± 3.3	44.4 ± 3.3	39.5 ± 3.4	39.7 ± 3.3
	----- % of DM -----			
CP	16.5 ± 0.5	16.4 ± 0.5	17.0 ± 1.4	16.9 ± 1.3
ADF	24.3 ± 2.3	24.2 ± 3.3	25.0 ± 1.7	24.4 ± 2.5
NDF	41.2 ± 3.3	41.8 ± 3.2	42.5 ± 2.4	41.4 ± 3.1
NFC	32.0 ± 3.1	31.4 ± 2.7	27.3 ± 2.6	29.3 ± 3.1
Ash	7.5 ± 0.4	7.7 ± .03	8.9 ± 0.6	8.0 ± 0.5
Ca	1.08 ± 0.08	1.18 ± 0.10	0.87 ± 0.07	0.80 ± 0.11
P	0.41 ± 0.01	0.41 ± 0.01	0.48 ± 0.03	0.47 ± 0.02
Mg	0.41 ± 0.02	0.49 ± 0.03	0.35 ± 0.03	0.34 ± 0.03
K	1.27 ± 0.06	1.31 ± 0.10	1.46 ± 0.15	1.38 ± 0.17
S	0.36 ± 0.03	0.35 ± 0.03	0.24 ± 0.02	0.25 ± 0.04
Na	0.17 ± 0.06	0.18 ± 0.06	0.78 ± 0.10	0.33 ± 0.08
Cl	0.77 ± 0.05	0.78 ± 0.06	0.73 ± 0.09	0.67 ± 0.09
	----- meq/100g -----			
DCAD ²	-4.23	-2.43	35.79	15.23
DCAD ³	18.27	19.44	50.79	30.86

¹CON = control diet, CMA = supplemental calcareous marine algae, and NBC = supplemental sodium bicarbonate.

²Calculated as: meq(Na + K) - (Cl + S)

³Calculated as: meq(Na + K - Cl)

Table 3. Dry matter intake, performance of cows fed diets CON or CMA prepartum with NBC or CMA postpartum.

Prepartum	CON ¹	CMA	CON	CMA		<i>P</i>		
Postpartum	NBC	NBC	CMA	CMA	SE	Prepartum	Postpartum	Interaction
DMI, kg/d	18.0	19.8	19.4	20.0	0.9	0.1743	0.3526	0.4633
Milk, kg/d ^d	38.1	39.0	37.3	38.0	2.2	0.3585	0.3526	0.9864
Fat, %	4.02	3.96	4.01	4.24	0.25	0.7276	0.5884	0.5436
Fat, kg/d ^c	1.53	1.54	1.49	1.61	0.08	0.2918	0.3820	0.6223
Protein, %	2.71	2.85	2.71	2.81	0.08	0.1204	0.7763	0.7766
Protein, kg/d	1.03 ^b	1.11 ^a	1.00 ^b	1.07 ^a	0.04	0.0453	0.3754	0.5307
Lactose, %	4.75	4.74	4.75	4.72	0.04	0.6103	0.8849	0.7974
Lactose, kg/d	1.81	1.85	1.77	1.80	0.05	0.6625	0.8628	0.9323
SNF, %	8.37	8.38	8.41	8.37	0.08	0.8634	0.8755	0.7209
SNF, kg/d	3.19	3.27	3.12	3.18	0.09	0.6107	0.9795	0.9137
3.5% FCM, kg/d ^c	41.3	41.9	40.2	42.6	1.6	0.2733	0.6618	0.7540
ECM, kg/d ^c	40.2	41.3	39.1	41.5	1.4	0.1428	0.7925	0.8876
Efficiency								
FCM/DMI ^c	2.30	2.12	2.07	2.13	0.13	0.3335	0.5327	0.5564
ECM/DMI ^c	2.23	2.08	2.01	2.08	0.11	0.3262	0.4739	0.5176
MUN, mg/dl	11.20	10.07	9.95	10.49	0.55	0.5720	0.4342	0.1179

¹CON = control diet, CMA = supplemental calcareous marine alge, and NBC = supplemental sodium bicarbonate.

^{ab}Means in the same row with difference superscripts differ ($P < 0.05$).

^cInteraction of prepartum treatment and week ($P < 0.05$).

^dInteraction of postpartum treatment and day ($P < 0.05$).

Table 4. Concentrations of select metabolites and minerals in serum and urine of cows prepartum.

	Treatment		SE	<i>P</i>	
	CON ¹	CMA		Treatment	TRT x WK
Serum					
NEFA, meq/L	0.82	0.83	0.16	0.9723	0.4483
Ketone, mmol/ml	0.38	0.37	0.04	0.6943	0.4194
Total protein, g/dl	6.51	6.44	0.12	0.6648	0.4161
Albumin, g/dl	3.50	3.48	0.06	0.7730	0.7050
Globulin, g/dl	3.02	3.00	0.14	0.9112	0.4732
Albumin/Globulin	1.18	1.14	0.09	0.8640	0.7512
Urea N, mg/dl	13.92	13.51	0.45	0.4863	0.6603
Creatinine, mg/dl	0.90	0.91	0.03	0.8756	0.3939
BUN/Creatinine	15.94	15.43	0.72	0.5954	0.4170
Total billrubin, mg/dl	0.17	0.17	0.05	0.9374	0.4823
Glucose, mg/dl	73.09	74.60	3.29	0.7290	0.7612
AST, U/L	75.46	74.93	4.68	0.9308	0.3786
Creatinine kinase, U/L	210.79	189.92	33.57	0.7889	0.5909
GGT, IU/L	13.80	13.02	1.30	0.6444	0.4172
Ca, mg/dl	9.21	9.08	0.11	0.3109	0.6691
P, mg/dl	6.09	6.28	0.15	0.3083	0.2002
Mg, mg/dl	2.42	2.36	0.05	0.3612	0.3208
Na, meq/L	143.32	142.55	0.29	0.0461	0.8850
K, meq/L	4.64	4.70	0.06	0.4879	0.7388
Cl, meq/L	104.55	104.86	0.43	0.5838	0.4934
Bicarbonate, mmol/L	28.15	27.73	0.43	0.4535	0.7686
Anion gap, mmol/L	14.75	15.52	1.04	0.5017	0.7030
Urine					
pH	7.35	7.00	0.16	0.0910	0.9116
Na, mmol/L	38.25	25.30	5.97	0.1039	0.0732
K, mmol/L	144.91	137.86	11.49	0.6387	0.4605
Cl, mmol/L	125.40	127.00	10.58	0.9076	0.4766

¹CON = control diet and CMA = supplemental calcareous marine alge.

Table 5. Concentrations of select metabolites and minerals in serum and urine of cows postpartum.

Prepartum	CON ¹	CMA	CON	CMA	SE	<i>P</i>		
Postpartum	NBC	NBC	CMA	CMA		Prepartum	Postpartum	Interaction
Serum								
NEFA, meq/L	1.92	1.92	2.31	2.29	0.33	0.9755	0.2306	0.9826
Ketone, mmol/ml	0.60	0.63	0.75	0.74	0.18	0.9463	0.4423	0.8810
Total protein, g/dl	7.01	6.92	7.15	7.01	0.16	0.4601	0.4330	0.8530
Albumin, g/dl	3.71	3.55	3.61	3.56	0.06	0.1029	0.4515	0.3366
Globulin, g/dl	3.30	3.36	3.55	3.45	0.18	0.9201	0.3371	0.6342
Albumin/Globulin	1.16	1.09	1.03	1.05	0.06	0.6564	0.1586	0.4384
Urea N, mg/dl	12.18 ^a	10.31 ^b	11.20 ^{ab}	11.70 ^a	0.51	0.1923	0.6026	0.0148
Creatinine, mg/dl	0.77 ^a	0.70 ^{bc}	0.65 ^c	0.77 ^{ab}	0.03	0.3168	0.2696	0.0005
BUN/Creatinine	16.93	16.23	22.79	16.29	2.62	0.1516	0.2502	0.2431
Total billrubin, mg/dl	0.26	0.28	0.25	0.24	0.04	0.9345	0.6075	0.7688
Glucose, mg/dl	52.47	53.45	49.45	52.14	2.66	0.4727	0.3755	0.7510
AST, U/L	97.93	99.61	90.81	96.48	6.70	0.5676	0.4252	0.7546
Creatinine kinase, U/L	188.47	184.74	179.18	130.79	31.28	0.3875	0.2943	0.4574
GGT, IU/L	18.57	22.95	22.24	24.48	4.12	0.4030	0.5110	0.7848
Ca, mg/dl	9.53	9.38	9.41	9.37	0.10	0.3039	0.4873	0.6113
P, mg/dl	6.03	6.00	5.72	5.68	0.22	0.8953	0.1434	0.9815
Mg, mg/dl	2.37	2.36	2.43	2.36	0.04	0.3291	0.5566	0.5042
Na, meq/L	140.80	140.40	139.61	140.00	0.33	0.9981	0.0154	0.2120
K, meq/L	4.64	4.55	4.52	4.52	0.06	0.3626	0.1902	0.4343
Cl, meq/L	98.68	98.51	97.77	98.15	0.51	0.8297	0.1974	0.5681
Bicarbonate, mmol/L	29.18	29.13	29.10	29.18	0.57	0.9818	0.9803	0.9109
Anion gap, mmol/L	17.59	17.34	17.39	17.39	0.49	0.7868	0.8640	0.7867
Urine								
pH	8.04	8.01	7.97	8.03	0.07	0.8105	0.6097	0.4791
Na, mmol/L	121.21 ^a	105.43 ^a	41.24 ^b	59.55 ^b	8.27	0.8723	<0.0001	0.0353
K, mmol/L	122.66	114.13	159.51	151.68	12.39	0.4890	0.0030	0.9762
Cl, mmol/L	61.76	60.60	71.22	66.89	5.67	0.6128	0.1525	0.7699

¹CON = control diet, CMA = supplemental calcareous marine algae, and NBC = supplemental sodium bicarbonate.

^{abc}Means in the same row with different superscripts differ ($P < 0.05$).

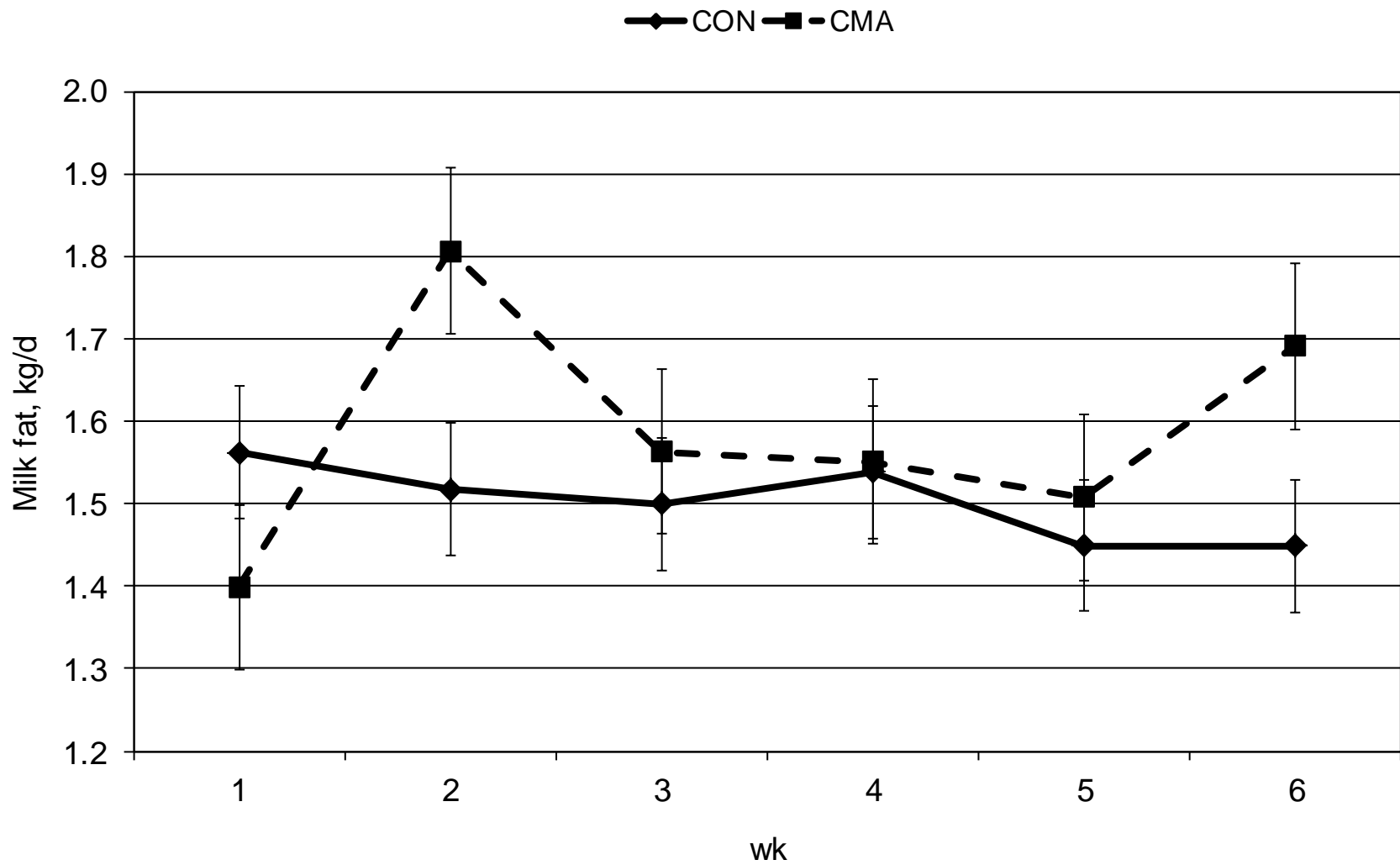


Figure 1. Interaction between prepartum treatments and weeks on milk fat yield. (CON = control and CMA = cows fed supplemental calcareous marine algae)

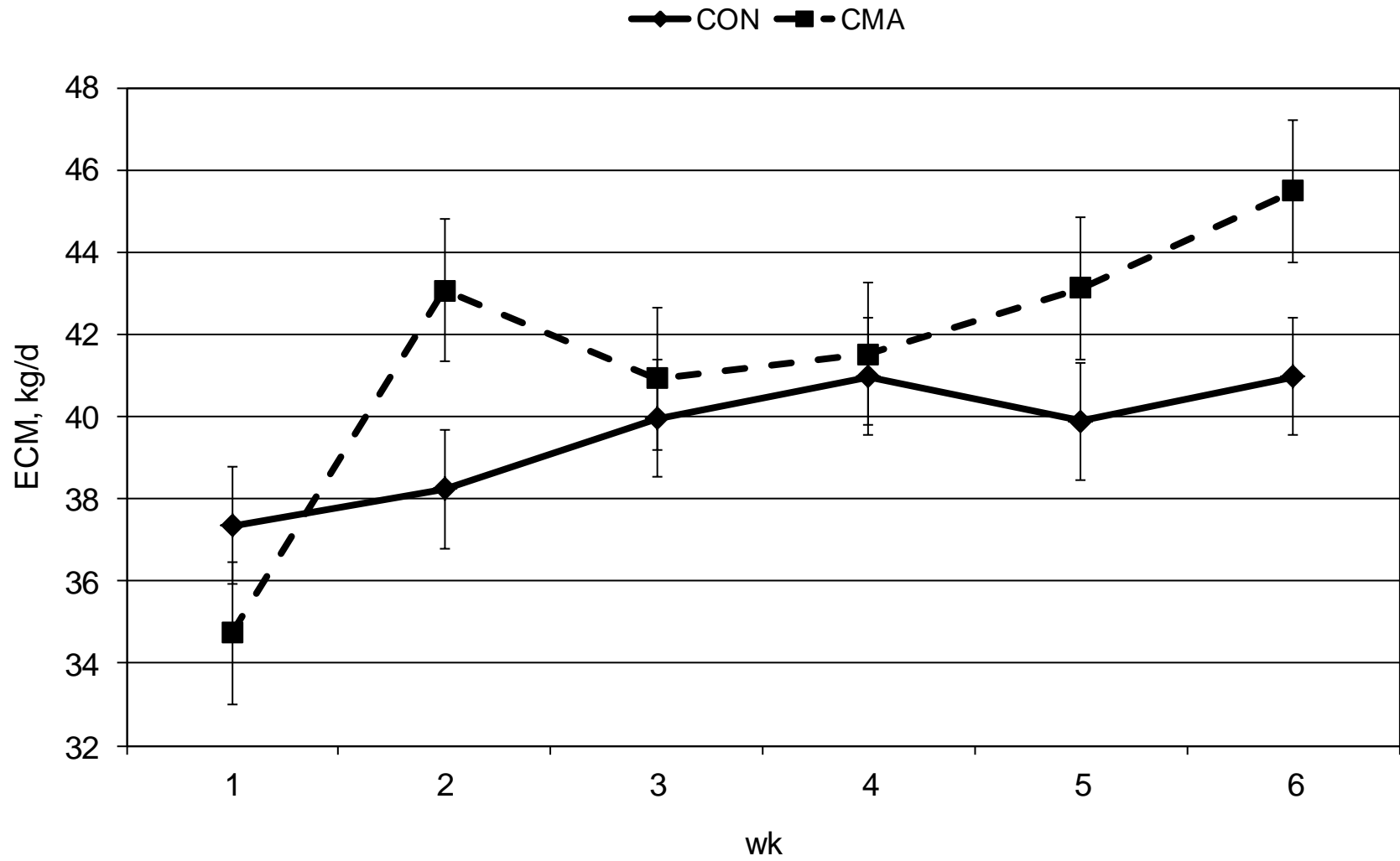


Figure 2. Interaction between prepartum treatments and weeks on energy corrected milk. (CON = control and CMA = cows fed supplemental calcareous marine algae)

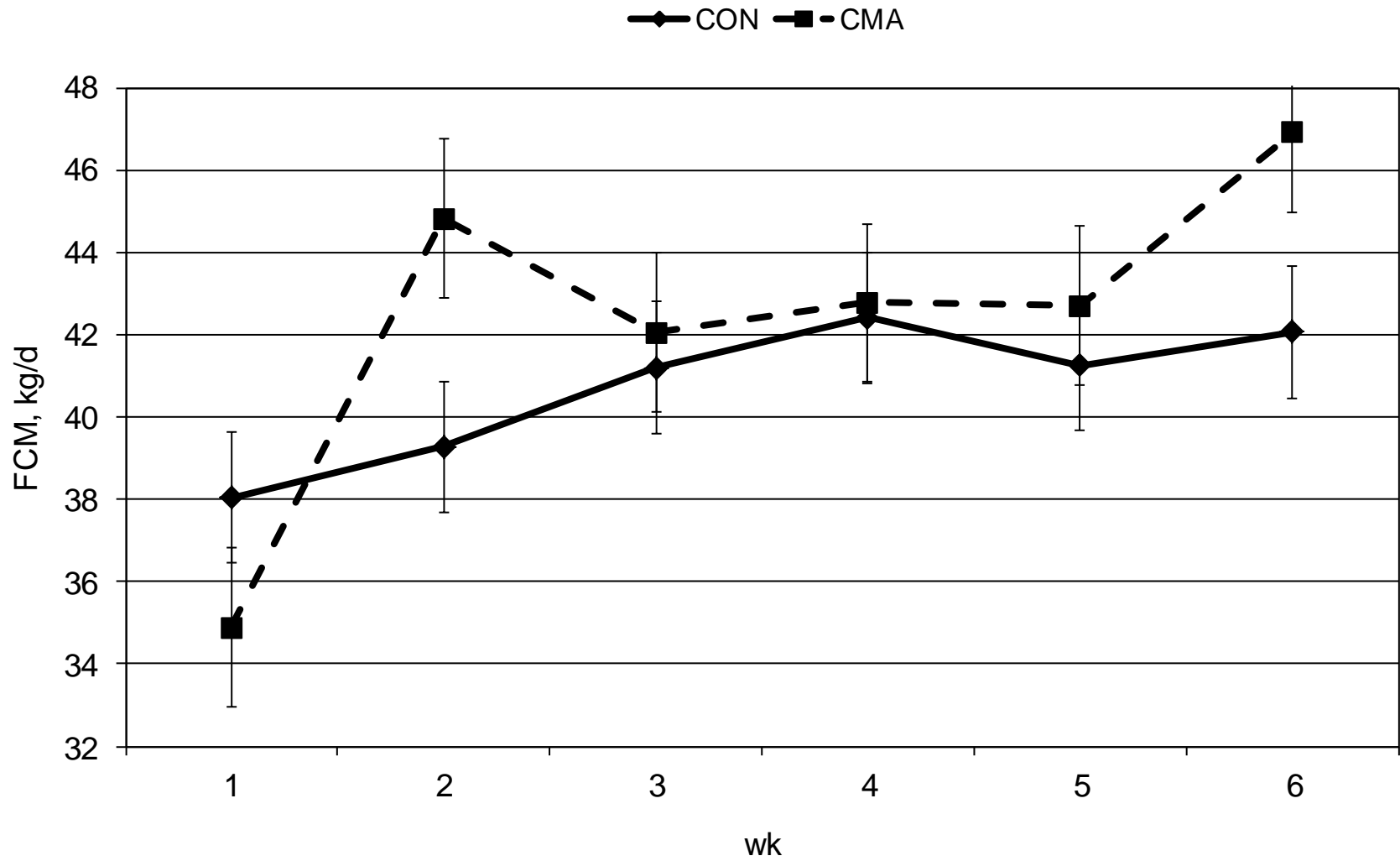


Figure 3. Interaction between prepartum treatments and weeks on fat corrected milk. (CON = control and CMA = cows fed supplemental calcareous marine algae)

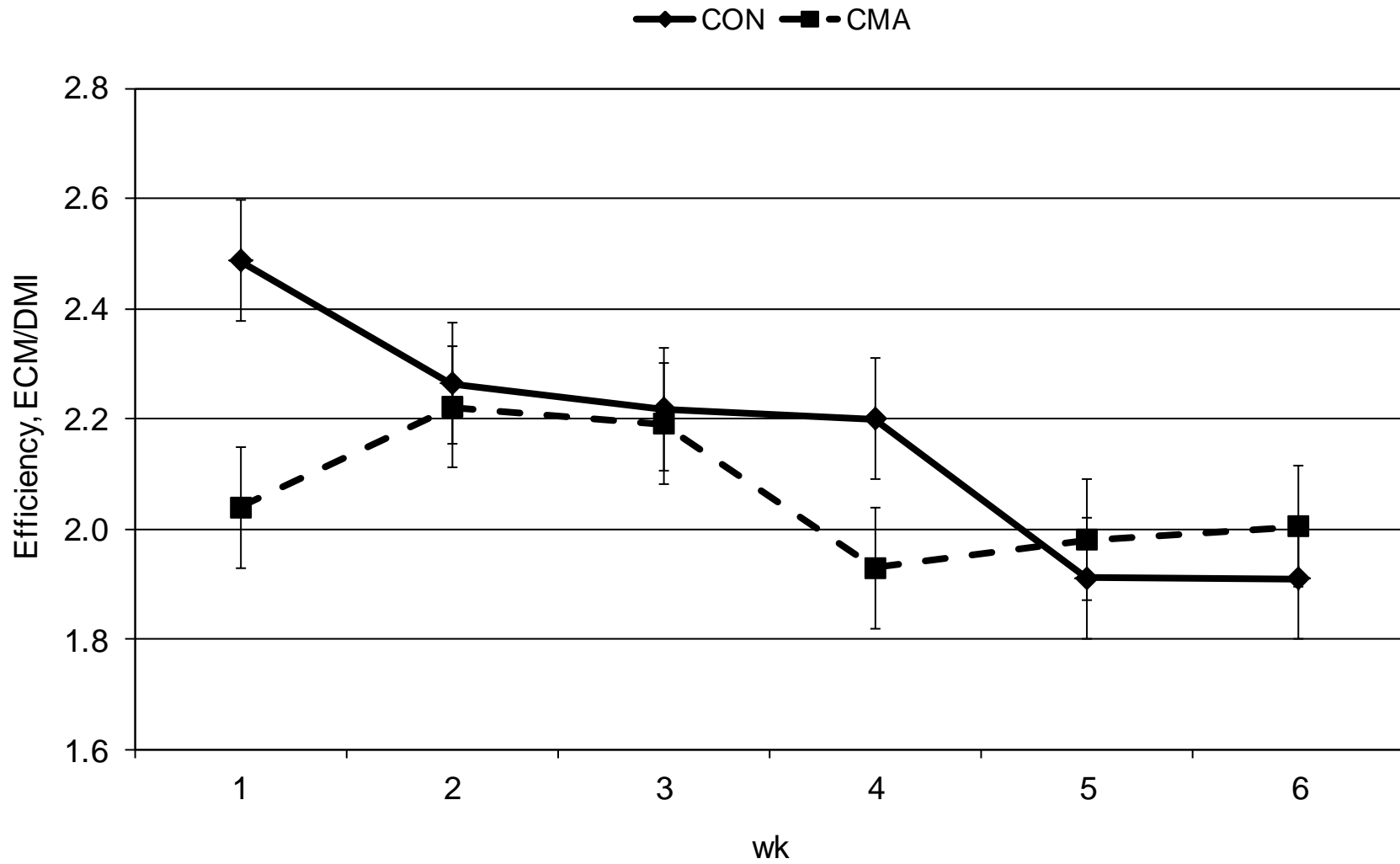


Figure 4. Interaction between prepartum treatments and weeks on milk efficiency¹, ECM/DMI. (CON = control and CMA = cows fed supplemental calcareous marine algae)

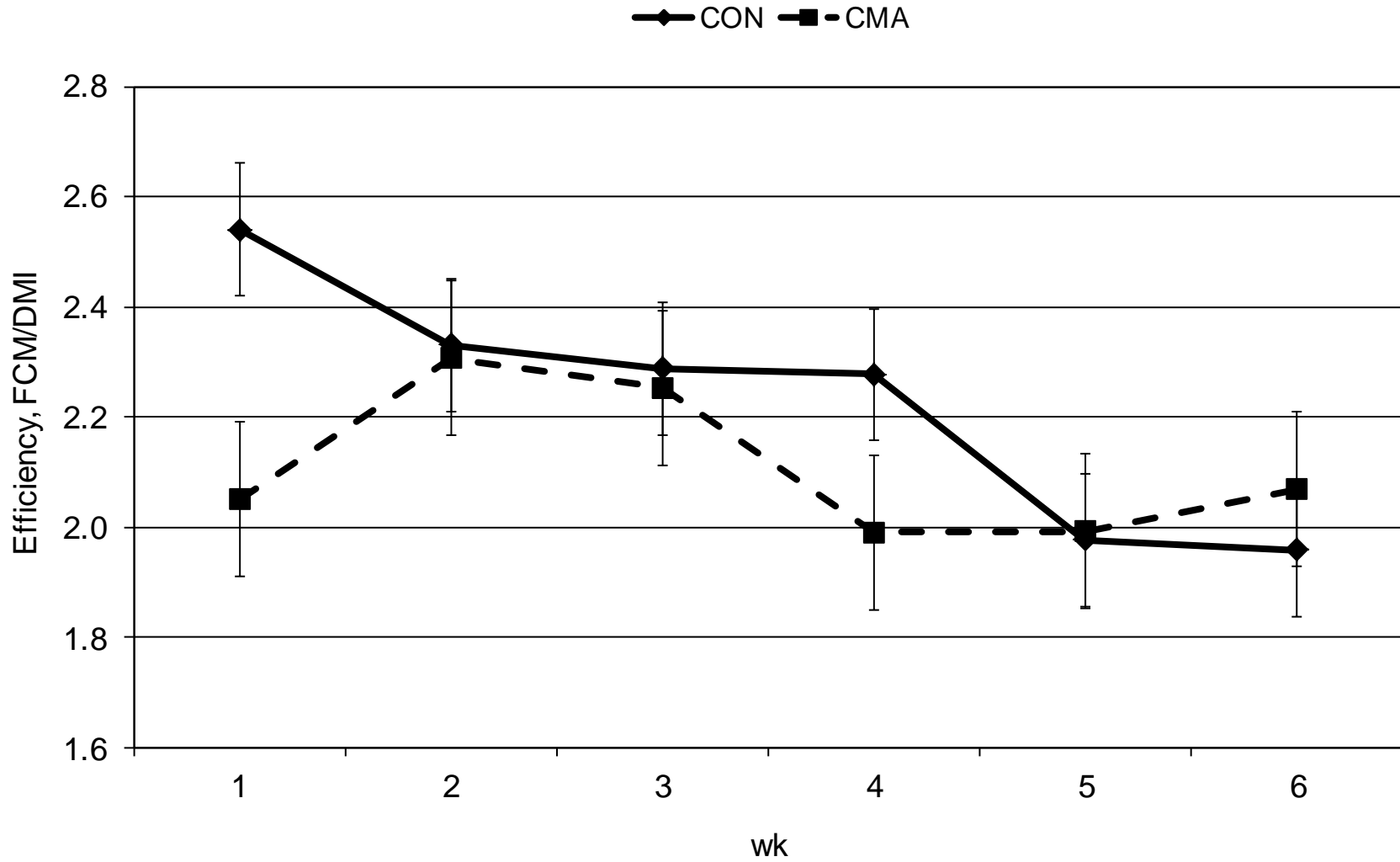


Figure 5. Interaction between prepartum treatments and weeks on milk efficiency, FCM/DMI. (CON = control and CMA = cows fed supplemental calcareous marine algae)

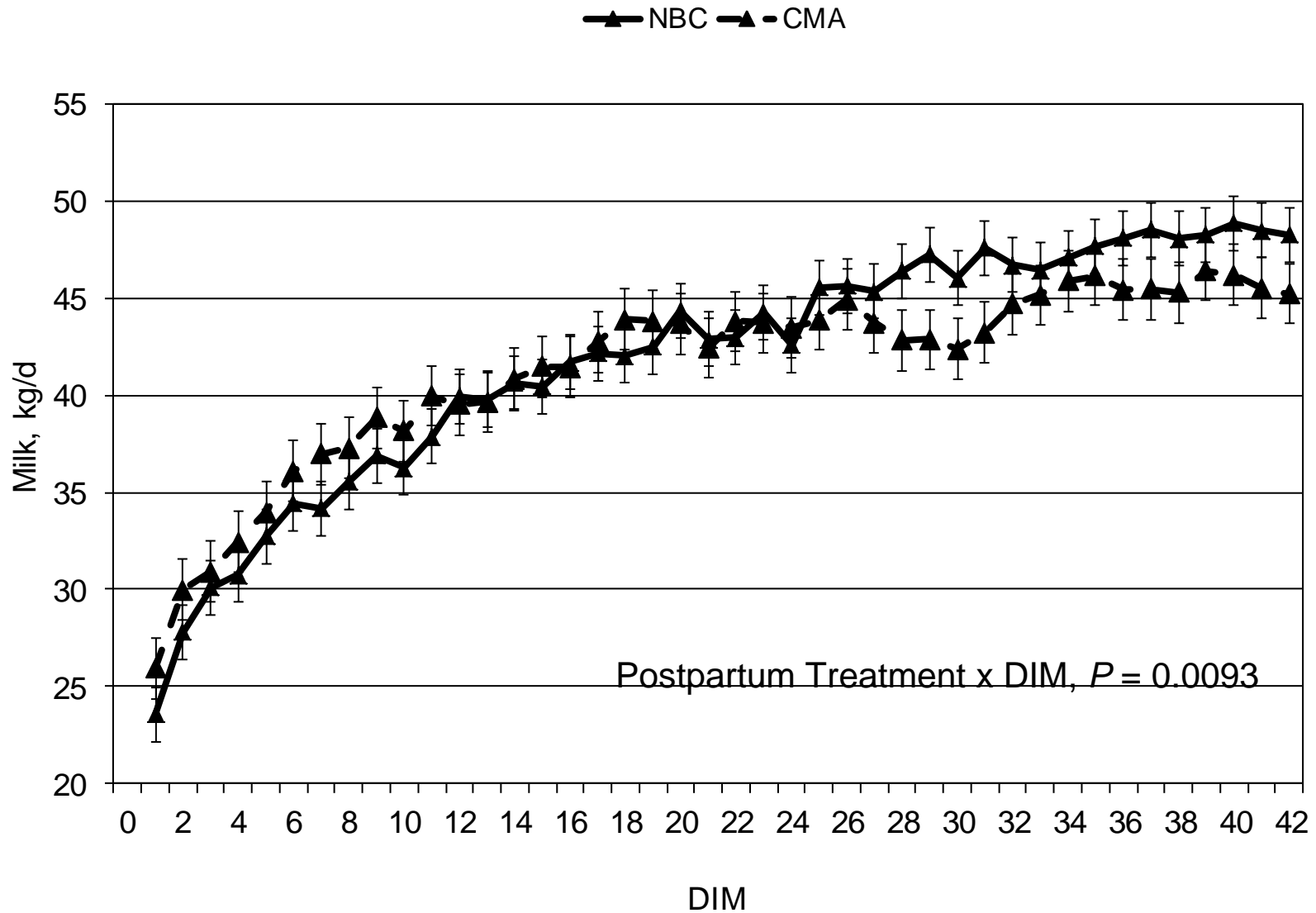


Figure 6. Interaction between milk yield and day. (CMA = cows fed supplemental calcareous marine algae and NBC = supplemental sodium bicarbonate)

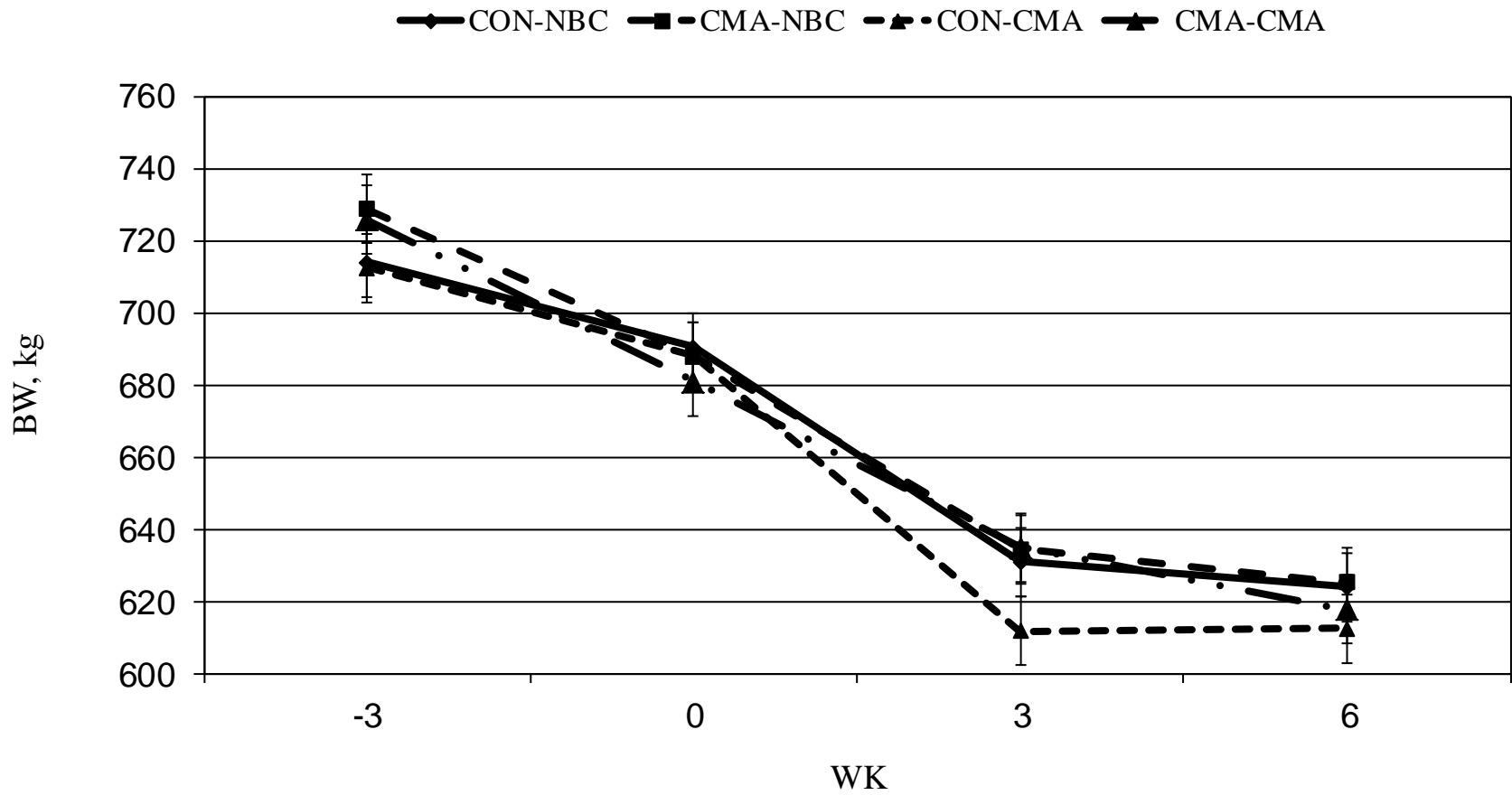


Figure 7. Body weight of cows during the trial (CON = no supplemental calcareous marine algae prepartum; CMA = supplemental calcareous marine algae prepartum or postpartum; or NBC = supplemental sodium bicarbonate postpartum).