Effects of oral vitamin E supplementation during late gestation in beef cattle that calved in late winter and late summer

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Objective—To determine effects of breed and oral vitamin E supplementation during late gestation on serum vitamin E and IgG concentrations in beef cows that calved in late winter and late summer and in neonatal calves.

Animals—73 Angus and 43 Hereford primiparous and multiparous cows and their calves.

Procedure—Cows in groups that were homogeneous regarding breed and age distribution were randomly allotted to groups that were orally supplemented (n = 59) or not supplemented (57) with vitamin E beginning 30 days prior to onset of 65-day calving seasons. Supplemental vitamin E was provided in a vitamin-mineral mix offered free-choice until parturition.

Results—Cows that calved in late winter and were supplemented orally with vitamin E had higher serum vitamin E concentrations at calving and after calving than did unsupplemented cows; differences between groups before calving were not significant. Calves from supplemented multiparous cows had higher vitamin E concentrations than did calves from unsupplemented cows. Winter-born calves from supplemented Hereford cows had heavier 205-day adjusted weaning weights than did winter-born calves from unsupplemented Hereford cows. Supplementation did not affect vitamin E or IgG concentrations in the herd that calved in late summer and did not affect calf growth.

Conclusions and Clinical Relevance—Oral vitamin E supplementation during late gestation may be economically beneficial in certain cow-calf operations in which late-gestation cows are consuming stored forages. (*Am J Vet Res* 2001;62:921–927)

Calves are born with physiologically low stores of vitamin E, a fat-soluble vitamin that crosses the bovine placenta in limited amounts.[1,2] Adequate vitamin E status is necessary for proper musculoskeletal development[3,4] and optimal immune system function.[5,6] Colostrum is the primary source of vitamin E for neonatal calves.[1,2] Producers may supplement neonatal calves with parenterally administered vitamin E in an attempt to improve vitamin E status. Less commonly, calves are given orally administered vitamin E, or cows are supplemented orally or parenterally during late gestation to increase colostral vitamin E content.

Harvested forages and dormant winter pastures typically contain less vitamin E than growing vegetative forages[7,8,a] and usually form most of the late gestation rations of beef cows that calve in late winter and early spring. Increased provision of vitamin E to cows during late gestation should increase vitamin E provision to newborn calves, because vitamin E is incorporated in colostrum during synthesis in late gestation,[9] and vitamin E concentration of colostrum is related to maternal intake.[10,11]

Results of studies of vitamin E supplementation in dairy cows in late gestation indicate enhanced immunity and performance,[12-17] whereas similar studies in beef cows have focused on effects in calves. The effects of vitamin E supplementation in pregnant beef cows vary among experiments. Parenteral administration of 3,000 units of vitamin E to crossbred beef cows approximately 1 month prior to parturition increases plasma vitamin E concentrations in calves and enhances their passive immune status.[18] However, Hayek et al[19] reported that treating beef cows with 1,000-unit injections of vitamin E approximately 2 weeks prepartum did not have an effect on either the passive immune status or serum vitamin E concentrations of the cows' calves. Weiss et al[20] determined that feeding 70 U of vitamin E/kg of diet (dry matter) during the dry period increases the colostral vitamin E content of Holstein cows, indicating the potential for oral vitamin E supplementation of the dam to increase vitamin E provision to the newborn calf. The purpose of the study reported here was to determine effects of breed and oral vitamin E supplementation during late gestation on serum vitamin E and IgG concentrations in beef cows that calved in late winter and late summer and in neonatal calves.

Materials and Methods

Study design—In trial 1, 58 Angus and 21 Hereford dams were allotted to groups that were homogeneous with respect to breed and age. Fifty-four dams were multiparous and between 3 and 9 years of age; 25 were nulliparous heifers. Members of homogeneous groups were randomly assigned to treatment and control groups approximately 1 month prior to the beginning of a 65-day calving season that extended from mid-January through March. A sorting error during establishment of the treatment and control groups resulted in 1 Angus heifer that was initially designated as a control cow being included with the treatment group for the duration of the study. The sorting error and uneven number

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of Hereford heifers involved in the study resulted in numerical differences between Angus and Herefords in the treatment and control groups of trial 1. The treatment group in trial 1 (n = 40) contained 19 and 7 multiparous Angus and Hereford dams and 11 and 3 nulliparous Angus and Hereford dams, respectively. The control group in trial 1 (n = 39) contained 19 and 9 multiparous Angus and Hereford dams and 9 and 2 nulliparous Angus and Hereford dams, respectively.

In trial 2, 37 beef dams that calved in late summer were allotted to groups that were homogeneous with respect to breed, age, and vitamin E concentrations in serum. Dams in each group were randomly assigned to treatment and control groups approximately 1 month prior to the beginning of a 65-day calving season that extended from late August through October. The study population comprised 15 Angus and 22 Herefords. Thirteen dams involved in the study were nulliparous heifers; all dams involved in the study were between 2 and 6 years of age, with the exception of an 11-year-old Angus cow. The treatment group in trial 2 (n = 19) contained 5 and 9 multiparous Angus and Hereford damsand 3 and 2 nulliparous Angus and Hereford dams, respectively. The control group in trial 2 (n = 18) contained 4 and 9 multiparous Angus and Hereford dams and 3 and 2 nulliparous Angus and Hereford dams, respectively.

For the purposes of this study, supplemental vitamin E refers to *dl*-α-tocopheryl acetate from a commercial premix,[b] which was added to a vitamin-mineral mix[c] offered free-choice. Cattle in the treatment group of each trial were provided supplemental vitamin E beginning 1 month prior to the start of the calving season and ending at parturition.

Vitamin-mineral mix provision and intake were monitored 2 to 3 times/wk. The concentration of vitamin E in the vitamin-mineral mix of the treatment groups was adjusted weekly, using the mean per head per day consumption rate of the previous week. This consumption rate served as the expected mean consumption for the forthcoming week. Samples of the vitamin-mineral mix with added vitamin E were analyzed to ensure agreement between calculated and actual vitamin E concentrations. Provision of supplemental vitamin E to treatment groups ceased at parturition; however, all cows still had free-choice access to the base vitamin-mineral mix.

In trial 1, dams consumed a grass hay-based ration during late gestation until 1 to 2 weeks prior to parturition, at which time corn silage was added to the ration. Vegetative pasture was provided ad libitum as the major component of the brood cow rations during provision of supplemental vitamin E in trial 2.

Each hay source was sampled by coring 10 to 12 randomly selected bales. The core samples from each lot were mixed and sealed in plastic bags after removing as much air as possible. Exposure of samples to direct sunlight was prevented at all times during collection. Samples were placed in dark brown plastic bags and frozen at –20 C until analysis.

Corn silage was sampled immediately after being unloaded from a concrete stave silo and placed in a feed bunk. Samples were taken randomly from 6 to 8 locations along the length of the bunk, mixed, and a subsample was taken for analysis. Exposure of samples to direct sunlight was prevented at all times during collection. Subsamples were sealed in plastic bags after removing as much air as possible, placed in dark brown plastic bags, and frozen at –20 C until analysis.

Samples were taken from each pasture involved in the study by walking an extended W-shaped pattern and randomly collecting pasture at 2 points along each leg of the W. Twenty-five to 30 collection points were used for each pasture. The forage was thoroughly mixed, and a subsample was taken for analysis. Subsamples were sealed in plastic bags after removing as much air as possible, placed in dark brown plastic bags, and frozen at –20 C until analysis.

Representative samples of forages fed during the study were analyzed for vitamin E content by use of **high-pressure liquid chromatography (HPLC)**. In an attempt to minimize any potential pasture effects, treatment and control groups within each trial were alternated between 2 pastures on a biweekly basis so that each group spent an equal amount of time on each of 2 respective pastures used during the supplementation phase of the experiment. The vitamin-mineral mix offered free-choice to all cattle contained 30 mg of Se/kg (as-fed basis).

Dams were moved to small pastures 1 to 2 weeks prior to their anticipated parturition dates so they could be more closely observed in the periparturient period. Dams and their calves were placed in maternity stalls shortly after parturition and typically remained there for 2 to 3 days to ensure calf well-being. Calves were allowed to nurse their dams, and colostrum intake was not monitored. After leaving the maternity stalls, all dams and calves from each trial were returned to pasture, managed, and fed as a single herd.

Sample collection and analysis—Blood samples were collected via coccygeal venipuncture 3 times from each dam after vitamin E supplementation began, as follows: approximately 1 to 2 weeks prior to calving, within 6 hours after calving, and 2 to 3 days after calving. A single blood sample was collected from each calf 24 to 48 hours after birth via jugular venipuncture. All blood samples were collected into evacuated glass tubes without additives.[d] Blood samples were allowed to clot for 30 to 60 minutes, centrifuged, and the serum from each sample was harvested and frozen at –20 C until analysis.

Colostral samples were obtained from each dam within 6 hours of calving for determination of vitamin E and IgG concentrations. For each dam, a teat (or teats) was wiped clean, stripped 3 to 4 times, and 20 to 30 ml of colostrum was collected in a sterile resealable polyethylene bag.[e] Presuckle colostral samples were desired and were successfully obtained from 83 dams (55 in trial 1 and 28 in trial 2). All colostral and serum samples were stored frozen at –20 C until the time of analysis.

Blood and colostral samples were placed in a covered cardboard box immediately after collection and kept out of direct sunlight to reduce exposure to ambient light and prevent radiant heating. Samples were maintained at 15 to 23 C between the time of collection and return to the laboratory. Blood samples from which serum was obtained were allowed to clot for 30 to 60 minutes in the covered cardboard box at room temperature (20 C) prior to centrifugation for serum collection. All serum and colostral samples were frozen in dark brown plastic bags during storage.

Calves in both trials were weighed at birth and again at weaning (late August for trial 1, late March for trial 2) to determine 205-day **adjusted weaning weights (AWW)**. Mean age of calves at weaning was 204 days. All calf weights were obtained by use of platform scales. Adjusted weaning weights were calculated, using the formula devised by the Beef Improvement Federation, and included standard adjustment factors for age of dam and calf sex.[21]

Serum vitamin E concentrations were determined by use of HPLC.[f] Colostral vitamin E concentrations were also determined by use of HPLC, although sample composition necessitated modification of the vitamin E extraction method.[f] Briefly, colostrum (500 mg) was diluted with 3 ml of HPLC-grade ethanol and vortexed. Three milliliters of HPLC-grade cyclohexane was added, and the sample was vortexed again. Samples were centrifuged for 10 minutes at 3,064 × g. The cyclohexane layer was removed, and the extraction procedure was repeated twice. The final volume of

cyclohexane was evaporated, the residue was reconstituted with 100 µl of cyclohexane, and the sample was placed on the HPLC instrument for analysis.

Serum and colostral IgG concentrations were determined via a **single radial immunodiffusion (SRID)** technique,[f] using a commercial kit.[g] Colostrum samples were allowed to thaw at room temperature (20 to 23 C). Each thawed sample was vortexed for 30 to 40 seconds. Colostrum (500 µl) was diluted with 1,500 µl of sterile saline (0.9% NaCl) solution.

Bovine IgG reference standards and diluted colostrum were added (3 µl) to wells in an agarose gel plate that contained anti-bovine IgG.[g] Plates were incubated for 18 to 22 hours before reading ring diameters of standards and samples.

Statistical analyses—Data from all trials were analyzed by use of commercially available statistical software.[h] The model for trial 1 included treatment, breed, parity, and all 2-way interactions. The model for trial 2 included treatment, breed, parity, and all interactions. Age in each trial was divided into 2 categories: nulliparous dams were categorized as heifers and multiparous dams as cows. Significant 2-way interactions were evaluated in each trial, using the SLICE option[22] to compare means of 1 factor within each level of the other factor. Significance was set at $P \leq 0.05$. Results are expressed as least squares mean ± SEM, unless otherwise indicated.

Results

Trial 1—Hay fed during mid- and late gestation contained a mean of 6.7 mg of vitamin E/kg (100% dry matter basis). Hay and corn silage fed during the last 10 to 16 days of gestation and first 2 to 3 days after calving (the periparturient period) contained 13.7 mg and 5.9 mg of vitamin E/kg (100% dry matter basis), respectively. On the basis of the concentrations of vitamin E in forage, all cattle in trial 1 consumed an estimated mean of 200 and 322 Uof vitamin E /head per day in the basal late gestation and periparturient rations, respectively. This estimation included vitamin E (approx 15 to 25 U/head per day) provided by the vitamin-mineral mix that was offered free-choice to all cattle. Dams in the treatment group of trial 1, therefore, consumed an estimated mean of 1,200 and 1,322 U of vitamin E/head per day in their late gestation and periparturient rations, respectively (basal rations plus 1,000 U/head per day supplemental vitamin E). All dams involved in trial 1 consumed a mean of 2.3 mg of Se/head per day for the duration of supplemental vitamin E provision.

Two calves were born dead, which reduced the sample size used to evaluate calf serum vitamin E and IgG concentrations by 2 observations. The sample size for analysis of 205-day AWW was further reduced because of the death of 1 calf at 3 days of age and the sale of 6 cow-calf pairs prior to weaning. The 205-day AWW analysis in trial 1 ultimately included 38 treatment- and 32 control-group calves.

Dams that received supplemental vitamin E (treatment) had significantly greater concentrations of serum vitamin E at calving and after calving than did unsupplemented dams; difference between groups before calving approached significance (**Table 1**). In trial 1, least squares mean ± SEM colostral vitamin E concentrations in control and treated dams were 11.3 ± 1.7 and 14.5 ± 2.2 mg/ml, respectively ($P = 0.36$). Colostral IgG concentrations in control and treated dams were 79.0 ± 4.3 and 79.6 ± 3.9 g/L, respectively ($P = 0.92$). Calves from treated multiparous cows had higher concentrations of serum vitamin E at 24 to 48 hours of age (1.9 ± 0.2 mg/ml) than did calves from untreated multiparous cows (1.5 ± 0.1 mg/ml; $P = 0.02$); values in calves from nulliparous heifers were not significantly different between groups (control-group calves, 1.7 ± 0.2 µg/ml; treatment-group calves, 1.5 ± 0.2 µg/ml; $P = 0.6$). Treatment did not affect serum IgG concentrations of 24- to 48-hour-old calves (19.6 ± 1.6 and 23.1 ± 1.6 g/L for the control and treatment groups, respectively; $P = 0.23$). Calves from treated Hereford dams had heavier 205-day AWW (242.3 ± 7.3 kg) than did calves from control Hereford dams (209.3 ± 4.8 kg; $P = 0.005$). The 205-day AWW of calves from treated Angus dams (247.8 ± 4.5 kg) was not significantly different from that of calves from Angus control dams (245.5 ± 5.5 kg; $P = 0.74$)

Angus dams had higher serum concentrations of vitamin E than Hereford dams at calving and after calving (**Table 2**). Before calving, the difference between Angus and Hereford dams approached significance ($P = 0.07$). The difference between Angus calves and Hereford calves for serum vitamin E at 24 to 48 hours of age also approached significance ($P = 0.08$).

Multiparous cows had higher concentrations of serum vitamin E than did primiparous heifers before calving (4.7 ± 0.2 vs 3.9 ± 0.2 µg/ml; $P = 0.04$), but heifers produced colostrum with significantly ($P < 0.001$) greater IgG concentration (92.3 ± 5.8 g/L) than did cows (66.3 ± 2.9 g/L).

Trial 2—One Angus cow did not calve, and 3 Hereford dams had twins from which samples were not obtained. One calf died at 7 days of age because of septicemia that developed after omphalitis. In addition, 5 cow-calf pairs were sold by consignment prior to weaning. Because of these occurrences, the 205-day AWW

Table 1—Serum vitamin E concentrations (µg/ml) determined during the periparturient period in beef cattle that calved during late winter and received oral supplementation with vitamin E (mean, 1,000 U/d; trial 1) or calved during late summer and received oral supplementation with vitamin E (600 U/d; trial 2). Control cattle were not supplemented

	Trial 1*			Trial 2†		
Sample period	**Control**	**Treatment**	***P***	**Control**	**Treatment**	***P***
1–2 weeks before parturition	3.9 ± 0.1	4.6 ± 0.3	0.07	6.3 ± 0.3 (18)	5.9 ± 0.4 (19)	0.42
Parturition	3.2 ± 0.1	4.3 ± 0.2	< 0.001	4.3 ± 0.2 (17)	4.8 ± 0.3 (18)	0.26
2–3 days after parturition	3.0 ± 0.1	3.6 ± 0.2	0.01	3.4 ± 0.2 (17)	3.8 ± 0.3 (17)	0.36

*Values are least squares means ± SEM of 39 and 40 observations for the control and treatment groups, respectively.
†Values are least squares means ± SEM of (n) observations for control and treatment groups, respectively.

Table 2—Serum vitamin E concentrations (μg/ml) determined during the periparturient period in beef cattle that calved during late winter and their calves (trial 1) and beef cattle that calved during late summer and their calves (trial 2)

	Trial 1*			Trial 2†		
Sample period	**Angus**	**Hereford**	***P***	**Angus**	**Hereford**	***P***
1–2 weeks before parturition	4.6 ± 0.2	3.9 ± 0.2	0.07	6.4 ± 0.3	5.8 ± 0.2	0.28
Parturition	4.2 ± 0.2	3.3 ± 0.2	0.01	4.9 ± 0.3	4.3 ± 0.2	0.17
2–3 days after parturition	3.6 ± 0.1	3.0 ± 0.2	0.01	4.0 ± 0.4	3.2 ± 0.2	0.07
Calves (24–48 h)	1.8 ± 0.1	1.5 ± 0.1	0.08	2.4 ± 0.3	1.3 ± 0.1	0.007

*Values are least squares means ± SEM of 58 and 21 observations for the Angus and Hereford dams, respectively, and 56 and 21 observations for the Angus and Hereford calves, respectively. †Values are least squares means ± SEM of 14 and 20 observations for the Angus and Hereford dams, respectively, and 14 and 19 observations for the Angus and Hereford calves, respectively.

analysis in trial 2 ultimately included 16 treatments and 11 control group calves. Pastures contained a mean of 1.7 mg of α-tocopherol/kg (100% dry matter basis).

Mean serum concentrations of vitamin E did not differ between treatment and control groups approximately 4 weeks prior to the beginning of supplementation (6.2 ± 0.3 and 6.4 ± 0.2 μg/ml, respectively; $P = 0.62$). Cattle in the treatment group consumed a mean of 600 U of supplemental vitamin E/head per day until parturition. Total vitamin E intake was not estimated as pasture intake was not verified with markers. Cattle in the treatment and control groups consumed a mean of 3.0 mg of supplemental Se/d during late gestation.

Supplementation with vitamin E did not result in significant differences between groups for serum vitamin E concentrations of dams before calving, at calving, or after calving (Table 1). Treatment did not result in group differences for colostral concentrations of vitamin E (treatment group, 15.4 ± 2.7 mg/ml; control group, 16.8 ± 2.8 μg/ml; $P = 0.73$) or IgG (treatment group, 89.9 ± 9.6 g/L; control group, 117.4 ± 12.7 g/L; $P = 0.14$). Treatment also did not result in significant group differences for serum concentrations of vitamin E (treatment group, 2.1 ± 0.2 mg/ml; control group, 1.6 ± 0.2 μg/ml) or IgG (treatment group, 26.4 ± 2.6 g/L; control group, 22.6 ± 3.1 g/L) in of 24- to 48-hour-old calves or their 205-day AWW (treatment group, 214.7 ± 11.2 kg; control group, 227.4 ± 12.9 kg).

At 24 to 48 hours of age, Angus calves had higher concentrations of vitamin E than did Hereford calves (Table 2). Likewise, serum IgG concentrations were higher in Angus calves at 24 to 48 hours of age than Hereford calves (Angus 31.4 + 2.6 g/L: Hereford 17.6 + 2.5 g/L; $P = 0.006$).

Discussion

In trial 1, beef dams that were given supplemental vitamin E in a free-choice vitamin-mineral mix during late gestation had higher serum vitamin E concentrations than did control dams at parturition and after parturition. Calves from supplemented multiparous cows in trial 1 had higher concentrations of serum vitamin E than did calves born to unsupplemented multiparous cows. These results are similar to those reported by Zobell et al[23] in 134 crossbred beef cows. Cows in that study were fed 1,000 U of vitamin E/head per day for the last 60 to 100 days of gestation. Supplemented cows had higher serum vitamin E concentrations before parturition and at parturition, higher colostral vitamin E concentrations, and their calves had higher serum vitamin E concentrations at 24 to 48 hours of age. The study reported by Zobell et al[23] was conducted during the fall and winter in Alberta, Canada; however, feed sources were not reported.

Mean concentrations of vitamin E in the serum of dams from trial 2 were consistently higher than for dams in trial 1 at all sampling times in treated and control groups. This difference was attributed to ad libitum consumption of vegetative pasture by the dams in trial 2, as reported elsewhere.[24-26] Mean serum concentrations of vitamin E in prepartum dams in trial 2 were similar to those reported for nonlactating dairy cattle fed pasture during the dry period.[24]

In trial 1, calves from treated multiparous cows had higher serum vitamin E concentrations than did calves from treated nulliparous heifers. This difference may have resulted from greater colostrum production by cows, because cows and heifers had similar concentrations of colostral vitamin E. Other factors that possibly contributed to this treatment × parity interaction include differences in the calves' vitamin E absorption,[7] serum lipoprotein concentration,[27,28] or vitamin E concentration within lipoprotein particles.[28]

Serum vitamin E concentrations in supplemented trial-1 cattle were greater at parturition and after parturition than in control cattle, whereas similar differences between groups were not detected in trial-2 cattle. Cattle in trial 1 consumed only harvested forage during provision of supplemental vitamin E, whereas cattle in trial 2 grazed vegetative pasture and are presumed to have had greater total intake of vitamin E,[24-26] although the analyzed concentrations of α-tocopherol in the pasture vegetation were quite low, compared with published values.[24-26] We believe our values were erroneous values and resulted from incomplete α-tocopherol extraction during sample preparation for analysis[29-31] or α-tocopherol degradation during storage of the samples before analysis. Furthermore, the consistently higher concentrations of serum vitamin E for dams in trial 2 support the hypothesis that they received more vitamin E than did the dams in trial 1 and that lack of differences between groups in trial 2 were attributable to these higher vitamin E concentrations.

There is no true tissue reservoir for vitamin E, whereas the liver may function as a storage depot for

vitamin A.[7] Attainment and maintenance of optimal vitamin E concentrations within the body are, therefore, dependent on consistent and adequate vitamin E intake[32] such as by ad libitum consumption of vegetative forage.[24,a] After vitamin E intake, tissue demand, and body concentrations attain homeostasis, supplemental vitamin E may not affect concentrations of vitamin E in serum or colostrum unless consumed in amounts much greater than those provided in the basal diet. Charmley et al[32] fed pregnant crossbred beef heifers 0, 1,000, 2,000, and 4,000 U of supplemental vitamin E/d for 21 days (basal dietary concentrations of vitamin E were not reported); heifers supplemented with vitamin E had higher concentrations of serum vitamin E than did unsupplemented heifers, but the response to supplementation appeared to plateau with the 1,000-unit treatment.

Other researchers have reported that cattle respond in a dose-dependent manner to total consumed vitamin E. Quigley and Bernard[33] reported a dose-dependent increase in serum vitamin E concentrations in neonatal dairy calves fed (mean values) 11, 111, and 1,011 U of vitamin E/d.[33] Weiss et al[34] reported higher concentrations of vitamin E in serum of periparturient dairy cows consuming 4,905 U of vitamin E/d than in serum of cattle consuming 940 or 1,900 U/d.[34] In another study,[20] dairy cows consuming 1,474 U/d during the dry period had higher concentrations of serum vitamin E at calving than did those consuming 574 U/d.[20] Garber et al[35] reported a linear dose-dependent increase in serum vitamin E concentrations of crossbred yearling beef steers fed 166, 465, 972, and 1,753 U/d for 112 days.

Approximately a 2-fold increase in the amount of ingested vitamin E appears necessary to increase concentrations of serum vitamin E in cattle. In dairy cattle, dose-dependent increases in serum vitamin E concentrations have been reported when the total amount of vitamin E fed is increased at least 2.5-fold.[20,33,34] In beef steers, dose-dependent increases in serum vitamin E concentration have been reported when the total amount of vitamin E fed is increased 1.8-fold.[35] In our study, increased serum concentrations of vitamin E in treated cattle in trial 1 were associated with at least an estimated 4-fold increase in the total amount of vitamin E consumed. Because supplementation did not affect serum vitamin E concentrations in trial 2, it is possible that the amount of supplemental vitamin E, relative to the basal amount in the pasture-based diet, was insufficient to induce differences between supplemented and unsupplemented cattle for the measured variables.

In trial 1, calves from treated Hereford dams had heavier 205-day AWW than did calves from control Hereford dams. Oral vitamin E supplementation has facilitated increased weight gain after weaning in dairy[5] and beef calves.[i,j] However, to our knowledge, a preweaning growth response in calves as a result of maternal vitamin E supplementation during late gestation has not been published previously.

Weaning weight and maternal milk production are highly correlated.[36-39] The heavier 205-day AWW of Hereford calves from treated dams in trial 1 may have, therefore, resulted from increased milk production. Lacetera et al[40] reported that administering 5 mg of sodium selenite and 25 U of *dl*-α-tocopherol acetate/100 kg of body weight to Holstein cows 3 and 1.5 weeks prior to calving increased colostral production by 22% and milk production during the first 12 weeks of lactation by 10%. Because vitamin E and Se have similar biological functions,[7,41] vitamin E supplementation may have increased milk production by the treated Hereford dams in trial 1 as Se and vitamin E supplementation did in the study by Lacetera et al.[40] Hereford cattle in both trials had lower vitamin E concentrations in serum than did Angus cattle; thus, they may have been most responsive to vitamin E supplementation and potential increases in milk production.

Colostral IgG concentrations were not affected by oral vitamin E supplementation in either trial of our study, which was in agreement with another study in which yearling heifers were fed either 400 or 800 U of vitamin E/d, beginning 36 days prior to calving.[k] Neither level of vitamin E supplementation affected colostral IgG concentrations, compared with a control group.[k]

Oral vitamin E supplementation of dams did not affect serum IgG concentrations of calves in either trial, a finding in agreement with others.[23,k] Conversely, a 46.7% increase in serum IgG concentrations in 36- to 40 hour-old calves from cows treated parenterally with 3,000 units of vitamin E approximately 1 month before calving has been reported, although this increase was not significant.[18] This increase could possibly be attributed to parenteral supplementation, although parenteral supplementation was used in a different study[19] in which differences between calves from supplemented (1,000 units, 2 weeks before parturition) and unsupplemented cows was not detected. The difference in responses to injected vitamin E may have been dose-dependent or related to the vaccine that was given concurrently with vitamin E to the cows in the former study.[18]

Breed-related differences in serum vitamin E concentrations were observed in both trials. Angus dams in trial 1 had higher concentrations of serum vitamin E than Hereford dams at precalving, calving, and postcalving. Angus calves had higher concentrations of vitamin E in serum than Hereford calves at 24 to 48 hours of age in trial 2. In trial 2, Angus dams had higher concentrations of vitamin E in serum 2 to 3 days after calving than did Hereford dams and also higher concentrations of colostral vitamin E. High concentrations of serum lipoproteins[27,28] and high degrees of vitamin E saturation of lipoprotein particles[20] increase circulating concentrations of vitamin E. One explanation for our findings may be that Angus cattle have higher serum lipoprotein concentration and vitamin E saturation than do Hereford cattle, although this has not been reported to the authors' knowledge. Breed-related differences in tissue concentrations of trace minerals have been reported for cattle.[42,43] Garber et al[35] reported differences in serum vitamin E concentrations between vitamin E-supplemented beef and dairy steers, and Charmley et al[32] suggested a breed-related difference between nonlactating dairy cows and pregnant cross-

bred beef heifers.[32]

Our results suggest that supplemental vitamin E during late gestation influenced the vitamin E status of dams that calved in late winter (trial 1) to a greater extent than in dams that calved in late summer (trial 2), likely because of high vitamin E content in the pasture-based summer diet. The heavier 205-day AWW attained by calves from treated Hereford cows in trial 1 indicates that economic benefits may result from maternal vitamin E supplementation (approx 1,000 U/head per day) during late gestation in certain production scenarios. However, oral vitamin E supplementation at the rate of 600 U/head per day beginning 1 month prior to the onset of the calving season does not appear justified in pregnant beef cattle that are primarily consuming fresh vegetative forages.

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