Selenium improves weight gain of beef calves

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Death from white muscle disease (WMD) is the most widely recognized and clearly defined result of selenium (Se) and/or vitamin E deficiency in young calves and lambs in California. Reduced weight gain from the same deficiency may cause equal or greater economic loss, but this loss is much less spectacular and more difficult to detect and measure. Animals suffer from the deficiency in California—particularly in the northern half of the state—but the exact distribution on a county-by-county basis is not known. In general, forage with less than .03 to .04 ppm Se causes selenium-responsive disease in cattle.

Although WMD and reduced weight gains are commonly treated with injections of a combination of Se and vitamin E (since vitamin E reduces the requirement for Se by keeping Se in a usable form, and Se reduces the vitamin E requirement by helping animals retain it), research in Oregon, New Zealand, and California indicates that vitamin E may not always be necessary for treatment to improve weight gains substantially in Se-deficient areas. Supplemental Se feeding is widely practiced in other parts of the world, but the U.S. Food and Drug Administration has not approved the practice for cattle in the United States.

The objective of these studies was to determine the effects of injections of selenium, vitamin E, and combinations of the two on post-weaning weight gains of beef calves raised in Se-deficient areas.

Field trials

Fourteen field trials involving 510 calves were completed between 1974 and 1977 on two ranches in Shasta County at 3,500- to 4,000-foot elevations. Because of the relationship of selenium deficiency to volcanic soils, the test area, being near Mt. Lassen (which last erupted in 1914-15), was particularly appropriate. Trials 1 through 6 were on ranch H; trails 7 through 14 were on ranch R. Experimental animals were Angus and Hereford weaner bulls, heifers, and steers, randomly assigned to treatment groups, individually identified and weighed, and ranging in weight from 350 to 550 pounds.

Treatments and materials used were:

1. Control
2. Selenium: sodium selenite solution containing 5 mg Se per ml
3. Vitamin E: solution containing 50 mg vitamin E per ml
4. Selenium and vitamin E: materials 2 and 3 above, injected separately
5. Selenium and vitamin E: a commercial preparation containing 5 mg Se and 50 mg vitamin E per ml
6. Selenium and vitamin E: a commercial preparation containing 1 mg Se and 50 mg vitamin E per ml
7. Selenium and vitamin E: materials 2 and 6 above, injected separately
8. Selenium, vitamin E, vitamin A, and vitamin D: a combination containing 5 mg Se, 50 mg vitamin E, 50,000 units vitamin

TABLE 1. Weight Gains in Trials with Control Groups

Trial no. and feed[1]	No. days	Treatment: Materials	Treatment: Day(s) administered	Gain/head: Total (lbs)	Gain/head: Lb/day	Gain improvement over controls (%)
1 = hay	77	control		59	.77a	
		12.5 mg Se + 125 mg E	1	94	1.22b****	58
		12.5 mg Se + 125 mg E	1,40	93	1.21b****	57
2 = hay + grain supplement early in trial	77	control		105	1.37a	
		12.5 mg Se + 125 mg E	1	133	1.73b****	26
		12.5 mg Se + 125 mg E	1, 40	129	1.67b****	22
3[2] = hay + <1 lb/head/da liquid supplement	112	control		43	.39a	
		10 mg Se	1	65	.58b*	49
		100 mg E	1	40	.36a	-8
		10 mg Se + 500 mg E	1	60	.53b*	36
6 = hay	49	control		57	1.17a	
		10 mg Se + 100 mg E	1	78	1.60b****	37
7 = hay + alfalfa-oat supplement	112	control		136	1.21a	
		12.5 mg Se	1	201	1.79c*	48
		100 mg E	1	166	1.48b*	22
		12.5 mg Se + 100 mg E	1	197	1.76c*	45
8 = hay	112	control		112	1.00a	
		10 mg Se, 100 mg E, 100,000 units A, 10,000 units D	1	154	1.38b***	38
		12.5 mg Se + 125 mg E	68			
10 = hay	123	control		91	.74a	
		10 mg Se	1	145	1.18b	59
		100 mg E	1	73	.59a	-20
		10 mg Se + 100 mg E	1	128	1.04b**	41
13 = hay + 1-2 lb concentrate/head/da + home-grown alfalfa grass and corn silage	159	control		185	1.16a	
		10 mg Se	1	215	1.35b**	16
		10 mg Se	117			
		5 mg Se + 250 mg E	1	238	1.50b**	29
		5 mg Se + 250 mg E	32			
		10 mg Se + 500 mg E	117			

[1]Hay was raised on the ranch; supplements were from non-ranch sources.
[2]All calves in trial 3 received 4 mg Se + 200 mg E 100 days prior to the trial start.
*P≤.05
**P≤.01
***P≤.005
****P≤.001
a,b,c Gains with different superscripts in each trial are significantly different as analyzed by Duncan's multiple range test.

A, and 5,000 units vitamin D per ml, used by itself or with added vitamin E

The general objective was to supply approximately 5 mg selenium per 200 pounds body weight—with vitamin E rates varying in different trials—but because of varying weights, the selenium treatment was not consistent among animals. (Treatment details are shown in tables 1 and 2).

The materials were administered by subcutaneous injection in the shoulder and neck region. Animals were weighed at the start and finish and periodically throughout the trials. Limited analyses of blood and feed samples for Se were provided by Oregon State University on a cooperative basis.

The feeding regime was typical for weaner calves wintered in the area. The diet was either all hay or hay plus limited supplements. The hay was raised on the ranch where each trial was conducted and was either alfalfa-grass or meadow hay. The hay was chopped on Ranch H and was fed long on Ranch R. Feeding was ad lib once a day.

It is common practice on both ranches to treat calves at birth or shortly thereafter with 2 to 3 mg Se and 100 to 150 mg vitamin E. Before this practice was initiated, death from WMD was a common occurrence in very young calves.

In all eight trials using a control group there was significant weight gain response to treatment with selenium alone and/or selenium-vitamin E combinations (table 1). In trials 3, 7, 10, and 13 selenium alone was compared with selenium-vitamin E combinations, and there were no significant differences in weight-gain reponse between the two treatments. A difference between Se and Se + E weight gains in trial 13, although not significant, was noted; but review of herd performance records indicates that the random assignment of calves to treatment groups as they came down the chute resulted in a greater number of inherently better performers in the Se + E group than in the Se group.

Vitamin E alone was administered in trials 3, 7, and 10. In trial 7 weight gain response to this treatment was significantly greater than that for the control group, but significantly less than that for the Se and Se + E treatments. In trials 10 and 3 the vitamin E groups gained less than the controls, although the difference was not significant, and gained significantly less than the Se and Se + E groups.

The remaining six trials (see table 2), where no control group was used, compared materials, dosages, or timing of treatment. Because there was a significant response to Se or Se + E in every case where a control group was used, it was felt that cattle in these six trials—under the same feed and management conditions as the other eight trails—would respond to selenium treatment. Every trial without control animals was run concurrently with a trial with control animals in which significant responses to selenium treatment were measured. Therefore, weight gains in Se-deficient calves in the six trials were considered to be responses to Se or Se + E treatment.

Four of these trials compared selenium treatment with selenium and vitamin E combinations. There were no significant differences in gain between the two treatments.

The addition of vitamins A, D, and E to selenium in one trial was of no benefit.

TABLE 2. Weight Gains in Trials without Control Groups

Trial No.	No. Days	Treatment: Materials	Treatment: Days(s)[1] administered	Gain per head: Total (lbs)	Gain per head: Lbs. per day
4[2]	112	10 mg Se	1	119	1.06
		10 mg Se + 500 mg E	1	116	1.03
		10 mg Se + 500 mg E + 100,000 units A + 10,000 units D	1	104	.92
5	58	10 mg Se	1	68	1.17
		10 mg Se	-91, 1	88	1.51
		10 mg Se + 100 mg E	-91, 1	77	1.33
9	86	10 mg Se + 100 mg E	1	90	1.05
		10 mg Se + 500 mg E	1	100	1.16
11	119	10 mg Se	1	213	1.79
		15 mg Se + 150 mg E	+91		
		10 mg Se + 100 mg E	1	219	1.84
		15 mg Se + 150 mg E	+91		
12	181	10 mg Se	1	282	1.56
		10 mg Se	1	281	1.55
		15 mg Se	+125		
		10 mg Se + 100 mg E	1	276	1.52
		15 mg Se + 150 mg E	+125		
14	159	10 mg Se	1	258	1.62a
		10 mg Se	1	295	1.85b*
		10 mg Se	+117		
		5 mg Se + 250 mg E	1	254	1.60a
		5 mg Se + 250 mg E	+96		

[1] Day 1 = trial start; minus = days before trial start; plus = days after trial start.
[2] All calves in trial 4 received 4 mg Se + 200 mg E 100 days before trial start.
a, b Gains with different superscripts are significantly different at P≤.05.

TABLE 3. Weight Gains of Single- and Double-Treated Calves — Trial 14

Group	Treatment	Gain per head, lbs: First 117 days*	Gain per head, lbs: Next 42 days*	Gain per head, lbs: Total 159 days†
1	10 mg Se day 1	201a	57a	258a
2	10 mg Se day 1 and day 117	202a	93b	295b
3	5 mg Se + 250 mg E day 1 and day 96	172a	79c	254a

*Significant at P≤.001.
†Significant at P≤.05

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A comparison of 100 mg E to 500 mg E, both with selenium, showed no difference in response.

Length of effectiveness

How long selenium treatment remains effective in this area is unknown. Retreatment after 40 days was of no advantage in one trial; and retreatment after 91 days in another trial produced no statistically significant difference 58 days later, even though gains increased slightly. Observations and incomplete post-trial weight and gain records indicated effectiveness disappeared between 100 and 130 days after treatment. With this time frame in mind, trial 12 was established to investigate retreatment after 125 days. There was no significant difference in gain resulting from retreatment after 125 days in a 181-day trial. This result was unexpected and is unexplained.

Similar calves on the same ranch were placed on another study of treatment intervals the following year (trial 14). Here, there was a significant difference from retreatment after 117 days with 10 mg (see table 3).

Two doses of 5 mg Se each (group 3) produced the same results as a single dose of 10 mg (group 1) given at the trial start for the total period, even though gains of group 3 were during the last 42 days.

Se deficiency

Blood samples taken from calves in trial 10, 94 days and 123 days after treatment, were analyzed for selenium. All of the control and vitamin E-treated heifers were below .04 ppm 94 days into the trial, and 10 of the 17 selenium-treated heifers were below .04 ppm. After 123 days, all selenium-treated calves but one were below .04 ppm. It appears that blood selenium levels were in a critical range by 94 days post-treatment.

Only one sample of hay fed during the trials was analyzed. This was from hay grown on ranch R and used for trials 7 and 8. The analysis showed less than .01 ppm selenium, .02 to .03 ppm less than levels low enough to cause selenium-responsive disease.

There were no visible symptoms by which one could consistently diagnose selenium deficiency. However, the calves in trial 10 showed considerable diarrhea at the start of the trial. The diarrhea gradually cleared up without treatment, but cleared up much more rapidly in the calves treated with selenium.

Conclusions

1. Treatment with Se produced significant increases in weight gain over controls. Improvements ranged from 16 percent to 59 percent, with an average of 43 percent on a trial-by-trial basis.
2. Addition of vitamin E to Se treatment produced no significant increase in weight gain over Se alone.
3. Addition of a combination of vitamins A, D, and E to Se treatment did not produce a significant increase in gain over Se alone.
4. Treatment with vitamin E alone produced a significant increase in gain over controls in one of three comparisons, but the increase was significantly less than that produced by Se treatments.
5. The reasons for the variation in the length of effectiveness of treatment are still unknown.

A simple, rapid, inexpensive method to diagnose Se deficiency is needed.

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