Feed Additives for Beef Cattle

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New products have complicated cattle feeding and management. A multitude of feed additives are available to add to cattle rations. These compounds generally do not supply essential nutrients to the cattle. Instead, they are designed to increase growth rate and/or improve the efficiency of growth through manipulating rumen fermentation or through controlling liver abscesses, digestive disorders, bloat, coccidiosis, and other conditions.

One point of confusion for many is at what point of inclusion does a nutritional supplement become a feed additive. Nutrient supplements are fed to supply essential nutrition. Once this level is grossly exceeded, the product is no longer a supplement and should be classified as an additive. Feeding levels of trace minerals or vitamins that exceed levels necessary to compensate for unavoidable low intakes is considered an extra label use by FDA and is therefore illegal.

Feed additives can be generally divided into six broad categories: 1) ionophores, 2) antibiotics, 3) coccidiostats, 4) estrus suppressants, 5) buffers, and 6) others. Each feed additive has its own properties, recommended level of feeding, and label clearances. A thorough understanding of these characteristics is necessary to achieve optimum response and maximum cost effectiveness.

The objective of this paper is to provide a basis for understanding the use and limitations of feed additives. Nonnutritive additives as well as vitamins and minerals are discussed in this paper.

Ionophores

Ionophores are a type of antibiotic that inhibit or depress the growth of specific rumen microorganisms. Rumen fermentation is altered in three ways:

1. The ratio of volatile fatty acids produced is altered, reducing energy losses and improving efficiency of energy ultimation during ruminal fermentation of feed.
2. The breakdown of feed protein may be reduced, thus improving protein utilization by growing cattle fed high-roughage diets.
3. The incidence of acidosis, grain bloat, and coccidiosis is reduced, resulting in less stress and improving the well-being and performance of cattle.

Monensin, lasalocid, laidlomycin, salinomycin, and narasin are five of more than 75 known ionophores. Only monensin (Rumensin®) and lasalocid (Bovatec®) are approved for beef cattle. Laidlomycin (Cattlyst®) is expected to be approved by spring of 1994. Monensin and lasalocid are approved coccidiostats in cattle.

Monensin

Monensin is marketed by Elanco Products Company, a division of Eli Lilly and Company under the trade name Rumensin®. Its label claim includes improved feed efficiency for beef cattle fed in confinement for slaughter, improved feed efficiency in beef cows, improved daily gain by cattle on pasture, and improved daily gain by replacement dairy and beef heifers. Rumensin is very toxic to swine and horses. Rumensin can be fed with tylosin (Tylan®) and melengestrol acetate (MGA®) and may be included in both liquid or dry supplements.

Lasalocid

Lasalocid is marketed by Roche Animal Health under the trade name Bovatec® for improved feed efficiency and rate of gain by beef cattle fed in confinement for slaughter and for improved rate of gain for cattle on pasture or replacement dairy or beef heifers. It is not cleared for use in cows and is not safe for horses and swine. Bovatec can be fed with either melengestrol acetate (MGA®) or oxytetracycline (Terramycin®) but not both simultaneously. Bovatec® may be included in both liquid or dry supplements.

Laidlomycin

Laidlomycin will be marketed by Syntex Animal Health under the trade name of Cattlyst®.

Antibiotics

Antibiotics are fed to feedlot cattle to control liver abscesses, as an aid in the prevention and treatment of bacterial scours, for the prevention and treatment of shipping fever, and to increase rate of gain and improve feed efficiency. Antibiotics approved by the FDA to add to cattle rations include chlortetracycline, oxytetracycline, bacitracin, and tylosin.

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Table 1. Approved antibiotics for beef cattle.

Antibiotic	Trade name	Dosage	Withdrawal	Indications for use
Chlortetracycline	Aureomycin Chlorachel Chloratel CLTC CTC	.1 mg/lb BW/day .5 mg/lb BW/day 70 mg/head/day 100 mg/head/day 350 mg/head/day	 48 hours	Calves weighing up to 250 lb. Milk replacers and starter feeds. Growth promotion and feed efficiency. Aid in prevention of bacterial diarrhea. Growth promotion and feed efficiency. Aid in the prevention of liver abscesses. Beef cattle weighing up to 700 lb: aid in reduction o bacterial diarrhea. Aid in prevention of foot rot. Beef cattle weighing over 700 lb: Aid in reduction of bacterial diarrhea. Aid in prevention of foot rot. Beef cattle: Aid in prevention of bacterial pneumonia and shipping fever (hemorrhagic septicemia). Aid in reduction of losses due to respiratory infection (infectious rhinotracheitis, shipping fever complex).
Chlortetracycline and sulfamethazine	AS-700	350 mg/head/day 350 mg/head/day	7 days 7 days	Feed for 28 days as an aid in maintenance of weight gains in the presence of respiratory disease such as shipping fever.
Oxytetracycline	Terramycin Oxtc	.05-.1 mg/lb BW/day .5 mg/lb BW/day .5 mg-5 mg/lb BW/day 25-75 mg/head/day	5 days 5 days	Calves (0-12 weeks). To increase rate of weight gain and improve feed efficiency. Calf starter feeds and milk replacers. An aid in the prevention of bacterial diarrhea. An aid in the treatment of bacterial diarrhea. Calves. To increase rate of weight gain and improve feed efficiency.
Oxytetracycline	Terramycin Oxtc	.05-.1 mg/lb BW/day .5 mg/lb BW/day .5 mg-5 mg/lb BW/day 25-75 mg/head/day 50 g/ton 100 g/ton 75 mg/head/day .5-2.0 g/head/day	5 days 5 days 5 days at 2 g level	Calves (0-12 weeks). To increase rate of weight gain and improve feed efficiency. Calf starter feeds and milk replacers. An aid in the prevention of bacterial diarrhea. An aid in the treatment of bacterial diarrhea. Calves. To increase rate of weight gain and improve feed efficiency. Calves. As an aid in the prevention of bacterial diarrhea. Calves. As an aid in the treatment of bacterial diarrhea. Finishing cattle. to increase weight gain and improve feed efficiency. As an aid in reducing incidence and severity of liver abscesses. For the prevention and treatment of the early stages of shipping fever complex.
Bacitracin	A.L. zinc bacitracin Baciferm Zinc bacitracin premix Zinc basitracin	70 mg/head/day or 250 mg/head/day (5 continuous days out of every 30) 35-70 mg/head/day		Feedlot beef cattle. Reduction in number of liver condemnations due to abscesses. Growing beef cattle. Increased rate of weight gain and improved feed efficiency.
Tylosin	Tylan	8-10 g/ton or 60-90 mg/head/day		For reduction in incidence of liver abscesses.

Only tylosin is approved for use in combination with monensin and/or MGA. Only oxytetracycline is approved for use in combination with lasalocid. Chlortetracycline can be used in combination with sulfamethazine. No other combinations involving antibiotics for cattle have been approved by FDA. Intermittent feeding of antibiotics for a short time while other feed additives are removed from the ration avoids

label restrictions associated with combined use of antibiotics. Often cattle fed 1 g/head daily for 3 out of 28 days or 400 mg/head daily for 7 out of 28 days perform the same as cattle fed antibiotics on a continuous basis.

Table 1, adapted from the Feed Additive Compendium shows trade names, dosages, intended usage, and withdrawal information for the various antibiotics.

Rust (1992) reviewed the literature concerning antibiotic use in cattle rations. Tables 2 through 5 are from that review. Table 2 shows the impact of feeding 2 g oxytetracycline per head daily for 14 days. Daily gain was improved in two out of the three studies by an average of 4%. Feed to gain ratio appears to have not been affected. Morbidity was reduced 48% in one of the studies.

Table 2. Effects of oxytetracycline on weight gain and health of newly received cattle.

		ADG, lb/d		Feed/gain		Morbidity, %	
		Control	OTC[a]	Control	OTC	Control	OTC
California	1973	1.75	1.72	2.8	2.8	84.0	44.0
Washington	1984	3.10	3.34	4.2	4.1	12.5	12.5
South Dakota	1986	2.51	2.58	5.4	5.4		
Average		2.45	2.55	4.1	4.1	48.3	28.3
Occurrence			2/3		2/3		1/2

[a]Oxytetracycline (OTC) was fed at the rate of 2 g/head/d for 14 d.

Feeding 2 g of chlortetracycline for 14 days also showed positive results (Table 3). Average daily gain was improved an average of 10.3% in three out of three trials reviewed. Feed efficiency was also improved (7.4%) in three of the three trials examined. Morbidity and mortality were reduced in the only study that reported such data.

Table 3. Effects of chlortetracycline on weight gain and health of newly received cattle.

		ADG, lb/head		Feed/gain		Morbidity, %		Mortality, %	
		Control	CTC[a]	Control	CTC	Control	CTC	Control	CTC
California	1985	2.10	2.30	3.79	3.56	44.4	3.5	6.9	0
Indiana	1987	1.74	2.11	5.30	4.80				
S. Dakota	1989	3.12	3.27	4.71	4.42				
Average		2.32	2.56	4.60	4.26				
Occurrence			3/3		3/3				

[a]Chlortetracycline (CTC) fed at rate of 2 g/head/d.

Table 4 shows the effects of AS-700 on performance and health of newly received cattle. Average daily gain was improved an average of 18.2% in 27 or 29 trials reviewed. Feed efficiency was improved 16.2% over controls in 23 of 23 trials where efficiency was reported. Morbidity was reduced an average of 29.2% in 12 of 15 trials that reported morbidity data.

Additional trials examined by Rust (1992) suggests that improvements in performance associated with feeding AS-700 could be maintained throughout the entire feeding period. Average daily gain was improved 5.1% and feed to gain was improved 3.2%.

Table 4. Effects of Aureo S-700 on performance and health of newly received cattle.

			ADG, lb/d		Feed/gain improvement	Morbidity, %	
		Weight, lb	Control	AS-700	over control, %	Control	AS-700
Iowa	1967	427	1.99	2.05	18		
Kansas	1967	660	1.20	1.40	17	19.7	11.8
Arizona	1968	547	2.50	3.40	26	13.9	9.4
Indiana	1968	466	1.90	2.50	27	8.8	0
Kansas	1968	374	1.70	1.45			
Texas		427	2.10	2.50	10	32.5	15.0
Wyoming	1968		1.30	1.70	29		
Nebraska	1969	404	1.30	1.50	14		
Kansas	1970	436	1.32	1.60	15	5.9	1.7
Montana	1970	428	1.47	1.73	25	23.0	23.0
Kansas	1971	491	1.51	1.68			
Nebraska	1973	468	2.70	3.40		34.0	12.0
S. Dakota	1973		2.20	2.30	2		
S. Dakota	1973	421	1.03	1.27	18	3.8	0.6
S. Dakota	1973	380	2.17	2.43	8		
Montana	1981	439	2.91	3.25			
Montana	1981	465	1.79	2.25			
New Mexico	1981	360	1.78	2.37	17	63.3	69.5
Kansas	1982	435	.37	.62	53	11.2	4.0
Arizona	1983	385	1.71	2.19	15	79.0	64.0
Ontario	1984	600	1.94	2.38	17	62.5	33.2
Ontario	1984		1.80	2.20	14	44.0	29.3
Ontario	1984		2.46	2.79	2		
Washington	1984	479	3.10	3.61	9	40.0	20.0
New Mexico	1985		2.35	1.66			
S. Dakota	1986	580	2.51	2.93	11		
Oklahoma	1987	367	1.50	1.75	8	62.5	63.9
S. Dakota	1991		2.92	3.27	10		
S. Dakota	1991		3.40	3.82	8		
Average			1.92	2.27	16.2	33.6	23.8
Occurrence				27/29	23/23		12/15

Coccidiostats

Amprollium (Corid®), decoquinate (Deccox®), lasalocid (Bovatec®), and monensin (Rumensin®) are approved for the control of coccidiosis in cattle. The incidence of coccidiosis is greater than originally thought. Western calves, at one time believed to be "clean," are often loaded with cocci when they arrive at feedyards in eastern South Dakota, Minnesota, and Iowa. An important consideration in controlling coccidiosis is obtaining adequate intake of medication.

Prichard and Thomson (1993) studied various monensin levels in feeder calf receiving diets. Levels studied were 0, 10, 20, and 30 g per ton. Additional treatments providing for 100 and 200 mg per head daily intake of monensin regardless of feed intake were also examined.

Ninety-six percent of the calves were shedding oocysts when they arrived at the feedlot. Monensin began to suppress oocyst shedding by day 10 of the experiment. The percentage of calves not shedding oocysts appeared dosage dependent and increased from 16% for control to 72% for the 100 mg per day treatment (Table 6).

Table 5. Effects of antibiotics for 28 days on subsequent performance.

	Length of adaptation (days)	Total length of period (days)	Adaptation AS-700[a] ADG	Adaptation AS-700[a] F/G	Overall AS-700 ADG	Overall AS-700 F/G
			% improvement over control			
S. Dakota, 1973	33	306	+9.1	--	+2.8	-3.6
Washington, 1984	28	56	+16.4	-9.6	+8.8	-4.2
S. Dakota, 1986	30	110	+16.7	-11.2	+3.9	-1.7
Average			+14.1	-10.4	+5.1	-3.2

[a]350 mg of CTC and 350 mg of sulfamethazine/head/d for 23-33 d.

Deccox® is often used to control coccidiosis by feeding .5 mg per kg body weight daily for 21 or 28 days. Many times Deccox® is removed from the diet and 10 days to 2 weeks later cattle break with coccidiosis. Perhaps intake of monensin or lasalocid was not yet high enough to control coccidiosis. Deccox® cannot be legally fed in combination with monensin or lasalocid. Some producers have fed Deccox® in the morning and the ionophore in the evening. Whether this approach will stand FDA scrutiny has yet to be determined.

If Deccox is used as a coccidiostat, perhaps 100 mg per head daily of monensin should be added immediately to the ration the day following the last feeding of Deccox.®

Most feeders have been constantly told of the need to step-up monensin in receiving diets for calves. Pritchard and Thomson (1993) demonstrated that monensin did depress feed intake about 5% (Table 7). However, this depression was diminished after 2 weeks and appeared to be not detrimental to the calf (Table 8). Daily gain and feed efficiency was similar for all treatments after 27 and 84 days on feed.

Table 6. Frequency of calves shedding oocysts.[a]

Sample day[b]	Oocyst[c] counts	Treatment[d] 0	10	20	30	100	200
		Percentage of calves					
0	0	5.41	5.26	5.41	0.0	0.0	7.89
	1-99	35.14	39.47	43.24	55.00	48.72	50.00
	100-499	59.46	55.26	51.35	45.00	51.28	42.11
	500 +	0.0	0.0	0.0	0.0	0.0	0.0
3	0	2.63	7.69	7.50	10.26	7.89	2.56
	1-99	65.79	71.79	62.50	56.41	68.42	71.79
	100-499	18.42	7.69	17.50	23.08	13.16	17.95
	500 +	13.16	12.82	12.50	10.26	10.53	7.69
6	0	13.51	18.92	12.82	23.08	23.68	21.62
	1-99	72.97	67.57	79.49	71.79	71.05	72.97
	100-499	13.51	13.51	7.69	5.13	5.26	5.41
	500 +	0.0	0.0	0.0	0.0	0.0	0.0
10[e]	0	16.22	35.90	45.00	32.50	72.97	62.16
	1-99	78.38	61.54	47.50	67.50	24.32	37.84
	100-499	5.41	0.0	5.00	0.0	0.0	0.0
	500 +	0.0	2.56	2.50	0.0	2.70	0.0
13[e]	0	23.08	50.00	58.97	57.50	70.00	72.50
	1-99	74.36	50.00	38.46	42.50	30.00	27.50
	100-499	2.56	0.0	2.56	0.0	0.0	0.0
	500 +	0.0	0.0	0.0	0.0	0.0	0.0
17	0	74.36	87.50	92.50	90.00	92.50	95.00
	1-99	23.08	12.50	7.50	7.50	7.50	5.00
	100-499	2.56	0.0	0.0	0.0	0.0	0.0
	500 +	0.0	0.0	0.0	2.50	0.0	0.0
20[e]	0	44.44	72.50	85.00	76.92	75.00	81.58
	1-99	55.56	27.50	15.00	23.08	25.00	18.42
	100-499	0.0	0.0	0.0	0.0	0.0	0.0
	500 +	0.0	0.0	0.0	0.0	0.0	0.0
24[f]	0	70.27	77.78	82.05	95.00	90.00	85.00
	1-99	29.73	22.22	17.95	5.00	10.00	15.00
	100-499	0.0	0.0	0.0	0.0	0.0	0.0
	500 +	0.0	0.0	0.0	0.0	0.0	0.0
26[e]	0	50.00	70.00	90.00	92.50	82.05	79.49
	1-99	50.00	30.00	7.50	7.50	17.95	20.51
	100-499	0.0	0.0	2.50	0.0	0.0	0.0
	500 +	0.0	0.0	0.0	0.0	0.0	0.0
54[e]	0	47.37	77.78	91.89	94.74	92.31	92.50
	1-99	52.63	19.44	8.11	5.26	7.69	5.00
	100-499	0.0	2.78	0.0	0.0	0.0	2.50
	500 +	0.0	0.0	0.0	0.0	0.0	0.0
81[e]	0	74.36	90.0	100.0	97.44	92.11	100.00
	1-99	25.64	10.00	0.0	2.56	5.26	0.0
	100-499	0.0	0.0	0.0	0.0	2.63	0.0
	500 +	0.0	0.0	0.0	0.0	0.0	0.0

[a]Percentage of calves within a treatment that were shedding oocysts at the rate listed.
[b]Days in the feedlot prior to sampling.
[c]Oocyst counts per gram feces.
[d]Monensin level as g/T or mg/head.
[e]Percentages differ between monensin treatments (P< .001).
[f]Percentages differ between monensin treatments (P= .055).

Table 7. Weekly dry matter intake summary.[a]

Item	Treatment[b] 0	10	20	30	100	200	P<[c] 0 vs rest	10 vs 20,30	20 vs 30	30 vs 200	100 vs 200
1 to 7 days	7.12	7.10	6.86	6.79	6.50	6.14	.0003	.0242	NS	.0001	.0136
8 to 14 days	9.92	10.10	9.38	8.87	8.88	8.73	.0591	.0288	NS	NS	NS
15 to 21 days	12.38	11.22	11.64	11.76	11.90	11.56	.1457	NS	NS	NS	NS
22 to 28 days	15.73	15.73	15.41	14.85	15.41	14.62	.1343	.1260	NS	NS	NS
29 to 35 days	15.61	15.87	15.85	15.10	16.06	15.56	NS	NS	.1150	NS	NS
36 to 42 days	15.80	15.01	15.97	15.20	16.21	15.19	NS	NS	NS	NS	.0689

[a]Pounds per head per day.
[b]Monensin concentration, g/ton air dry basis or mg/head.
[c]NS = P>.15.

Table 8. 84-day feedlot performance summary.

Item	Treatment[a] 0	10	20	30	100	200	SEM
Initial wt, lb	546	549	549	548	547	549	1.4
Days 1 to 27							
Body weight, day 27	625	621	621	621	622	624	4.9
Avg daily gain, lb	2.93	2.67	2.81	2.70	2.80	2.76	.168
Dry matter intake, lb	10.65	10.32	10.18	10.04	9.98	9.72	.255
Feed/gain, lb	3.70	3.98	3.63	3.75	3.60	3.54	.202
Gain/feed, lb/cwt	27.03	25.10	27.53	26.70	27.79	28.25	1.526
Days 1 to 84							
Avg daily gain, lb	2.33	2.25	2.38	2.22	2.41	2.35	.056
Dry matter intake, lb	14.49	14.41	14.51	14.01	14.29	13.94	.221
Feed/gain, lb	6.25	6.44	6.09	6.32	5.93	5.94	.172
Gain/feed, lb/cwt	16.00	15.53	16.41	15.82	16.86	16.85	.518

[a]Monensin level, g/ton air dry basis or mg/head.

Estrus Suppressants

Melengestrol acetate (MGA®) is a synthetic hormone with structure and activity very similar to that of progesterone. It is marketed by TUCO, a division of the Upjohn Company. MGA is fed at .25 to .5 mg/head daily and improves gain and efficiency (3-7%) of intact open heifers and suppresses estrus. Suppression of estrus reduces wasteful energy expenditures due to riding and chasing. Injuries due to riding are also reduced.

MGA is approved for use in liquid and dry supplements and can be fed in combination with monensin and tylosin or with lasalocid. Combinations with oxytetracycline and lasalocid simultaneously are not allowed. A 48-hour withdrawal prior to slaughter is required.

Buffers

Buffers are compounds with both acid and base properties. They resist changes in rumen or intestinal pH when acids are present. Sodium bicarbonate (.75-1.5% of dry matter, limestone (1% of dry matter), sodium bentonite (1-2% of dry matter), and magnesium oxide (.5-.75% of dry matter) have all been fed to cattle to reduce acidosis on high grain diets or to improve fiber digestion on corn silage based diets.

Response to dietary buffers has been variable. When acidosis is observed in cattle, generally some other

management consideration causing the acidosis overwhelms the ability of the buffer to effectively control pH. In other words, buffers will not correct management problems causing acidosis. Factors such as erratic feed deliveries, improperly processed grain, improperly processed roughage, improperly mixed and formulated diets need to be corrected first.

Others

Sarasponin (Sevarin®) is classified as a natural product of plant origin and is free of FDA regulations. It is recommended for feeding at a level of .5 to .6 g/head daily in conjunction with monensin or lasalocid. Results vary with a range of 0-4% improvement in gain and efficiency.

Poloxalene (Bloat Guard®) is marketed by SmithKline Animal Health Products, a division of SmithKline Corporation. It is approved for the prevention of legume bloat in cattle. It is available in liquid and dry supplements and no withdrawal period is required.

Probiotics are microbial products that may be fed to cattle or administered directly to the rumen through the use of a bolus, drench, or paste. These products are intended to aid the digestive system's naturally occurring population of organisms to digest feed. This is perceived to result in increased intake and performance.

Rust (1992) summarized the results of 35 trials examining probiotics and found what could be classified as mixed results at best (Table 9). An average of 63% of the trials noted an improvement in daily gain that averaged .22, .13, and .03 lb per head daily after 14, 28, and 84 days on feed. Thirteen of 21 trials demonstrated favorable feed efficiency responses after 28 days on feed. Morbidity was reduced in 13 of 20 trials and mortality was reduced in two of the five trials that reported that data.

Table 9. Effects of probiotics on weight gain and health of newly received cattle (35 trial summary).

	Average response		
	Control	Probiotic	Positive responses
ADG, lb/d			
14	1.59	1.81	8/11
28	1.87	2.00	20/33
84	2.18	2.21	5/9
Feed/gain			
28	6.83	6.77	13/21
84	6.04	5.99	4/8
Morbidity, %	30.60	26.27	13/20
Mortality, %	4.86	3.27	2/5

Responses in these trials were reported to be greater if the cattle were transported more than 400 miles. Therefore, it appears that the greater the stress on the cattle, the more likely probiotics would help.

Nutritional Supplements

Recent biotechnological advances have greatly improved our ability to purify or synthesize a host of nutrients for livestock. Many companies are promoting the inclusion of these nutrients in cattle rations. Unfortunately, the availability of these products has greatly exceeded our understanding of the nutrient requirements for cattle.

Currently, the impact of minerals, or more specifically chelated mineral, supplementation on immune response is popular. There are dozens of reports that do indeed show an increase in immunoglobulins in the blood stream when various mineral chelates are administered. However, extremely little information exists proving that these improvements will lead to a reduction in disease or an increase in performance.

Cattle response to super fortification is generally related to intake. Dietary concentration of trace minerals for example are listed as parts per million (ppm). The suggested level of copper in beef diets is 8 ppm according to NRC (1984). However, dietary copper intake of a 500 lb calf eating 2.5% of his body weight is five times greater than copper intake of a 500 lb stressed calf eating only .5 of his body weight. Elevated copper in the diet of the stressed calf may be warranted.

Caution should be used when applying this logic to all situations. In the above example, the range for acceptable copper intake given by NRC (1984) is from 4 to 10 ppm. The maximum tolerable level is listed as 115 ppm or 14 times the requirement. The suggested value for sulfur is listed as .10% with a range of .08 to .15%. The maximum tolerable level is only .4% or four times the requirement. Two references are recommended if dietary fortification with vitamins and minerals are used. "Mineral Tolerance of Domestic Animals" and "Vitamin Tolerance of Animals" both published by the National Academy Press should be consulted to ensure that no undesirable or toxic nutrient imbalances are created.

Nutrient supplements are fed to supply essential nutrition. Elevated levels are permitted by FDA to account for unavoidable low intake by cattle. Recommended mineral levels for receiving programs are shown in Table 10. Once feed intake recovers, these levels are no longer necessary to meet the nutrient requirements of cattle. Feeding trace minerals or vitamins at levels that grossly exceed nutrient requirements are considered an extra label use by FDA and are therefore illegal. Extra-label drug use authority does not extend to feed uses.

Evaluating Feed Additives

Producers, veterinarians, nutritionists, and other consultants are continually bombarded with a multitude of products, all of which are "guaranteed to

improve" some component of production. Dr. Michael Hutjens, Dairy Specialist at the University of Illinois, published a series of five articles in Dairy Herd Management magazine in March of 1987. These articles dealt with the difficult question of evaluating feed additives. Hutjens advised dairy producers to apply the "4 R's" (Response, Returns, Research, and Results) to evaluate potential feed additives. Applying the "4 R's" to beef cattle feeding operations is required to objectively evaluate additives.

Table 10. Suggested mineral concentration in starter diets.

Mineral	Concentration
Calcium, %	.67
Phosphorus, %	.45
Potassium, %	.8-1.40
Magnesium, %	.25
Copper, ppm	10-15
Iron, ppm	100-200
Manganese, ppm	20-30
Zinc, ppm	50-75
Cobalt, ppm	.1-.2
Selenium, ppm	.1-.2

Adapted from Wagner *et al.* (1988) and Hutcheson and Cummins (1987).

Responses refers to what the cattle feeder can expect when a feed additive is used. A list of potential responses follows:

1. Greater dry matter intake.
2. Improved growth rate.
3. Improved feed efficiency.
4. Reduced cost of gain.
5. Reduced stress.
6. Improved health.

If a producer observes and measures a response, the economic *return* must be favorable. For example, if a reduction in foot rot is an important criterion, the value of reduced treatment costs and improved performance must exceed the increased cost associated with using an additive designed to reduce foot rot.

The results of *research* that has been conducted under controlled and unbiased conditions complete with statistical analysis needs to be thoroughly studied in order to evaluate potential feed additives. Field studies that are directly applicable to the conditions encountered on a producer's own farm also should be considered. Do not rely solely on testimonials.

The bottom line must be whether the additive works in the farmer's own herd or feedyard. Each producer must objectively compare the *results* of using the additive to responses observed prior to making the change in the feeding program.

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