Table 3. Average For Selected Live Animal and Carcass Measurements.

Breed	Dorset		Black-face	
Ration	Standard	HE	Standard	HE
Measurement				
Av. Daily Gain, Lbs.	0.46	0.47	5.54	0.47
Loin Width Inc.*, In.	0.82	0.68	0.76	0.60
Leg Cir. Inc.*, In.	0.74	0.45	0.45	0.47
Rump Length Inc.*, In.	2.13	1.79	2.14	2.00
Body Length Inc.*, In.[3]	2.65	1.84	2.92	3.00
Hg. Cir. Inc.*, In.	4.35	4.23	4.05	4.13
Dressing Percent[6]	52.73	55.59	52.13	53.77
Specific Gravity[3]	1.0463	1.0335	1.0426	1.0384
LEA[1]/cwt. Carcass, Sq. In.	4.28	4.18	4.43	4.36
BF[2]/cwt. Carcass In.	0.66	0.76	0.63	0.67
Percent Trmd. Leg[4]	22.62	21.70	23.60	23.49
Percent Trmd. Loin[5]	6.77	6.45	7.07	6.46
Percent Trmd. Rack	5.56	5.61	5.61	5.48
Percent Trmd. Shoulder	20.75	21.05	20.97	21.48
Yield Trmd. Lean Cuts (Live Wt. Basis)[5]	29.34	30.35	29.83	30.56
Percent Lean In Carcass	52.39	50.98	53.10	52.44
Percent Fat In Carcass[3]	29.84	32.47	28.29	29.54
Percent Bone In Carcass[4,5]	14.54	13.41	15.81	14.84

*Increase of, during feeding period
[1] Loin-eye area
[2] Backfat
[3] Significant difference ($P \leq .05$) between breeds
[4] Significant difference ($P \leq .01$) between breeds
[5] Significant difference ($P \leq .05$) between rations
[6] Significant difference ($P \leq .01$) between rations

Trace Minerals In Beef Cattle Feeding In Oklahoma

Allen D. Tillman

INTRODUCTION

Many localized areas in the United States have been found to be unsatisfactory for the raising of beef cattle because of severe endemic disorders. By close study of such disorders, which result primarily from trace mineral deficiencies in the indigenous forage, new areas are being found each year. Such acute deficiency symptoms are important, but it must be emphasized that the greatest loss in beef production results from the subclinical deficiencies. In such cases no definite symptoms appear.

Rather, the metabolism rate of the animal slows down in compliance with the level of the limiting nutrient. This results in slower growth, less resistance to infection, less resistance to parasites, less milk production, and lowered efficiency.

As techniques for detecting subnormal performance associated with a limiting nutrient are improved, it is predicted that new areas showing suboptimum trace mineral levels will be discovered at an increasing rate. This is true in Oklahoma where improvements in sanitation accompanied by the judicious use of drugs have reduced the incidence of infectious diseases and parasite damage, and selection and performance testing has increased the genetic potential for fast growth to a level never before found in this animal. Biological bottlenecks, such as trace mineral deficiencies, which limit growth and performance, become apparent much sooner under improved conditions which place greater stress on animals. When one considers the cost-price squeeze that the Oklahoma beef producer now faces, it becomes apparent that even more stress will in the future be placed upon this animal in an attempt to make him gain faster and more efficiently in terms of both feed and money.

The purpose of this paper is to discuss the importance of trace minerals in the production of beef cattle. For convenience, the paper will be divided into three sections: (1) identification and metabolic function of trace elements; (2) listing of the quantitative requirements; and (3) a discussion of the possible need for each trace mineral in Oklahoma.

ESSENTIAL TRACE MINERALS

The proof of essentiality of a trace mineral rests upon the effects of variations in dietary levels upon growth rate, structural changes, and their functioning in enzymes associated with the general well-being of the animal. Under these conditions, the following minerals are *definitely* dietary essentials for cattle. *Iron, cobalt, copper, iodine, manganese* and *zinc*. Molybdenum and selenium are of doubtful importance, thus will receive only brief consideration.

GENERAL FUNCTIONS AND DEFICIENCY SYMPTOMS

Iron. Iron functions in many enzyme systems in the body and it is well known that nutritional anemia results from an iron-deficient diet. Nutritional anemia can occur at anytime during the life span; however, it is most likely to develop during the suckling period when milk, which is a very poor source of iron, is the major or only component in the diet. The young calf, on essentially a milk diet shows the following sequence of symptoms: (a) feed refusal (b) scouring (c) paleness of buccul mucous membranes and of the conjunctiva, (d) reluctance to move (e) high pulse rate with slow return to normal after forced exercise and (f) progressive loss of appetite. A steady fall is found in the hemoglobin level from about 13% to as low as 4%.

Some field trials in Scotland show that a mild anemia exists in calves 2-3 months of age and that iron-dextran administration will prevent or alleviate the condition. The practical significance of this discovery is in doubt at the moment and the whole area awaits results of similar trials conducted under Oklahoma conditions. In this connection, it is of great interest to note that Indiana workers found that the injection of 300 mg. of a iron-dextran mixture into lambs at 1 and again at 10 days of age resulted in increased gains and reduced mortality.

Copper. Where the vegetation supplies 5 ppm or less copper, adult cattle suffer from "falling disease," which is characterized by (a) loss of weight, (b) diarrhea, (c) anemia, and (d) sudden death caused by heart failure; the weight of the heart is often doubled. Infertility in cows is quite frequent. Calves from copper-deficient cows show (a) poor growth, (b) fading of hair color, (c) a stilted gait resulting from either poor muscular development or failure of bone deposition in the matrix of copper-deficient calves.

There is a reduction in the synthesis of phospholipids or in animals when copper is deficient and the failure to form phospholipids at the normal rate is a possible explanation of the demyelination of the myelin sheath noted in copper-deficient calves and lambs, resulting in an outward condition called "swayback."

A deficiency of copper in sheep results in a marked decrease in wool growth; copper-deficient wool has more sulfhydryl and less disulfide groups than normal. The bleaching of the haircoat probably represents a failure in melanin formation, a process requiring the enzyme, tyrosinase.

Copper requirements and copper deficiency symptoms around the world are influenced by dietary levels of phosphorus, molybdenum, sulfates, and zinc. For example, a high level of molybdenum will result in a copper deficiency if the level of inorganic sulfates is sufficient. In this case, the animals will respond to additional dietary copper. The toxicity of excess molybdenum is less if low levels of inorganic sulfates are present. An excess of zinc results in an anemia which also can be alleviated by additional copper. An interpretation of the experimental data would indicate that in forages containing excess molybdenum, the requirements for copper, sulfur, and phosphorous are increased. There are some indications in Oklahoma studies that the copper level of forages might be lower in plants which contain high levels of manganese and iron, a characteristic of plants grown on the more acid soils found in the southeastern part of the state.

Cobalt. Cattle utilize cobalt for the ruminal synthesis of vitamin B_{12}, thus the symptoms of a cobalt deficiency in the ruminant animal are essentially those of a vitamin B_{12} deficiency in the non-ruminant. Cattle grazing indigenous forages containing less than 0.07 ppm become (a) listless, (b) lose appetite, (c) lose weight, (d) become weak, (e) become anemic, and (f) finally die. *The lowering of the vitamin B_{12} content in the blood is the only specific symptom.* The only certain diagnosis of a cobalt deficiency rests upon the response of the animal to the feeding of cobalt. The response is rapid. Appetite improves within a week or less and the animals begin to gain in weight and general appearance within several weeks. Australian workers have described a new procedure for supplying small amounts of cobalt to cattle and sheep; a cobalt oxide pellet is placed in the esophagus and, after the animal swallows, is trapped in the reticulum. The pellet releases a small amount of cobalt continually over a fairly long period of time. Ruminal bacteria utilize this source of cobalt to synthesize vitamin B_{12}, which is utilized by the animal.

Apparently ruminants require a high level of vitamin B_{12} because it is required for the utilization of propionic acid, one of the major end products of microbial breakdown of dietary carbohydrates in the rumen.

Cobalt levels in plants reflect levels of that element in the soil. This element apparently has no important role in plant nutrition, but is necessary for an active microbial population in the soil. The variety of soils which are deficient in cobalt is too great to make definite associations but rain-leached hills low in organic matter is an example of a inadequate soil, which will produce a plant deficient in this elemnet.

Iodine. The mature bovine contains no more than 0.00004% iodine, more than one-half of which is found in the thyroid gland. Iodine functions as a part of thyroxine, a hormone concerned with the regulation of the metabolic rate. A deficiency of iodine results in an enlargement of the thyroid gland, a condition called goiter. Goiter results because of compensatory hypertrophy of the thyroid gland, i.e., an enlargement of the thyroid gland in an effort to supply more thyroxine. The condition is much more prevalent in the young born of mothers deficient in the element.

Iodine deficiency is an area problem and fortunately Oklahoma is not located in an area in which the soil, water and forages are deficient in this element.

Manganese: Manganese deficiency symptoms in the bovine include (a) poor growth (b) poor body development, (c) leg deformities (shorter and thicker bones), (d) poor fertility (e) frequent abortion and (f) a dull, dry haircoat. The element is an activator of a number of enzymes, which perform important functions in the body. It has been found, in particular, that cattle receiving manganese-deficient diets have lower bone phosphatase activity than normal animals, thereby offering a possible explanation as to why the bones fail to grow in length. Other enzymes which are more active in the presence of manganese are phosphoglucomutase, intestinal peptidases, cholinesterase, cozymase, isocitric dehydrogenase, the carboxylases, arginase and adenosine triphosphatase. Small wonder that numerous deficiency symptoms are found when the diet contains a suboptimum level of this element.

Fortunately, most forages in the world contain higher levels of manganese than is required by the bovine. In fact, some contain levels that are too high. Forages containing an average of 734 ppm of manganese have caused a drop in the magnesium level in the blood and lactation tetany in studies conducted in England. In Oklahoma studies the addition of 250 or 500 ppm of manganese to the diets of beef cows over a period of several years had no pronouneed effect upon reproductive and lactation performance. In fact, work with other animal species indicate that if the ration is balanced as regards other minerals, animals can tolerte high levels of manganese.

Zinc: Since natural feeds contain 30 ppm or more of zinc, studies of absolute deficiencies of this nutrient have hitherto been limited to the rat. Then a conditional deficiency of zinc has been found widespread in pigs reared under commercial conditions. High levels of dietary calcium combined with the relative low availability of zinc found in natural feedstuffs of vegetable origin seem to be the conditioning factors causing a deficiency of zinc.

Georgia workers, using a purified diet, produced a zinc deficiency in calves. The outward symptoms appeared about 8 weeks after the animals were placed on the low-zinc diet and were as follows: (a) slightly red and inflamed nose and mouth (b) mild swelling above the rear feet in front of the fetlock, (c) loss of hair on the rear legs and rest of the body (d) breaks in the skin around the hoofs (e) rough and scaly skin especially on the rear legs (f) and a dull, listless appearance. Similar lesions have been noted in beef and dairy cattle kept under natural conditions; cattle grazing the Berbice savannahs have many of the above parakeratotic lesions which cover over 40% of the body. Response to zinc given orally (2 gm./week) or by subcutaneous injection (1 gm./week) was rapid; new growth of hair appeared within one week and the animals appeared normal within three weeks. The unsupplemented control animals in the meantime became steadily worse.

In Finland, the writer saw a number of dairy cows which exhibited the above symptoms. These cows (a) produced less milk, (b) made less efficient use of their feed, (c) required more services for conception and (d) had more abortions than animals not having these abnormalities. Zinc supplementation gave a prompt alleviation of the parakeratotic lesions and later disappearance of the other conditions.

Zinc functions in the metaloenzymes. For example it functions in carbonic anhydrase, an enzyme concerned with the formation of carbonic acid. It, as a part of pancreatic carboxypeptidase, functions in protein digestion. There is also evidence that it is found in glutamic dehydrogenase as well as in lactic dehydrogenase. Red blood cells contain relatively high levels as do some sexual secretions. Males show irreversible atrophy of the testicular epithelium if kept on zinc-deficient diets.

Molyebdnum: is required in xanthine oxidase, an enzyme concerned with purine metabolism. Oklahoma workers have found that rations containing 0.10 ppm of molybdenum met the requirements of ruminants unless nitrates were used as nitrogen sources. As molybdenum is required for the reduction of nitrates to nitrites, a higher level is probably required when ruminant diets contain nitrates.

Forages containing high levels of molybdenum are toxic. The unhealthy pastures contain 20 to 100 ppm of molybdenum causing severe scouring, a condition called "teart" in England and other affected areas. As pointed out previously, there is an interaction between molybdenum, inorganic sulfates and copper. If the first two are high, molybdenum toxicity can be overcome by adding copper to the diet.

Fortunately, there appear to be no large areas in Oklahoma in which toxic levels of molybdenum are present.

Selenium: Interest has shifted from the toxic aspects of selenium in animals kept in some areas of the United States to its possible essential role in nutrition. Several groups of workers have found that selenium, given orally or subcutaneously to lambs, prevents "stiff lambs disease" and muscular dystrophy in calves. It appears that selenium, when given to the dam prior to partuirition, affords some protection against muscular dystrophy. It is also just as effective as is vitamin E in the cure or prevention of muscular dystrophy in the young calf.

The physiological function of selenium is not known at the present time.

QUANTITATIVE REQUIREMENTS FOR TRACE MINERALS BY BEEF CATTLE

The quantitative requirements of beef cattle for the trace minerals are shown in table 1.

ARE TRACE MINERALS NEEDED BY BEEF CATTLE IN OKLAHOMA?

There is no simple answer to this question, thus let us consider conditions which do or might lead to a deficiency of one or more trace minerals in beef cattle diets; however, should the experimental evidence definitely indicate a need for trace minerals, such information will be given along with a definite recommendation as regards whether these should be provided in the diet.

For further consideration of the problem the state is divided into east and west sections, using Highway 81 as the division line. The land

Table 1. Requirement of Cattle and Sheep for the Trace Minerals.

	Cobalt, p.p.m.	Copper, p.p.m.	Iron p.p.m.	Iodine mcgm.	Manganese p.p.m.	Zinc p.p.m.
Beef cattle	0.07	5-10	80-150	200-400	15-30	30
Dairy cattle	0.07	5-10	80-150	200-400	15-30	30
Sheep	0.07	5-10	80-150	200-400	15-30	30

to the west of the line tends to be more alkaline in nature. Such soils are generally lower in available iron and manganese but contain higher levels of phosphorus, copper and molybdenum than the more acid soils. Thus, it becomes apparent that the cows grazing plant indigenous to the west may show a greater liklihood of iron or manganese deficiency than for the other trace elements. If the more alkaline soils, whether they be in the east or west, contain high levels of calcium, there is a possibility that zinc absorption by plants is poor. Thus ranchers running cattle on the limestone soils must be aware of the possibilities of zinc deficiency symptoms, which have been described.

East of the division line, the soils tend to be more acid in nature. These soils may contain higher levels of available iron and manganese, but lower levels of phosphorus and molybdenum than those from the more alkaline soils in the west. There are some indications that the forages which contain high levels of iron and manganese have lower levels of copper. Whether the combination of adverse factors would serve to make copper a limiting nutrient is of conjecture but is not beyond the realm of possibility.

Incomplete analyses of some feeds available to Oklahoma livestock producers are shown in table 2. Such analyses are difficult and expensive to obtain, thus our information concerning the effect of trace minerals of soils upon their contents in forages is very limited. As a result, the third factor, i.e., the effect of the trace mineral analysis of the plants upon animal performance is not very well documented unless severe deficiency symptoms are encountered. The important interrelationship of trace minerals of the soil, their subsequent uptake by plants and their effect upon the productive performance of Oklahoma beef cattle must be studied in carefully controlled experiments. From results of such studies, specific recommendations could be made. Advances in the technology of trace mineral analyses of soils, plants and certain animal fluids now place such a study in the realm of possibility. Until such a study is made and the results made available, only certain general statements can be made and many of these are conjectures.

Table 2. Mineral Composition of Some Feeds

Mineral	N	Ca	P	Mg	K	S	Mn	Co	Cu	Fe	Zn
Level	%	%	%	%	%	%	ppm	ppm	ppm	ppm	ppm
Feeds											
Corn	1.44	0.02	0.28	0.11	0.30	0.04	5.5	0.23	4.2	20	20.0
Milo	1.60	0.03	0.28	0.13	0.35	0.05	13.2	0.30	16.0	40	21.0
Barley	1.92	0.06	0.40	0.13	0.60	0.15	17.6		11.7	80	31.0
Urea	42.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	00.0	00	00.0
Cottonseed meal	6.71	0.20	1.10	0.52	1.48	0.40	22.9	0.27	18.5	160	31.0
Soybean meal	7.20	0.27	0.63	0.25	1.77	0.33	32.3	0.21	18.0	130	26.6
Corn and Urea (6:1)	7.23	0.02	0.24	0.09	0.26	0.03	4.7	0.20	3.6	17	17.0

As pointed out previously, cobalt apparently has no function in plants; however, it is of interest to note that cobalt level in plants decreases as the leaf to stem ratio decreases; most of the cobalt is found in the leaves. From meager results, it appears that the eastern section of Oklahoma offers the best possibilities for obtaining cobalt deficiency symptoms. Forages from leached soils, which have low fertility, are probably the most susceptible.

When cottonseed meal or cake was the protein supplement for range cattle during the winter season, trace mineral supplements in many Oklahoma studies have not improved the performance of beef cattle. A few years ago the author, however, feeding in drylot identical twin Angus steers a ration of weathered range forage, which was clipped in the winter from the Lake Carl Blackwell Range Area, plus one and one-half pounds of cottonseed meal daily, found that a trace mineral mixture containing cobalt, copper, iodine, iron, manganese, and zinc did not greatly affect gains. There were striking differences, however, in the general appearance of the animals. Those receiving trace minerals had a glossy haircoat showing neither dryness nor dandruff in their hair while the control animals exhibited a dull haircoat that appeared quite dry and contained much dandruff. Kansas workers conducted a similar experiment in which cattle were fed a ration of prairie hay plus cottonseed meal, with and without trace minerals, and obtained the same results as regards gains and condition of the haircoat.

If such conditions were duplicated in the field, a need for trace minerals could be shown in a practical feeding trial. In many of the early trace mineral studies conducted by Oklahoma Researchers, steamed bone meal was included in the control ration as a source of phosphorus. As bone meal is also an excellent source of trace minerals, there were not valid tests; however, results of more recent tests in which dicalcium phosphate was used as a mineral source indicate that trace minerals also did not improve the performance of cattle consuming native grass plus cottonseed meal or cake. Even though these practical field results indicate that trace minerals are not needed when cottonseed meal is used to supplement native range grasses during the winter season, the author feels that it is risky to omit trace minerals from the added feeds or salt during the winter season. These minerals are not expensive to feed and do provide a measure of protection should all conditions of soil, climate and stress factors on the animal be favorable for causing a trace mineral deficiency.

With the present emphasis, particularly in the more humid section of the state, upon improved pastures by the use of different grasses and fertilization programs, coupled with the greater stress upon a better animal for faster growth, there are greater possibilities for a trace mineral to become an item limiting growth or other productive functions. Trace minerals in the feed could result in faster and more efficient gains. They could also cause animals to be better able to resist parasites and infection, resulting in less death losses.

When urea plus corn or milo replaces some or all of the oil meals, the resulting mixture contains a lesser quantity of minerals than do the oil meals. A mixture containing 6 lb. of corn or milo plus 1 lb. of urea is equivalent in nitrogen (N) to 7 lbs. of soybean meal, thus it becomes of interest to consider the mineral composition of the mixture as compared to the oil meals. This has been done in table II and it will be noted that the mixture contains less of all minerals, in many cases less than one third as much. As urea is pure chemical compound, containing no minerals, the figures in this table permit other comparisons. The results of a series of Oklahoma feeding trials, in which urea replaced some of the oil meals in protein supplements, show that the addition of trace minerals consistently improved the performance of beef cattle. Trace minerals, therefore, must be provided in the diet if urea is included in winter protein supplements which are fed to Oklahoma beef cattle.

In recent years, barley has been used in "all barley ration" for fattening cattle. Oklahoma studies have shown that a mixture of trace minerals when added to such rations has consistently improved gains and the efficiency of feed utilization. Also, Kansas studies show that trace minerals have consistently improved the performance of cattle fed fattening rations containing corn.

The results of most feeding trials indicate that the milo grains provide a sufficient supply of trace minerals when this grain is the major grain in fattening rations. In such trials, the oil meals have been the protein source. When urea replaces the oil meals and milo from irrigated soils is fed, the possibilities of showing mineral deficiencies are increased. Further research of this nature should be conducted, especially since there are indications that milo or corn grains produced on alkaline soil could be deficient in zinc.

SUMMARY

The trace elements known to be essential for the bovine are cobalt, copper, iodine, iron, manganese and zinc. Molybdenum and selenium may be present in toxic amounts but the importance of this is unknown. The functions as well as outward deficiency symptoms are discussed for each trace mineral. Also quantitative requirements are listed for each.

In discussing the possible need for trace minerals by Oklahoma beef cattle, the author, using Highway 81 as a reference line, divided the state into east and west sections. The soils in the west tend toward alkalinity, thereby tending to be lower in manganese and iron than those in the east. If the alkalinity be caused by high levels of calcium, there is a possibility of a zinc deficiency; it being emphasized that limestone soils in either section could produce plants deficient in zinc. Soils east of the reference line tend toward an acid condition, thus have high levels of iron and managanese, with some evidence of lower copper levels. Cobalt doesn't seem to be a critical element, but forages from the leached hills in east seem most likely to be deficient in this element.

Feeding trials with cows grazing the dry winter forage supplemented with natural protein indicate no advantage in adding trace minerals. In more critical trials, cottonseed meal did not greatly affect gains but greatly improved the general appearance of the animals; the cattle receiving trace minerals had glossy haircoats in comparison to a dull, dry haircoat in the control cattle.

When urea is substituted for some of the oil meals in protein supplements for winter feeding, trace minerals must be added.

Fattening rations containing high levels of corn or barley are improved by additions of the trace minerals. Milo apparently contains higher levels of the trace minerals than corn or barley; however, changes in production procedures are affecting the mineral composition of the milo grains, and there is some evidence that those produced on alkaline soils are deficient in zinc.

Relationship of Some Growth Factors With Carcass Composition in Milk Fat Wether Lambs

A. W. Munson, L. E. Walters and J. V. Whiteman

This study was designed to determine the relationship between excellence in the carcass and the pattern of growth and development of the lamb from birth to market weight. Breed and type of rearing were of particular interest with respect to their association with carcass composition.

Figure 1, drawn from classical works, illustrates the increase in weight of fat, lean and bone in the lamb carcass. It can be seen from the figure that bone growth is rather constant while the increase in the other two components, fat and lean, varies with the age of the lamb. During early life, muscle growth is relatively faster than fat deposition. However, during some period, probably between the tenth and fifteenth weeks, the growth rate of lean begins to decrease and the rate of deposition of fat increases. Restriction of feed intake during early life should reduce lean development during the period prior to the onset of heavy fat deposition. Will an increased lean growth rate follow such restriction or will the gain be the result of the fat deposition that is more normal at this age? Twin lambs, while nursing a ewe, have the naturally occuring environmental effect of restricted diet when compared to single lambs.