MINERALS IN LIVESTOCK FEEDING

By H. H. MITCHELL, Professor of Animal Nutrition

The thirteen separate and distinct mineral elements known to be required in the proper nourishment of animals perform many important functions in the body. They contribute to the structure, particularly bones and teeth: 50 to 60 percent of the dry matter of bones consists of salts of calcium, magnesium, and phosphorus. They aid in muscular activities, in the reproductive processes, and in lactation and egg production. They promote digestion of food, repair of body tissues in maintenance, formation of new tissue in growth, and liberation of energy for muscular work and activity and the production of heat. It is not surprising that an animal fed a mineral-free diet will soon die.

Symptoms of mineral deficiencies may be mild or severe, even to the point of death, but they are not usually typical of any particular mineral lack. The cause of the malnutrition cannot be immediately traced to a lack of calcium, or iron, or some other mineral by mere inspection of the animal. An accurate diagnosis ordinarily cannot be made without an analysis of the blood, or of the ration, or of the soil upon which the feed is grown.
Areas in the United States where mineral deficiencies of animals are known to occur. Dots indicate the approximate location of soils with observed deficiencies. Lines not terminating in dots indicate a generalized area where specific locations have not been reported. The goiter region is also a generalized area. (Reproduced from U. S. Dept. Agr. Misc. Pub. 664, courtesy of Dr. K. C. Beeson)
Mineral-deficiency diseases in livestock are best prevented in three ways:

By maintaining the fertility of the soil so that pastures and feed crops will contain their normal amounts of the various minerals an animal needs. The soil-management procedures required to produce feeds of good nutritional quality will also increase crop yields.

By combining feeds into rations to the best advantage so that, in so far as possible, the mineral needs of the animal are covered. A properly balanced ration will insure not only against mineral deficiencies but against protein and vitamin deficiencies too. It will also increase the feed economy of milk production, egg production, and gains in weight.

Where the first two steps fail to secure the desired results, by supplementing the ration with minerals, either home mixed or in commercial mixtures. This step is sometimes taken with little attention to the first two, resulting in the needless purchase of mineral supplements or mixtures and often in providing more minerals than the animal needs, possibly even more than is good for it.

**Occurrence of Mineral Deficiencies in Livestock**

In certain areas of the country, mineral deficiencies in livestock occur because of mineral deficiencies in soils and waters (see map).

The “goiter belt” of the United States, where iodine deficiency is prevalent, is the best-defined deficient area. This area extends over the northwestern states, the Great Lakes region (including the northern and eastern counties of Illinois), all of Indiana and Ohio, and into Pennsylvania.

Phosphorus deficiency in livestock is also widespread. Phosphorus-deficient areas along the Gulf coast and up into the Great Plains as far north as the Canadian border have been recognized. Other areas have been located in Tennessee, Kentucky, West Virginia, New York, Michigan, Wisconsin, and Minnesota.

In isolated areas of the country, deficiencies of calcium, copper, iron, and cobalt have been recognized in livestock. Much attention recently has been given to cobalt deficiencies in grazing animals. Cobalt deficiencies in cattle and sheep have been reported from Florida, eastern Pennsylvania, the Cape Cod area in Massachusetts, northeastern New York, Michigan, and Wisconsin.

It thus appears that Illinois is remarkably free from deficiencies in all minerals except iodine. It is quite possible, however, that mild
chronic deficiencies of some of the minerals needed by livestock occur in Illinois but have not been recognized because their effects are evident in subnormal growth, appetite, and feed utilization rather than in disease symptoms. This may be inferred from the fact that the crop-producing capacity of most Illinois soils can be improved by proper soil-treatment, as shown in Illinois Bulletin 516. Furthermore soils that now contain sufficient quantities of the minerals needed by plants and animals may eventually lose them by leaching, erosion, and high crop yields. For example, hybrid corn because of its higher yields removes minerals more rapidly from the soil than does open-pollinated corn.

These facts suggest that pasture and feed crops in Illinois may well be deficient in minerals or may soon become deficient. These deficiencies can be corrected by proper soil treatment and crop rotation, which will both increase yields and add quality to the crop.

Phosphorus deficiencies in particular should be watched for among grazing animals.

**Signs of Mineral Deficiencies in Livestock**

The outward signs of mineral deficiencies usually are not enough to tell what mineral is at fault. One may note only such general symptoms as depressed or possibly depraved appetite, retarded growth, unthrifty appearance, inefficient use of food, and subnormal milk or egg production. Other symptoms are more specific and useful in diagnosis.

**Iodine deficiency:** Goiter in new-born animals, hairlessness in pigs.

**Salt deficiency:** An intense craving for salt, rapid weight loss, lusterless eyes, diminished milk production in dairy cows.

**Phosphorus deficiency:** Fragile bones, stiff joints, bone chewing or the chewing of wood, hair, rags, and other materials not ordinarily of interest to the animal. Rejection of phosphorus-deficient hay.

**Calcium deficiency:** Weak bones, extreme irritability. Symptoms of calcium deficiency are slow in developing, because bone calcium may be drawn upon to supplement a deficient supply of calcium in the feed.

**Iron deficiency or copper deficiency:** Anemia, recognizable by paleness of membranes of the mouth. "Thumps" in suckling pigs. Extreme copper deficiency may lead to bleaching of the hair in cattle and to "stringy" wool in sheep.
Manganese deficiency in poultry: Slipped tendon; in laying hens, low egg production, low hatchability of fertile eggs, low eggshell strength, deformed embryos.

Magnesium deficiency: Listlessness, but the animal may be thrown into convulsions when disturbed.

Cobalt deficiency in ruminants: Loss of appetite, progressive emaciation, listlessness, scaly skin, rough hair coat, anemia, and frequently diarrhea. Fertility and milk production are impaired.

Potassium deficiency: Impaired growth, depraved appetite, low blood pressure.

Other and more informative signs of mineral deficiencies may be detected by blood analysis and other laboratory procedures.

Maintain Soil Fertility to Prevent Mineral Deficiencies

A most important step in the proper mineral nutrition of farm livestock is the production on the farm of pastures, hays, silages, and grains that will contribute as much mineral nutriment to farm rations as possible. This can be done by maintaining the fertility of the soil by fertilization and proper crop rotation. Correction of soil deficiencies in mineral nutrients will produce not only better yields of crops but also yields of maximum nutritive quality for the crop in question. When grown on fertile soil, pasture crops may provide a most nutritious feed for grazing animals, but if the soil is very poor, they may produce malnutrition, associated with poor growth, inefficient utilization of feed, and even death if the condition is not corrected.

Furthermore, maintenance of a high fertility level in the soil means that a wider choice of crops can be grown in the interests of better nutrition of farm animals. For example, liming acid soil makes possible a larger proportion of legumes in the forage, which in turn means more calcium and protein for the animal.

Proper Balancing of Rations

Some feeds, such as grass in the early stages of growth, are complete feeds in themselves, requiring no supplemental feeds to correct mineral (or other) deficiencies. Only their high water content limits their value in supporting a high rate of production in livestock. But most feeds are not of this description. They are too low in one or another of the mineral nutrients. For their proper use in rations, they
should be combined with other feeds rich in those minerals in which they themselves are deficient. Thus the deficiencies of grains in calcium are corrected when fed with legume pastures or hays which are rich in calcium, while possible deficiencies of these legume forages in phosphorus, if they have not been produced upon good soil, are corrected by the relatively high phosphorus content of grains. For these and other reasons, roughages are natural supplements for grains.

The information summarized in Table 1 has been assembled to permit a more effective consideration of the principles that should guide the balancing of rations with respect to minerals. The upper part contains estimates of the average basic requirements for minerals by the various classes of livestock, in so far as available information permits. Young animals may require somewhat more than these averages and older animals somewhat less. The table also contains average mineral analyses for a few feeds, selected for their availability for livestock feeding in the corn belt. Individual samples of these feeds may, of course, differ in composition considerably from the averages given, and this point must be kept in mind in balancing rations at safe mineral levels.

The mineral requirements and feed compositions in Table 1 are expressed on the moisture-free, or dry-matter, basis to make them comparable. On the fresh basis, for example, soybean meal is a much better source of calcium than milk, but merely because the latter is diluted with water that could just as well be consumed as such. Water is the most variable constituent of feeds, and at the same time contributes nothing to their nutritive value that cannot be provided at the water trough. While the table affords a good comparison of feeds as sources of minerals, it cannot be used without further calculations in the balancing of rations with feeds containing their natural content of water. The data are, however, directly applicable when computing the dry-matter requirements of animals.

A practicable ration, reasonably well balanced in other respects, is likely to contain adequate levels of potassium and magnesium. This follows from the fact that the requirements for these two minerals in the ration (dry basis) — 0.15 to 0.20 percent of potassium and 0.04 to 0.07 percent of magnesium — are so much lower than the percentages of these minerals in dry feeds.

The same is true for copper, cobalt, and iron, except in restricted areas where the soils, waters, and forage crops are deficient in one or another of these elements. In such areas special measures to combat mineral deficiencies are required. The occurrence of iron and copper
| Table 1. — Mineral Requirements of Farm Animals and Mineral Content of Farm Feeds*
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<tr>
<td>(On basis of dry feed)</td>
<td>Calcium</td>
<td>Phosphorus</td>
<td>Potassium</td>
<td>Magnesium</td>
<td>Manganese</td>
<td>Iron</td>
<td>Copper</td>
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<td>Requirements for growing stock on basis of dry ration</td>
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<td>Chickens</td>
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<td>.20</td>
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<td>Pigs</td>
<td>.4</td>
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<td>Sheep</td>
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<tr>
<td>Cattle</td>
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Feed composition on dry basis

| Feed composition | per cent. | per cent. | per cent. | per cent. | p.p.m. | p.p.m. | p.p.m. | p.p.m. |
|---|---|---|---|---|---|---|---|
| Corn | .027 | .32 | .37 | .13 | 6 | 10 | 10 | 1.0 |
| Oats | .10 | .46 | .57 | .18 | 45 | 80 | 80 | 80 |
| Barley | .10 | .57 | .56 | .18 | 20 | 55 | 55 | 55 |
| Rye | .05 | .45 | .48 | .18 | 29 | 53 | 53 | 53 |
| Wheat, spring | .06 | 1.41 | 1.23 | .56 | 127 | 211 | 211 | 211 |
| Wheat bran | .16 | 1.41 | 1.23 | .56 | 127 | 211 | 211 | 211 |
| Wheat middlings, standard | .16 | 1.41 | 1.23 | .56 | 127 | 211 | 211 | 211 |
| Cottonseed meal, 34 to 37 percent protein | .48 | 1.03 | .37 | .58 | .46 | 624 | 624 | 624 |
| Linseed meal, 34 to 37 percent protein | .29 | .68 | .27 | .33 | .32 | 154 | 154 | 154 |
| Soybean meal, 44 to 48 percent protein | .29 | .68 | .27 | .33 | .32 | 154 | 154 | 154 |
| Tankage, digester, 60 percent protein | .6 | .30 | .50 | .24 | 2472 | 47 | 47 | 47 |
| Meat scrap, 52 percent protein | .6 | .30 | .50 | .24 | 2472 | 47 | 47 | 47 |
| Fishmeal, Menhaden | .6 | .30 | .50 | .24 | 2472 | 47 | 47 | 47 |
| Skim milk | .14 | 1.2 | 2.54 | .15 | 3 | 58 | 58 | 58 |
| Milk whey | .97 | 1.2 | 2.54 | .15 | 3 | 58 | 58 | 58 |
| Alfalfa meal | .16 | 1.6 | .32 | .46 | .30 | 48 | 48 | 48 |
| Alfalfa leaf meal | .17 | 2.4 | .66 | .30 | 48 | 48 | 48 | 48 |
| Clover hay, red | 1.30 | 2.2 | 3.83 | .30 | 139 | 186 | 186 | 186 |
| Lespedeza hay | .87 | 2.1 | 3.02 | .36 | 200 | 191 | 191 | 191 |
| Soybean hay | .38 | 2.4 | 3.77 | .28 | 212 | 212 | 212 | 212 |
| Timothy hay | .31 | 1.6 | 1.36 | .07 | 96 | 96 | 96 | 96 |
| Corn stover | .32 | .06 | .50 | .24 | 127 | 219 | 219 | 219 |
| Corn fodder | .26 | .18 | .90 | .24 | 96 | 96 | 96 | 96 |
| Corn silage | .11 | .20 | .90 | .24 | 96 | 96 | 96 | 96 |
| Blue grass | .34 | .24 | 1.40 | .24 | 96 | 96 | 96 | 96 |
| Sudan grass | .55 | .46 | .38 | .24 | 127 | 219 | 219 | 219 |
| Broome grass | .48 | .32 | 1.16 | .24 | 96 | 96 | 96 | 96 |
| Oat straw | .21 | .11 | 1.50 | .24 | 733 | 203 | 203 | 203 |
| Bone meal, steamed | 30.2 | 15.6 | .30 | .13 | .31 | .11 | .11 | .11 |

| Minerals in Livestock Feeding |
|---|---|---|---|---|---|

* The mineral contents of feeds collected in this table have been secured from various sources, though special acknowledgment should be made to the following publication: Composition of Feeds, Supplement to Report No. 1, Vitamin and Mineral Content, Committee on Feed Composition, National Research Council, Division of Biology and Agriculture, November, 1947. Blank spaces in the table do not indicate that the feed is completely lacking in the mineral in question; they indicate no information is available on the corresponding analyses. The moisture contents of the feeds listed in the table are approximately as follows: dried roughages 10 to 12 percent; grains 10 percent (No. 2 corn will carry about 15 percent moisture); oil meals 8 to 10 percent; fishmeal, meal meal, and tankage 6 to 8 percent; steamed bone meal 4 percent; blue grass, broom grass, and Sudan grass (as pasture) 70 to 75 percent; corn silage 65 to 75 percent (very variable); skim milk 21 percent; and whey 36 to 44 percent.

b Parts per million.
deficiency in suckling animals, especially pigs, due to the deficiency of the dam’s milk in these minerals, presents a special case when pasture or other solid feed is not available during the first few weeks of life.

Poultry rations, especially if based largely upon corn, may have less manganese than required, justifying the routine use of a manganese supplement. For other classes of livestock, however, there is no reason to suspect manganese deficiency in practical rations.

Calcium and phosphorus undoubtedly require special attention in balancing farm rations because many feeds contain less than is needed. Grains and grain products as a class are grossly inadequate in calcium, but less often inadequate in phosphorus. Protein concentrates of plant origin are also too low in calcium but adequate in phosphorus, while those of animal origin, to the extent that they contain bone, are rich in both calcium and phosphorus. Legume forage and hay crops are rich in calcium but of variable phosphorus content, depending in large part on the content of available phosphorus in the soils upon which they are grown. Nonlegume pasture crops and hays are not particularly reliable sources of either calcium or phosphorus.

For these reasons calcium deficiencies are more prevalent among swine and poultry, which consume rations made up largely of grains and seed products, while phosphorus deficiencies are more prevalent among grazing animals, cattle and sheep.

A close relationship exists between the requirements of animals for phosphorus and the requirements for protein. By combining protein concentrates with grains and grain products to produce rations containing adequate levels of protein for livestock, the phosphorus content of the mixture is usually raised above 0.3 percent. If animal protein concentrates are used, it may be raised considerably above 0.4 percent. The needs of growing animals for phosphorus, except for the very young animal, are mostly 0.3 percent or less, and reach 0.45 percent only for the chicken.

In very early growth, about 0.04 pound of phosphorus is required for each pound of protein required. In the fully grown animal, the ratio drops to 0.02 pound or less of phosphorus per pound of protein. Since in the hen’s egg the ratio of phosphorus to protein is 0.015 to 1, and in 3.5 percent milk, 0.025 to 1, one would not expect that either egg production or milk production would raise the ratio of phosphorus required to protein required beyond this range of 0.02 to 0.04 to 1. In cereal grains the ratio of phosphorus to protein varies from 0.027 to 0.033 to 1, and in vegetable protein concentrates from 0.015 to 0.030 to 1. In packinghouse byproducts containing much bone, the ratio may be very much higher.
Thus it may be concluded that if the protein in a farm ration is raised to an adequate level by the proper combination of available feeds, the phosphorus content will usually be raised to an adequate level simultaneously, without the need of a mineral supplement. The young chick or the young pig will be exceptions to this statement if animal protein concentrates are not used.

**Use of Mineral Supplements**

**Salt.** The requirements of animals for the minerals contained in common salt (sodium and chlorine) are probably not covered by rations composed of plant feeds only. The addition of 0.5 percent of salt in grain mixtures for swine and poultry is sufficient to cover this need, and is probably too much when the mixture contains considerable amounts of animal feeds. Certainly larger proportions are not to be recommended for swine and poultry. Grain mixtures for dairy cows should contain 1 percent of salt. The free offering of salt separate from the ration is a common practice, though not without a rather remote hazard in exceptional cases. Horses doing hard work in hot weather need more than the usual amounts of salt because of losses in the sweat.

**Iodine.** In those areas of the country, including the northern and eastern counties of Illinois, where the iodine in feed and water may be so low as to cause thyroid troubles, the use of iodized salt is advisable, especially for pregnant females. Iodized limestones are also available for this purpose. As little as 0.01 percent of potassium iodide in salt, if some stabilizing agent is included also, is all that is needed.

**Copper, iron, cobalt.** In other parts of the country where the herbage and the waters are unusually low in copper, iron, or cobalt, salts of these minerals should be added to farm rations regularly in amounts to cover the basic requirements indicated in the table, with some to spare for safety. The salts used should preferably be easily soluble ones to insure ready availability by the animal. Such insoluble compounds as iron oxide are of little use in animal rations.

In correcting the condition of "thumps" in baby pigs, due to the iron and copper deficiency of sow’s milk, a solution of either hydrated ferric sulfate or copperas (1 pound of either in 3 quarts of water) may be spread over the udder of the sow with a brush once a day. In this way the pigs get their iron, containing copper as a contamination, when they take their milk feedings. Access to soil or pasture may be equally effective.
Manganese. As mentioned above, it is advisable to add manganese to all poultry rations, especially those based mainly on corn. About two-fifths of an ounce of manganese sulfate (feeding grade) per 100 pounds of mash is sufficient. Other animals are not likely to need it.

Calcium and phosphorus. Occasions will arise, due to unavailability of desirable feeds or to intensified requirements of the animal, when mineral supplements of calcium or of phosphorus should be added to the ration. The intensified requirement for calcium of the laying hen is provided for by the free-choice offering of calcium carbonate preparations, such as oystershells, mussel shells, or limestone. The young chick or pig or the pregnant sow may need extra phosphorus as a mineral supplement, because early rapid growth and pregnancy intensify the need for this mineral element.

The expanding use of vegetable protein concentrates, containing lower levels of phosphorus than such animal concentrates as meat scraps, tankage and fish meal, has increased the demand for phosphorus mineral supplements. Also, soybean meal, the most important protein concentrate in present day feed mixes, and other concentrates of plant origin contain a large proportion of their phosphorus in a form, known as phytin, that is not efficiently utilized by poultry.

When calcium and phosphorus supplements are required, the choice should of course be made among those minerals known to be highly available to the animal and uncontaminated by toxic impurities. Bonemeal (13 percent phosphorus, as an average for raw, steamed, or special steamed), dicalcium phosphate (generally guaranteed to contain 18 to 20 percent phosphorus), and tricalcium phosphate (18 percent phosphorus) are excellent sources of both calcium and phosphorus. Rock phosphate cannot be recommended because of its usually high content (2 to 4 percent) of fluorine, an element definitely toxic at concentrations above 0.01 percent in the total ration for four-footed animals. Rock phosphate is unsafe for all classes of livestock in the amounts that would serve as an effective ration supplement, although poultry are much less susceptible to fluorine injury than are cattle, sheep, or swine. Superphosphate and colloidal phosphate are also unsafe mineral supplements because of their fluorine contents. Defluorinated phosphates (containing 13 to 18 percent phosphorus as currently marketed), prepared from rock phosphate by heat treatment, may be used in animal feeding in proportion to their fluorine content (generally ranging from 0.05 to 0.3 percent). The fluorine content of the total ration due to the use of mineral phos-
phates should never exceed 0.01 percent on the dry basis for cattle, sheep, and swine, or 0.05 percent for poultry. For breeding stock and dairy cows, which are fed for longer periods of time than are meat-producing stock, the fluorine content of the ration should be no higher than 0.005 percent.

The defluorinated products made from rock phosphate, quite aside from their content of fluorine, are of widely different values as phosphorus supplements. Defluorination by the fusion process has yielded the more satisfactory products with phosphorus availabilities approaching or equaling that of bone meal. Defluorination by the superphosphate procedure, involving calcination and treatment with acid, yields less uniform and less satisfactory products. The phosphorus in some of them is poorly utilized by the animal.

A wide variety of calcium supplements, other than phosphates, can be used in animal feeding. These include the carbonates, such as oystershells, limestone, and calcite. Marl and dolomitic limestone are calcium carbonates mixed with clay and magnesium carbonate respectively in varying amounts. The purer carbonates contain 38 to 39 percent of calcium. The dolomitic limestones containing considerable amounts of magnesium carbonate are correspondingly less valuable as calcium supplements and are not recommended, especially in poultry rations. Calcium sulfate (gypsum), containing 25 percent of calcium, is also a good calcium supplement.

The full value of all calcium and phosphorus supplements, or calcium and phosphorus components of feeds, is realized only when the ration contains enough vitamin D, or when the animals are exposed to adequate amounts of sunlight. Exposure of farm animals to direct (or even diffused) sunlight is the usual method of providing vitamin D. Sunlight filtered through ordinary window glass is ineffective. Sun-cured hays will contribute some of the vitamin also, but under special conditions the inclusion of vitamin D concentrates (fish oils or commercial preparations of vitamin D) in the ration is advisable.

Mixtures. When mineral supplements are fed to animals as mixtures, outside of the ration and offered free choice, it is convenient to prepare simple combinations that will serve special or general purposes, even though this practice may not be the most economical of minerals. A mixture composed of 2 parts ground limestone and one part salt (preferably iodized) will correct calcium deficiencies satisfactorily. For rations containing adequate amounts of a high-phosphorus protein concentrate, it is the best, cheapest, and most convenient mixture to use.
A mixture of 2 parts bonemeal (or dicalcium phosphate or defluorinated rock phosphate) and 1 part salt (preferably iodized) will supply both calcium and phosphorus in a favorable ratio and in available forms.

A mixture of equal parts of finely ground limestone, bonemeal, dicalcium phosphate or defluorinated rock phosphate, and salt (iodized if insurance is desired against thyroid troubles) will supply much more calcium than phosphorus and may be considered as a good all-purpose mineral mixture under Illinois conditions.

The inconvenience of securing and mixing the ingredients of these mineral mixtures may be overcome by buying commercial mixtures put out by reliable manufacturers. The simpler these mixtures are, within limits, the more economical they will be. Complex mixtures containing many minerals other than salt, iodine, calcium, and phosphorus are not known to be necessary in the corn belt and are more expensive than simple mixtures. But if the livestock man wants to buy insurance against possible deficiencies in his animals of cobalt, copper, iron, manganese, and other trace minerals, the most convenient course is to buy complex mixtures, rather than to make up his own mixture. It is true that the mineral requirements of animals are complex, but nature has simplified the problem of mineral feeding by putting most of the needed minerals in plant feeds in amounts adequate for the animal.

Some mineral mixtures on the market contain laxatives, worm expellers, tonics, and other substances of no known value, such as charcoal. Healthy animals do not need such medicines, nor can their use diminish the need for sanitary measures in livestock management. Bowel movements in animals are better controlled by favorable levels of fiber (ballast) in the ration. Worm expellers, when needed, should be given in controlled doses, not dependent upon the appetite of the animals for mineral mixtures.

**An Excess of Minerals May Be Harmful**

In balancing rations for farm animals, it is wise to set the mineral levels above the estimated basic requirements as given at the top of the table. A reasonable margin of safety is good. But there is a limit to such margins, beyond which there may be a nutritional hazard. Many of the nutritionally essential minerals, such as manganese, copper, and cobalt, are toxic above certain low levels of intake or possess undesirable physiological effects. Even common salt, when consumed in excess, may lower the iodine content of the thyroid gland or lead to edema.
and the accumulation of fluid in the abdominal cavity. Also inter­
actions occur among minerals in the digestive tract, whereby one
mineral will precipitate another in an insoluble form. Thus a soluble
phosphate, coming in contact with soluble salts of iron or aluminum
(present in some forages), will precipitate insoluble phosphates, im­
pairing the utilization of both phosphorus and iron. Such insoluble
mineral precipitates may adsorb other minerals and prevent their
utilization. These interactions among minerals in the gastrointestinal
tract occur at all times, but may be disastrous if one of the precipi­
tated minerals is present in the ration in an amount which is borderline
with reference to requirements.

The element calcium seems particularly capable of disturbing the
assimilation of other minerals. The utilization of the main form of
phosphorus in grains (phytic acid) is impaired by ratios of calcium
to phosphorus in the feed of 2 to 1 or higher. Many salts of calcium
greatly reduce the assimilation of iron. Excess calcium depresses the
assimilation of manganese and of iodine. For similar reasons excess
liming of the soil may reduce the amounts of trace elements in pastures
and forage crops.

Unless rations for farm animals have enough minerals, impairment
of appetite and inefficient use of food will result, followed by patho­
logical symptoms and then death. But the mineral content of the
ration needs to be kept within bounds, not only because of the bad
effects of excess minerals and of the immobilization of essential
minerals in insoluble precipitates, but also because minerals con­
tribute no food energy to the animal. The higher the mineral content
of a ration, the lower its energy and fattening value. Farm animals
must have minerals, but minerals in moderation.

Needs of Different Classes of Livestock

Swine. Salt should be fed to all swine irrespective of their rations.
This is the only mineral supplement needed when enough tankage,
skimmilk, or buttermilk is fed to balance the ration in protein. Es­
pecially in the northern and eastern counties of Illinois, and in other
areas in the “goiter belt,” the use of stabilized iodized salt in brood
sow rations is recommended.

The calcium deficiencies of a corn ration will be adequately taken
care of by including in the ration about 8 percent of tankage (60 per­
cent protein), or 15 percent of a trio mixture consisting of equal parts
alfalfa meal, soybean meal, and either tankage, meat scraps, or meat
and bone scraps, or by feeding about 6 pounds of skim milk for each pound of corn.

Legume pasture, if abundant, reduces largely the need for calcium supplements. Five pounds of fresh alfalfa daily is probably sufficient to supply the calcium requirements of a 100-pound pig. If the protein supplement is of vegetable origin (one of the oil meals, for example), a calcium supplement is needed. The mineral mixture selected (pages 9 to 12) is most conveniently self-fed. If incorporated in a grain mixture to insure its consumption, 2 percent of it should be enough.

A special need for iron salts develops in pigs farrowed in the late winter and early spring months and kept in a barn for 4 to 6 weeks with no access to soil and forage. Under these conditions the little pigs become severely anemic, because milk is extremely deficient in iron salts. Their breathing becomes labored (thumps), they take on a swollen appearance, especially around the head and shoulders, become weak, and often die unless their diet is corrected with iron salts. The iron salts needed are effectively got to the pigs by smearing on the dam’s udder a solution of commercial iron sulfate (or other soluble iron salt) in water. The little pigs then take their iron supplement when they take their milk.

**Chickens.** Chickens should be provided with common salt at all times. One-half percent of common salt should be added to an all-mash chick starter, and 1 percent to a ration of laying hens.

When rations for growing chicks or laying hens contain as much as 10 to 15 percent of meat scrap, tankage, or fish meal, depending upon the content of calcium, it is not necessary to include any additional calcium or phosphorus in the form of mineral supplements. Milk products are much less efficient in this respect; about 65 percent of them (on the dry basis) would be required in a ration in order to supply as much calcium as 10 percent of tankage supplies. When meat scrap, tankage, or fish meal is replaced in whole or in part by vegetable protein concentrates, the mineral deficiency may be corrected by adding 1 pound of steamed bonemeal (or of a mixture of equal parts of steamed bonemeal and limestone) for each 4 to 5 pounds of supplement replaced. Laying hens also have a very high calcium requirement for egg-shell formation and should be given free access to oystershell or other satisfactory form of calcium carbonate at all times.

Excessive feeding of minerals may have an unfavorable effect on growth and bone formation and should therefore be avoided.

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\[A \text{ solution containing 1 pound of either hydrated ferrie sulfate or copperas in 3 quarts of water is effective when applied to the udder once daily.}\]
Rations consisting largely of corn, milk products, meat scraps, and bone products may be deficient in manganese both for the breeding flock and for growing chicks. Hens will produce eggs of low hatchability containing deformed embryos, and chicks will develop perosis or slipped tendon. The condition can be prevented by substituting oats for half the corn in the ration; by the inclusion of high-manganese feeds, such as wheat bran, standard wheat middlings, and rice bran; or by adding to the ration \( \frac{1}{2} \) pound of manganese sulfate (feeding grade — 80 percent) per ton of feed.

**Beef cattle, sheep, and horses.** When raised on nonlegume forage, especially if the soil is acid, beef cattle, sheep, and horses should usually be given calcium and phosphorus supplements, especially pregnant and lactating females. A mixture of limestone, steamed bonemeal, and salt in equal parts is conveniently self-fed.

If these animals are grazed during the pasture season on good legume forage, and for the rest of the year receive at least one feed per day of good-quality legume hay, no such supplements are needed, though free access to salt should be provided at all times.

**Dairy cattle.** All dairy cattle should be given free access at all times either to boxes of fine salt or to block salt. In addition an excellent plan for dairy cows in milk is to include 1.5 to 2 pounds of salt in 100 pounds of grain mixture. Calf starters for young calves should contain approximately 1 percent salt.

Calcium may be deficient in dairy rations that include no legumes, particularly if the roughage is grown on acid soils or on soils of low fertility. Roughages grown on soils rich in lime may contain twice as much calcium as the same kinds of roughages grown on highly acid soils.

According to present knowledge, legumes, used as pasture crops, silages, or as well-cured hay, are the best sources of calcium for dairy cows. When legumes cannot be supplied, calcium may be furnished in ground limestone or in bonemeal of feeding grade. These may be mixed with the grain at the rate of 1 pound for each 100 pounds of grain mixture or, for cows on pasture, a mixture consisting of 2 parts of bonemeal, 2 parts of limestone, and 1 part of salt may be supplied in boxes to which the cattle have free access. *Rock phosphate contains harmful amounts of fluorine and should not be fed to cattle unless defluorinated to remove most of the fluorine in it.*

Phosphorus may be deficient when the dairy ration is made up largely of roughage, since most roughages contain relatively small
amounts of this element. Roughages grown on soils poor in phosphorus may be especially low in phosphorus. This deficiency, which may lead to very serious disturbances in the health of the animals, can be remedied easily. The best way usually is to supplement grain mixtures with feeds that are good sources of phosphorus as well as protein. If the grain mixture contains as much as 5 percent of cottonseed meal or wheat bran, 8 percent of linseed meal, or 12 percent of soybean meal, it probably is adequately supplied with phosphorus, though not necessarily with protein. Special care should be taken to provide a phosphorus source to heavy milking cows and growing animals that are on pasture but are not receiving any grain. *Steamed bonemeal and dicalcium phosphate are among the best minerals for remedying phosphorus deficiencies when inadequate amounts of high-protein feeds are used.*

Unless evidences of iodine deficiency have been observed, as in the northern and eastern counties of Illinois, no benefit is likely to be derived from feeding iodine supplements to dairy cattle. The deficiency is evidenced by the presence of goiter in the calf at birth or by the development of goiter soon after birth. The trouble is easily prevented by substituting iodized salt for ordinary salt supplied to cows during the last five months of pregnancy. Fish meal and kelp are also possible sources of iodine for cattle, but may be more expensive than iodized salt.

The use of trace-mineralized salt in animal feeding is in the experimental stage as far as the state of Illinois is concerned.

No mineral feeding program has yet been found that will prevent milk fever in cows or prevent or cure brucellosis (*Bang's disease*).