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Mineral Feeds

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5. The minerals most likely to be deficient in ordinary farm rations are common salt, calcium (lime), phosphorus, and iodine.

6. Economy and good nutrition demand that mineral supplements be chosen with reference to the probable deficiencies of the ration with which they are to be fed.

7. Livestock should always be allowed free access to common salt.

8. In goiterous regions, iodine should be supplied as directed in this Bulletin.

9. Sterilized bone-meal or flour, specially prepared for animal feeding, usually supplies calcium and phosphorus economically in about the proportions in which these elements are stored in the animal body. Where lime only is needed, finely ground, high-grade limestone is an economical supplement.

10. When in doubt concerning the need of mineral supplements, an accurate description of the kind and amount of feedstuffs used will often enable your Experiment Station to make valuable suggestions concerning the probable need of mineral supplements.

Mineral Feeds

By

J. R. HAAG

INTRODUCTION

AN adequate discussion of this subject would presuppose an exact knowledge of mineral requirements that we do not now have. We do know, however, that efficient and economical production and continued health and freedom from reproductive disturbances require an adequate intake of essential mineral elements.

The mineral-feed problem is not an invention of the modern nutrition specialist. The old European scientific journals contain many accounts of troubles experienced generations ago. The difficulties experienced fifty or a hundred years ago have been multiplied by modern breeding and management practices. In place of the primitive hen that once produced a few dozen eggs we now have the 300-egg hen. In place of the cow that once produced barely enough milk to raise her calf, we now have the 30,000-pound cow. In many sections the fertility of the once-virgin soils has been reduced to such an extent as to complicate our feeding difficulties. All of these conditions contribute to the complexity of the mineral-feed problem.

Chemists recognize the existence of some 90 elements. Many of these are found in plants and animals. Certain of these elements are recognized as being essential to normal nutrition. About others there is considerable doubt as to whether they are essential or merely accidentally present. While it is not now possible to give a final list of the essential mineral elements, such a list should at least include sodium, potassium, calcium, magnesium, sulfur, phosphorus, chlorine, iron, copper, and iodine. For practical purposes it is necessary to consider only those elements that are likely to be lacking in ordinary farm rations. Emphasis will therefore be placed on a comparatively small number of the foregoing list of essential elements.

It is seldom, if ever, true that all of the elements mentioned are deficient in any ration. Such deficiencies as may occur will depend on a number of factors, among which are the species of animal, the rate of growth, the amount of milk or eggs produced, the kind of crops fed, the geographical location, rainfall, and a variety of other factors.

Unfortunately, we do not know the exact mineral requirements of various farm animals. Any statements made concerning requirements are therefore subject to revision as future experimental work and field observations increase our knowledge. For practical purposes, however, it is necessary to make rather specific recommendations in order to make clear our position in this respect.

ESSENTIAL MINERAL SALTS AND ELEMENTS

Common salt. Probably the first mineral salt supplied to livestock was common salt. Common salt is made up of the elements sodium and chlorine and is known to chemists as sodium chloride. The craving for salt varies with the species of animal and with the diet. Just what factors are responsible for this craving is not clearly understood. It is recognized, however, that for practical purposes the appetite of the animal is a helpful guide in determining salt requirements. The daily salt requirements of farm animals are said to vary from about ½ ounce for calves and sheep to perhaps 3 ounces for high-producing cows. While it is a frequent practice to add ½ to 2 pounds of salt to each 100 pounds of grain mixture for dairy cattle, it is considered wise to allow all classes of farm animals free access to salt at all times. This will assure an abundant supply and will avoid the danger of overeating, often encountered where salt is not supplied regularly. Animals that have been denied salt for some time and then given free access to it may eat such large quantities as to cause digestive disturbances and even death. Such animals should be given small quantities of salt daily until the intense craving for salt has largely disappeared.

Sulfur. Sulfur is an essential element. Sulfur apparently is useful only in the organically combined form as it occurs in proteins. There is no evidence to indicate any value in the routine feeding of sulfur in its elemental form (ordinary sulfur) or in the form of some of its compounds such as Epsom salts or Glauber's salts.

Potassium. Potassium is also an essential element, but occurs so abundantly in many crops that a possible deficiency of this element need not worry the livestock feeder.

Magnesium. Magnesium occurs so abundantly in nature that we need not worry concerning magnesium deficiencies. In fact, there are occasions where there may be some concern about a possible excess of magnesium. In some sections of the United States the large amount of magnesium occurring in the drinking water in the form of Epsom salts has caused some concern. The use of high magnesium limestones, particularly for poultry feeding, may result in an excessive intake of magnesium.

Iodine. Iodine is recognized as an essential element. A deficiency of iodine is usually a regional problem, corresponding roughly to the goiterous regions for human beings. A deficiency of iodine results in disturbances of the thyroid gland. These disturbances take the form of goiter, "big neck," and "hairlessness" and are usually most severe in the new-born animal. Calves, foals, kids, lambs, and pigs may be affected. In the case of foals, general weakness and inability to "stand and suck" may be dominant symptoms, even though the enlargement of the thyroid gland may be hardly noticeable. An adequate supply of iodine is particularly important during the gestation period.

The exact requirements for iodine are not known. The quantity required, however, is known to be very small. Iodine may conveniently be supplied in the form of iodized salt (common salt containing about one pound of potassium iodide in 5,000 pounds of salt). In Oregon generally satisfactory results have been obtained by feeding 5 grains of potassium

iodide once a week to pregnant cows, sheep, and hogs. This recommendation may be carried out by sprinkling on the feed, once a week, one tablespoonful of a solution of 3 ounces of potassium iodide in 1 gallon of water. For pregnant mares this amount is better increased to 2 or 3 tablespoonfuls. There is no evidence that warrants the routine feeding of iodine in regions where goiter is seldom, if ever, known to be present. The use of excessive quantities of iodine may be harmful; it is also a useless expense.

Iron and copper. Iron has long been recognized as an essential constituent of hemoglobin, the red coloring matter of blood. A marked deficiency of iron results in nutritional anemia, a condition in which the blood is deficient in the red coloring matter just referred to. In recent years it has been shown that animals cannot properly utilize the iron in their rations unless a trace of copper is also present. There are a few regions in which livestock is known to suffer from a lack of iron or copper or both. There is as yet no substantial evidence that well-fed livestock in this section of the United States will benefit from the feeding of iron and copper salts. It is true that suckling pigs reared in strict confinement will usually become anemic, but this condition may be prevented by putting a box of sod and soil in the pen. The soil should come from land not used for pig pasture in order to insure its freedom from parasitic contamination.

Calcium and phosphorus. Calcium (or lime) and phosphorus requirements may well be considered together for several reasons. A large percentage of the calcium and phosphorus stored in the body is deposited in the bones in the rather constant ratio of about twice as much calcium as phosphorus. Milk and eggs contain considerable quantities of calcium and phosphorus. The animal body can use calcium and phosphorus independently of each other to only a limited extent. Utilization of both calcium and phosphorus is intimately tied up with vitamin D.

The exact calcium and phosphorus requirements of farm animals are not known. These requirements are known to vary with the species of animal, the rate of growth, reproductive requirements, and the production of milk and eggs. For cattle it may be assumed that a ration is likely to be deficient in calcium and phosphorus when its dry matter contains less than about 0.2 per cent phosphorus and 0.4 per cent calcium.

Disturbances in calcium and phosphorus nutrition in farm animals are shown in a variety of ways including rickets-like disorders, retarded growth, decreased milk production, reproductive disturbances, and depraved appetite. In the case of poultry, these disturbances cause rickets or leg weakness, decreased egg production, and soft-shelled eggs. To insure normal calcium and phosphorus nutrition the ration must provide:

1. An adequate amount of calcium.
2. An adequate amount of phosphorus.
3. A suitable ratio or proportion between the amounts of calcium and phosphorus present in the ration.
4. An adequate amount of vitamin D or its equivalent in direct sunshine.

An ample supply of vitamin D is necessary for the proper utilization of the calcium and phosphorus contained in the ration. The calcium of good pastures or of carefully cured hay seems to be better utilized than that contained in improperly cured or in bleached hay.

The significance of the calcium to phosphorus ratio in nutrition has probably been overemphasized at times. In the absence of more specific information, it may be assumed that the normal ration of most farm animals should contain about 1½ to 2 times as much calcium as phosphorus. Minor variations in this ratio need not cause any concern.

CALCIUM AND PHOSPHORUS CONTENTS OF FEEDSTUFFS

In order to select rations that will meet the calcium and phosphorus requirements of farm animals it is necessary to know something of the calcium and phosphorus contents of representative types of feedstuffs. Table I shows the approximate calcium and phosphorus contents of some of the common types of feedstuffs encountered in Oregon.

TABLE I. APPROXIMATE CALCIUM AND PHOSPHORUS CONTENTS OF SOME COMMON FEEDSTUFFS*

Crop	Percentage of calcium	Percentage of phosphorus
	%	%
Corn	.01	.30
Oats	.09	.35
Barley	.02	.37
Wheat	.05	.36
Wheat bran	.10	1.25
Linseed-oil meal	.38	.75
Skim milk powder	1.28	1.00
Meat scrap (25% ash, 55% protein)	8.70	4.30
Fish meal (22% ash, 65% protein)	7.40	3.70
Alfalfa hay	1.20	.20
Red-clover hay	1.00	.16
Vetch hay	.74	.23
Oat hay	.34	.17
Oat-vetch hay	.62	.22
Cheat hay	.37	.19
Wheat straw	.22	.04
†Corn silage	.49	.21
†Kale	1.62	.47
†Poor pasture	.14	.13
†Good pasture	.70	.30
†Ladino clover pasture	1.57	.39

*The analyses given in this Table have been compiled largely from Station Bulletin 197 and other records of the Oregon Agricultural Experiment Station. A few figures have been taken from the publications of other stations.

†In the case of corn silage, kale, and pastures, percentages are expressed on dry-matter basis.

A study of the analyses contained in Table I helps to explain some of the mineral-feed problems encountered in various parts of the country. It is easy to see why a corn- or barley-fed hog, receiving very little milk, meat-meal, pasture, or alfalfa, should suffer from rear-end paralysis, a rickets-like condition, caused by a deficiency of calcium. It is also easy to understand why a cow, fed largely on alfalfa, does not need extra calcium (lime) but may need extra phosphorus.

CALCIUM AND PHOSPHORUS SUPPLEMENTS

Obviously one of the feeder's objectives should be to choose feeds with some attention to their calcium and phosphorus contents. When it does not prove practicable to provide all of the needed calcium and phosphorus through the proper choice of feeds, mineral supplements may be resorted to. This is particularly true in the case of poultry.*

The choice of mineral supplements is one of considerable nutritional and economic importance. Table II shows the approximate calcium and phosphorus contents of a number of staple products commonly used as mineral feeds.

TABLE II. CALCIUM AND PHOSPHORUS CONTENTS OF MINERAL SUPPLEMENTS

Product	Percentage of calcium	Percentage of phosphorus
	%	%
Oyster-shell flour	38	....
High-grade limestone	37–39	....
Bone meal	20–30	10–15
Calcium carbonate	40	....
Tri-calcium phosphate	39	20
Di-calcium phosphate	23	18

Rock phosphate and other fluorine-bearing minerals have not been included in Table II because of the toxic nature of fluorine. While it is undoubtedly true that certain amounts of fluorine-bearing minerals can be tolerated by farm animals, long-continued use of such minerals should not be resorted to until the fluorine tolerances of the various classes of livestock have been definitely established. It should hardly be necessary to emphasize that all materials used as mineral feeds should be of a high grade especially prepared for animal feeding. In the case of limestone, a high calcium product, finely ground is to be preferred. In the case of bone-meal or bone-flour, products properly sterilized and free from objectionable odors should be insisted upon.

WHEN TO USE MINERAL SUPPLEMENTS

There are occasions where it is generally recognized that the calcium and phosphorus derived from the ordinary feedstuffs contained in the ration are not adequate for rapid growth and maximum production. This is particularly true in the case of poultry where the use of such products as oyster shell and bone-meal is standard practice. In the case of grain-fed pigs where the supply of milk, good pasture, and meat- or fish-meals is limited, the use of limestone or its equivalent is sound practice. In the case of dairy cattle, beef cattle, and sheep the problem is somewhat more complicated.

It is well known that the calcium and phosphorus requirements of high-producing cows are much higher than those of beef cattle and sheep, but since beef cattle and sheep spend much of the year on pastures and ranges not used for dairy cattle, it is not always safe to assume that the

*For information on mineral recommendations for poultry, the reader is referred to Oregon State Agricultural College Extension Bulletins 433 and 435.

dairy cattle of a particular section will be the first or only class of farm animals to show symptoms of a mineral deficiency. Rations containing liberal quantities of good pastures and legume hays are not likely to be deficient in calcium (lime). Rations containing liberal quantities of wheat bran or other wheat by-products, oil-meals, and good pastures are not likely to be seriously deficient in phosphorus. Animals fed large quantities of legume hays certainly do not need extra calcium, but they may need extra phosphorus. This Station has obtained evidence which indicates that dairy cattle, restricted largely or entirely to alfalfa hay, do not obtain enough phosphorus for high milk production.

The need for the extensive use of mineral supplements with well-chosen rations for dairy cattle has probably been overemphasized. The routine use of one or two pounds of bone-meal per 100 pounds of grain mixture is to be looked upon as a precaution against possible deficiency rather than as a scientifically demonstrated necessity.

It is relatively easy to express an opinion concerning the probable calcium and phosphorus intakes of farm animals fed relatively simple rations made up from crops whose calcium and phosphorus contents are known to be more or less constant. In the case of dairy cattle, the calcium and phosphorus contents of the pasture are often not even approximately known. In the case of beef cattle or sheep that spend much of the year on the range, it is usually extremely difficult to make an estimate of the probable calcium and phosphorus contents of the ration. In spite of these uncertainties, it is wise to remember that farm animals require perhaps one and one-half to two times as much calcium as phosphorus and to choose mineral supplements with this principle in mind. Farm animals wintered largely on alfalfa hay often receive something like 6 to 8 times as much calcium as phosphorus. To feed such animals large quantities of limestone, oyster-shell flour, or a high-calcium low-phosphorus mineral feed, such as No. 10 in Table III, is a waste of money and may even be harmful.

When in doubt concerning the need of mineral supplements, an accurate description of the kind and amount of feedstuffs used will often enable your Experiment Station to offer valuable advice concerning the probable need of mineral supplements.

PROPRIETARY MINERAL MIXTURES

It has been the experience of most states that the discovery of mineral deficiencies in livestock has been followed by active campaigns to sell proprietary mineral feed mixtures. Proprietary mineral feeds vary all the way from simple mixtures of such materials as salt, limestone, and bone-meal to complex mixtures claimed to contain materials such as sulfur, molasses, strychnine-bearing drugs, charcoal, copper sulfate, iron oxide, Epsom salts, rock phosphate, fenugreek, and tobacco. Some are honestly compounded and advertised and reasonably priced. Others are made up largely of relatively cheap materials, backed by the most extravagant claims, and sold for exorbitant prices.

During the past few years, a considerable number of mineral feeds offered for sale in Oregon have been submitted to the Experiment Station by farmers, county agents, and feed dealers. Table III gives an idea of the wide variation in the composition of such mixtures. It will be noted that

a considerable number of the mixtures analyzed contained from 20 to 35 per cent calcium, and some 4 per cent phosphorus. The amount of common salt (NaCl) varied all the way from insignificant traces to more than 90 per cent of the mixture. Most of the mixtures analyzed may therefore be regarded as good sources of lime, but relatively poor sources of phosphorus. In other words, four pounds of wheat bran contain more phosphorus than one pound of most of the mineral feeds analyses of which are shown in Table III. Those mixtures analyzed for both calcium and phosphorus contained an average of approximately ten times as much calcium as phosphorus. In this connection, it should be recalled that farm animals require perhaps twice as much calcium as phosphorus and that phos-

TABLE III. APPROXIMATE COMPOSITION OF PROPRIETARY MINERAL FEEDS

Mixture No.	Percentage of calcium	Percentage of phosphorus	Percentage of salt
	%	%	%
1	15.6	*	*
2	18.6	*	*
3	24.4	4.5	*
4	19.0	7.0	*
5	2.1	*	75.0
6	21.1	4.5	35.5
7	29.8	4.7	8.8
8	35.4	5.0	1.2
9	23.1	4.4	.0
10	35.4	1.0	.8
11	26.3	1.4	*
12	24.9	4.1	*
13	25.0	5.1	*
14	†	†	93.3
15	†	†	87.8
16	31.9	2.9	‡
17	29.0	4.1	‡
18	29.9	4.2	‡
19	11.1	1.5	‡
20	1.9	.1	87.5
21	32.7	1.8	‡

*No analysis.
†Small amount.
‡Trace.

phorus deficiencies are probably as common in Oregon as are calcium deficiencies. Mixtures 5, 14, 15, and 20 are valuable largely for the common salt which they contain. We have not examined these mixtures for the large variety of drugs and miscellaneous materials often claimed to be present because nutrition experts do not recognize such materials as having any value in the routine feeding of livestock.

The wide variation in quality and prices of proprietary mixtures makes it advisable for the farmer to purchase his mineral feeds from reputable dealers and manufacturers who are able and willing to describe their products accurately and to guarantee their contents of calcium, phosphorus, salt, and iodine. Finally, farmers should remember that mineral mixtures should be judged by the value of their useful ingredients in terms of such common commodities as limestone, calcium carbonate, oyster shell, bonemeal, calcium phosphate, salt, and potassium iodide.

HOW TO FEED MINERALS

Mineral feeds are not satisfactory substitutes for careless feeding practices. It is obviously good economy as well as sound nutrition to attempt to determine the nature of the mineral deficiency, if any, of the ration and to choose mineral supplements accordingly. The deficiencies most often encountered are those of common salt, calcium (lime), phosphorus, and iodine. It must be remembered that there is no one mixture which will prove adequate and economical under all conditions. The following specific recommendations must not be looked upon as the final solution of all mineral feed problems, but merely as helpful suggestions.

1. Make sure that the ration has been carefully chosen with respect to its mineral content as well as with respect to its content of other nutrients. It may be found, for example, that the extra phosphorus needed in the ration can be most economically supplied by a product such as wheat bran.

2. Farm animals should always have free access to common salt, even though some salt has been added to the grain mixture.

3. In goiterous regions iodine should be supplied as indicated on page 6 of this Bulletin.

4. When lime only is deficient, limestone will prove an economical supplement.

5. If the ration is likely to be deficient in calcium or phosphorus, one or two pounds of sterilized bone-meal may be added to each 100 pounds of grain mixture.

6. Perhaps the best procedure for the farmer who feels that he must feed a mineral supplement and who wishes to insure an adequate supply of calcium and phosphorus, is to allow livestock free access to sterilized bone-meal or bone-flour at all times. This is a good practice in regions where farm animals show a craving for bones, sticks, and dirt. Cows allowed free access to bone-meal will probably consume less than 50 pounds per year, unless the deficiency is acute.

7. Limestone and bone-meal are sometimes mixed with a little common salt (1 part salt in 10 parts mixture) to increase palatability. Free access to salt must be allowed as usual.

8. The use of mixtures containing large amounts of limestone, oyster shells, or calcium carbonate, should be confined to those sections where calcium is likely to be a major deficiency. Such mixtures are usually of little value in sections where alfalfa hay or other legumes are fed in liberal quantities.

ACKNOWLEDGMENTS

This Bulletin represents an attempt to compile in non-technical language the available information bearing on the mineral-feed problem in Oregon. It brings together the accumulated experience of a large number of persons, some of whom have been in touch with Oregon's livestock industry for many years.

Acknowledgment is made of the generous cooperation of the departments of Animal Husbandry, Dairy Husbandry, Poultry Husbandry, and Veterinary Medicine. Suggestions made by Professors P. M. Brandt, E. L. Potter, and B. T. Simms have been particularly helpful.