Minerals for Horses: Calcium and Phosphorus

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Minerals are involved in a variety of functions in the body, including enzymes, structural components, energy transfer and acid base balance. Minerals are also incorporated into vitamins, amino acids, and hormones. Thus proper mineral nutrition is vital to have a healthy horse. The minerals that are needed in the largest quantities by horses are referred to as the macro-minerals. These include calcium (Ca), phosphorous (P), magnesium (Mg), potassium (K), sodium (Na) and chloride (Cl). These minerals are needed in the diet in concentrations of g/kg or percentages, versus ppm or mg/kg of micro-minerals. This fact sheet addresses the most commonly talked about and often deficient in equine nutrition, Ca and P.

A note of caution

When creating diets for horses, it is important to remember consider not only how much mineral is in the diet, but also the ratio of particular minerals in relationship to others. Minerals have very complex interactions with each other, and excesses or deficiencies of minerals can greatly affect the absorption, metabolism and excretion of others. Therefore horse owners who "tinker" too much with their horse's diet through overzealous supplementation may be doing more harm than good for their horse.

Definitions:

Osteopenia — a decrease in bone mineral density below normal. In humans, this is considered to be a precursor to osteoporosis. Horses don't really suffer from osteoporosis.

Ossification — essentially proper bone formation replacing cartilage as the horse grows, not to be confused with calcification. While calcification is a normal process of ossification, abnormal calcification can also occur, for example the formation of splints.

Nutritional secondary hyperparathyroidism — bone disease caused by too much P and not enough Ca. Calcium is removed from the bone, which can result in brittle, weak bones. Often manifests in shifting lameness in early stages. Previously referred to as Big Head Disease.

Gastrin — a peptide hormone secreted by the parietal cells of the stomach which stimulates secretion of gastric acids (HCL) and increases gastric motility. Gastrin release is stimulated by the presence of protein in the stomach, as well as conditions of hypercalcemia.

Calcium Function

Most people think of calcium's role in the body as that of bone development and integrity. Certainly, the skeleton accounts for 99 percent of the calcium in the horses' body. However, Ca is absolutely essential for neuromuscular function, blood clotting, cell signaling and an array of enzymes. Because of its importance, calcium concentrations are very tightly regulated in the blood. When Ca in the diet is inadequate, the bone serves as a major reservoir. Thus, the body will sacrifice calcium within the bone to maintain blood Ca homeostasis. A prolonged period of Ca deprivation can lead to a weakened skeleton. In addition, this means that blood values of Ca are relatively poor indicators of Ca status in the horse. Calcium deficiencies are especially detrimental to young growing horses as this can lead to osteopenia. Improper ossification can lead to enlarged joints or improper growth patterns of the long bones. Therefore, it is critical to look carefully at the diet of lactating mares, foals and young horses.

Phosphorus Function

Phosphorus is important for bone growth and skeletal health in horses. While Ca is the major player, P makes up 14 to 17 percent of the mineral component of a horses skeleton. But that is not all it does. Phosphorous is vital in energy transfer (ATP), DNA and RNA synthesis, cell membranes etc. Therefore, phosphorus is an important aspect of mineral nutrition.

Environment and Phosphorus

In many situations, dietary P is adequate to meet P needs without additional supplementation. However, phosphorous runoff is an environmental concern, and not something that horse owners should ignore. Horse manure is similar to that of ruminants and has a high proportion of water soluble P. However, there is less total P as a percentage and is less of a threat of contributing to run-off compared to poultry and swine manure, especially in a pasture management situation. This may not eliminate the need for concern for larger stables with more concentrated numbers of animals. Overfeeding of phosphorus leads to more excretion of phosphorus into the feces, thus into the environment. High calcium diets may also lower the ability of the horse to absorb P. This does not hurt the horse, as they are still absorbing a sufficient amount to meet their needs. But when absorption from the gut is decreased, excretion increases through the feces. While horses may not be under the same scrutiny as feed yards and confinement swine facilities, the random supplementation of minerals to horses without full consideration of the diet should be avoided.

Phosphorous deficiencies and excess

Phosphorous deficiencies are typically not seen in mature horses, even when exercising. However, just like with Ca, special attention needs to be paid to the broodmares and foals, both of which are forming new bone. Inadequate P results in a slowing of the growth rate of young horses, and can lead to improper bone formation. However, excess P can be more of a concern because it can inhibit Ca absorption. This interaction of minerals is why random supplementation is strongly discouraged. Prolonged conditions of excessive P can lead to the development of secondary nutritional hyperparathyroidism. Horses should not be fed more than 1 percent of their diet as P. Typically, this is not an issue unless the feed source is predominantly cereal grains (like wheat bran or oats), which are high in P. Conceivably, this could happen on all grass forage (i.e., not legumes) with a high grain intake containing no mineral supplement high in calcium.

Ratio of Calcium to Phosphorus

The ratio of Ca and P is always important when looking at horse rations. A ratio of two parts Ca: one part P is ideal, with a range of 1:1 to 6:1 being acceptable. Because phosphorous competes with Ca for absorption in the gut, total diets that are less than 1:1 or contain more P than Ca should be avoided. Remember to calculate the entire diet! If only one component of the diet has an inverted ratio, the total combined diet might still be fine. It is also possible to have the correct ratio, but still be deficient in these minerals, insufficient quantities are in the feed.

How much is too much?

Calcium has been fed as high as five times the horse's requirement without any ill effects, provided that the P intake is adequate. The maximal concentration of Ca in the horse's diet is 2 percent, however it would be hard to find feeds that reach that level. However, excess Ca has been implicated as a causative factor of ulcers due to an increase in gastrin secretion. Alternatively, others have found that alfalfa diets (thus, higher Ca) may decrease the incidence of ulcers. Clearly more work regarding Ca and ulcer formation in the horse is needed.

Ca and P requirements for maintenance and work

Adult horses which aren't exercising have low calcium requirements (Table 1). There is loss of Ca in the sweat of exercising animals that is represented in the increase in requirements for work. In addition, the increase in Ca requirements for exercising horses is presumably due to an increase in bone deposition. Horses undergoing intense exercise experience an increase in bone mass, thus have a greater need for calcium. It is unlikely that light exercise, or exercise that the horse is already adapted to (essentially no change in work intensity) results in much change in calcium requirements. Additionally, most studies of calcium and exercise have focused on the young, growing horse. However, in an effort to err on the side of safety, the National Research Council recommends higher intakes of calcium. As the following tables show, maintenance horses will fairly easily meet their P requirements. In exercising horses, most of the requirements were determined using young horses who were also concurrently experiencing bone growth and increased bone density. However, again, the P requirements for mature exercising horses are estimated to be higher, more as a margin of safety.

Table 1. Calcium and phosphorus requirements (grams/day) for adult horses at maintenance or work.

Weight (lbs)	*Maintenance*		*Light work*		*Moderate work*		*Heavy work*	
	Ca (g)	*P (g)*	*Ca (g)*	*P (g)*	*Ca (g)*	*P (g)*	*Ca (g)*	*P (g)*
900	16	11	24	14	28	17	32	23
1,000	18	12	27	16	31	19	36	26
1,100	20	14	29	18	34	21	39	28
1,200	21	15	32	19	38	23	43	31
1,300	23	16	35	21	41	24	46	34

Ca and P for mares

For gestating mares, requirements of Ca and P increase the greatest for the 9th, 10th and 11th month of gestation, which is concurrent with the most rapid increase in fetal growth. There is also substantial fetal growth in the 7th and 8th month of gestation as well, therefore mineral requirements are elevated in this period compared to maintenance (shown as the sixth month of gestation in Table 2). Lactating mares clearly have an increase in Ca and P demand to support milk production for foal growth. Mares fed an inadequate amount of Ca actually experience a decrease in bone density, as calcium is removed from bone to supply adequate minerals for the foal through milk. In comparing Table 1 with Table 2, at least in terms of Ca, horses at light to moderate work would be considered to be comparable to gestating mares. However, demands of lactation exceed the working horses in needs of calcium. Therefore, one should either choose a feed or supplement designed to meet the needs of lactating mares and foals. After the first three months of peak lactation, the mineral demands on the mare taper off as the foal derives more nutrition from the feed it consumes.

Foals

Obviously foals get much of their Ca and P from their mothers' milk, but as they start to ingest new feeds and taper off their reliance on the mare, a balanced diet must be ensured. Table 3 lists the approximate Ca and P requirements in grams per day of growing foals from four months until two years of age. Remember, because the foal is much smaller, and eats much less per day, the concentration of Ca and P in feed must be greater. For example, a foal which consumed 2 percent of its body weight in alfalfa hay that was 1 percent Ca

Table 2. Calcium and P requirements (g/d) for gestating and pregnant mares.

Weight (lbs)	*Month of Gestation*						*Month of Lactation*							
	6th		*7th-8th*		*9th-11th*		*1st*		*2nd*		*3rd*		*4th*	
	Ca	*P*	*Ca*	*P*	*Ca*	*P*	*Ca*	*P*	*Ca*	*P*	*Ca*	*P*	*Ca*	*P*
900	16	11	23	16	29	21	48	31	47	31	45	29	34	21
1,000	18	12	25	18	32	23	53	34	53	34	50	32	37	23
1,100	20	14	27	20	35	26	58	38	58	37	55	35	41	26
1,200	21	15	30	21	39	28	63	41	63	41	60	39	45	28
1,300	23	16	32	23	42	30	69	44	68	44	65	42	48	30

Table 3. Approximate Ca and P requirements (g/d) for growing foals based on their estimated mature weight.

Estimated Mature Weight	*4-7 mo*		*8-14 mo*		*15-24 mo*	
	Ca	*P*	*Ca*	*P*	*Ca*	*P*
900	31	17	30	17	30	16
1,000	35	19	34	19	33	18
1,100	38	21	37	20	36	20
1,200	42	23	41	22	40	22
1,300	45	25	44	25	43	24

would meet its requirements. If it was eating orchard grass hay that was 0.4 percent Ca, definitely not! There is not a large decrease in overall mineral requirements as the foal matures. But as the foal matures and reaches a larger body size, it will consume more , thus the concentration of Ca and P needed in the diet will go down. Foals being fed for rapid growth without properly balanced Ca and P levels in the diet can lead to joint disease.

How big will the foal be?

If nutrient requirements are based on expected mature body weight, how do you know what size the young horse will ultimately be? Look at both the mare and the sire, then use an average. However, foals from maiden mares and older mares, tend to be smaller. Don't forget that the nutrition program and environment that the dam and sire were subjected to also played a large role in their final mature weight. Also, recipient mares will have a large influence on a foal's size due to uterine influences, in addition to their genetic dam. Thus, most farms choose larger mares for embryo transfer programs to carry donor mare's offspring. In addition, the earlier a colt is gelded, the larger they may be at maturity. There is no firm way to know, but these guidelines can be used to estimate mature body weight.

What's in a feed

Before formulating diets, it might be helpful to look at some typical feed stuffs used to create diets for horses. The following values are estimates only. Remember that forages grown on mineral-deficient soils may have lower values. Typically, most grains are going to be higher in P than Ca. This should not pose a problem because concentrates should be fed to provide the extra energy or protein the horse needs, rather than making up the majority of their diet. The exception in Table 4 is beet pulp, which isn't a cereal grain at all. When looking at some typical hays, legumes (the alfalfa and red clover) provide much greater amounts of Ca than do grass hays. This makes them ideal choices for broodmares and foals. Even most grass hays have Ca in the correct proportion to P, which makes feeding an imbalanced ratio hard to do. Note however, that orchard grass may be an exception.

Table 4. Common concentrates fed to horses. All percentages are on a dry matter basis.

Concentrate	*% Ca*	*%P*
Beet pulp	0.89	0.09
Barley	0.06	0.39
Cracked corn	0.04	0.30
Rolled oats	0.11	0.40
Rice bran	0.07	1.78
Wheat bran	0.13	1.18

Table 5. Common forages fed to horses. All hays are assumed to be harvested at the mid-bloom stage. Remember: soil type and stage of maturity can alter hay nutrient content.

Forage	*% Ca*	*%P*
Coastal Bermuda	0.19	0.27
Alfalfa	1.27	0.24
Brome grass	0.29	0.28
Red Clover	1.38	0.24
Fescue	0.41	0.30
Orchard grass	0.27	0.34
Timothy	0.48	0.23

Now, let's put some of these numbers together. For simplicity, we will work with a generic 1,100-pound horse, then compare nutrients with the table values for different classes of horses. The first example will feed this horse two different diets, one solely Bermuda coastal grass hay, and one of alfalfa at 2 percent of his body weight per day. All values above are on a dry matter basis.

First, determine how much the horse will eat.

1,100 pounds x .02 = 22 pounds

As Ca and P requirements are in grams, convert pounds to kilograms.

22 pounds x 1 kg/2.24 pounds= 9.82 kg of hay

The horse will eat 9.82 kg of hay per day.

For the grass hay, multiply the amount fed by the percentages of Ca and P in that hay.

9.82 kg x 0.0019 =0.0187 kg of Ca

Then, convert kg into grams.

0.0187 kg x 1000 g/kg = 18.7 g Ca

Now for P.

9.82 kg x 0.0027 x 1000 g/kg = 26.5 g P

Finally, calculate your Ca to P ratio.

18.7 g Ca/26.5 g P = 0.71 to 1

So, what does this tell us? First, a mineral supplement should be supplied for the horses to avoid the inverted Ca to P ratio. Alternatively, some legume hay could be added to its diet. When looking at simply meeting the requirements of the 1,100-pound horse, the diet is deficient in Ca if it is a working horse and certainly very low if that was all that was fed to a gestating or lactating mare.

Now, what if alfalfa hay was fed instead? Use the same calculations, but insert the new percentage of Ca and P for alfalfa.

9.82 kg x 0.0127 x 1000 g/kg =124 g Ca

Now for P.

9.82 kg x 0.0024 x 1000 g/kg = 23 g P

Finally, calculate the Ca to P ratio.

124 g Ca/23 g P = 5.4:1

Now the Ca to P ratio is more desirable. Looking at the horses' requirements, the Ca requirement has been more than met for all classes of mature horses, and is adequate for P for all working horses except those in heavy work. For mares, the diet is adequate until the last part of gestation and through lactation. Thus, broodmares should be fed a better quality diet than other horses.

Lastly, what happens if we decide to add 6 pounds of oats to this 1100-pound horse's diet? Note: This is done solely for the purpose of calculations. There should always be some rationalization for why concentrate is added to a horse's diet. In this example, there is no information regarding class of horse or what its body condition score is.

For this example, the hays fed will be red clover and orchard grass.

Begin with the red clover.

9.82 kg x 0.0138 x 1000 g/kg =135 g Ca

Now for P.

9.82 kg x 0.0024 x 1000 g/kg = 23 g P

Now calculate the contribution from oats.

6 pounds x 1 kg/2.24 pounds = 2.7 kg oats

2.7 kg x 0.0011 Ca x 1000 g/kg = 3 g Ca

2.7 kg x 0.0040 P x 1000 g/kg = 11 g P

Add the two values together for hay and oats.

135 g Ca from hay + 3 g Ca from oats = 138 g Ca

23 g P from hay + 11 g P = 34 g P

Calculate the ratio

138 g Ca/34 g P=4.1:1

The ratio of Ca to P is appropriate.

Now again, compare across the classes of horses. Calcium is adequate for all classes, and P requirements are met for all horses except the lactating mares.

Lastly, add the oats to the orchard grass hay.

9.82 kg x 0.0027 x 1000 g/kg =26.5 g Ca

Now for P.

9.82 kg x 0.0034 x 1000 g/kg = 33.4 g P

The oat values will remain the same as above.

Add the two values together for hay and oats

27 g Ca from hay + 3 g Ca from oats = 30 g Ca

33 g P from hay + 11 g P = 44 g P

Calculate ratio of Ca to P.

30 g Ca /44 g P =0.68:1

This ratio is inverted and should be avoided.

Remember that these diets are a simple exercise in calculating the contribution of calcium and phosphorous from different feed sources. These are not recommendations for actual diets, as no attempt was made to adjust amount fed, supplements added or appropriate concentrates selected.

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