# Phosphorus in Animal Nutrition

In the animal body, about 80 percent of P is found in the skeleton. Its major role is as a constituent of bones and teeth. The remainder is widely distributed throughout the body in combination with proteins and fats and as inorganic salts.

Phosphorus constitutes about 22 percent of the mineral ash in an animal's body, a little less than one percent of total body weight. It is essential in transfer and utilization of energy. Phosphorus is present in every living cell in the nucleic acid fraction.

Calcium and P are closely associated with each other in animal metabolism. Adequate Ca and P nutrition depends on three factors: a sufficient supply of each nutrient, a suitable ratio between them, and the presence of vitamin D. These factors are interrelated. The desirable Ca:P ratio is often between 2:1 and 1:1.

Phosphorus (P) is an essential nutrient for all animals. Deficiency of P is the most widespread of all the mineral deficiencies affecting livestock. Phosphorus must be balanced in the animal diet with adequate calcium (Ca) and vitamin D for growth, reproduction, gestation, and lactation.

Vitamin $D_3$ is essential for Ca utilization. Inadequacies in the vitamin will imbalance the available Ca:P.

A liberal supply of Ca and P is essential for lactation. Calcium and P make up about 50 percent of the ash of milk.

Earliest symptoms of P deficiency are decreased appetite, lowered blood P, reduced rate of gain, and "pica", in which the animals have a craving for unusual foods such as wood or other materials. If severe deficiency occurs, there will be skeletal problems.

Milk production decreases with P deficiency, and efficiency of feed utilization is depressed. Long-term P deficiency results in bone changes, lameness, and stiff joints.

**Cattle:** Young and growing animals require relatively more P than do mature ones. Gestating and lactating animals need more P than other classes of mature animals. Specific P requirements for maintenance, growth, lactation, and pregnancy depend on many factors. Recommendations in National Research Council (NRC) publications are based on complex models that consider body size, breed, milk production levels, and environmental conditions.

For dairy cattle, the Ca:P ratio should be at least 2.4:1 for cows when lactating, but should be less than 1.6:1 for dry cows to minimize Ca intake during that period. For beef cows and feedlot cattle, the ratio is not so critical, although normally it would not be allowed to exceed 4:1.

Supplemental dietary P is needed under most practical feeding situations. Deficiency of P is the most widespread and economically important of all the mineral deficiencies affecting grazing livestock.

On grazed pasture, where soils are low in P, fertilizing with P can reduce risk of grass tetany. Research in Missouri showed that adding about 60 lb/A of $P_2O_5$ increased the magnesium (Mg) content of tall fescue leaves.

Phosphorus enhances reproductive performance at several stages in the reproductive cycle. In Arizona tests, P increased rebreeding efficiency for beef cows. Irregular estrus periods have been associated with moderate P deficiency, infertility with marginal P levels, and anestrus with low P levels in Australia. In Texas tests, 64 percent of the control cows produced a calf on range alone compared to 85 percent of the cows on range plus P supplement.

Phosphorus has been shown to increase fertility, calving rates, calf growth rates, and, when applied to pastures, carrying capacity.

**Swine:** A suggested ratio of total Ca to

total P is between 1:1 and 1.25:1. When based on available P, the ratio between total Ca and digestible P should be 2.8:1 to 3.3:1. Adequate vitamin D is needed for Ca and metabolism, but a very high level of vitamin D may mobilize excessive amounts of Ca and P from bones.

The biological availability of P in cereal grains is variable, ranging from less than 15 percent in corn to as much as 46 percent in wheat (see **Table 1**). The greater availability of wheat P is due to a naturally occurring phytase enzyme. Estimates of availability of P differ somewhat between European and North American sources. In particular, the European feed industry is tending to use monocalcium phosphate in preference to dicalcium phosphate. Low-phytate varieties of corn and barley are being developed. These will likely have normal P content with much higher bioavailability to both swine and poultry (non-ruminants).

Microbial phytase can be added to cereal grain-oilseed meal diets to make grain P more digestible. The P in a typical corn-soybean meal diet is only about 20 percent digestible, but adding phytase can increase the digestibility to as much as 46 percent.

The use of phytase can reduce dietary P requirements and lower P excretion by as much as 30 percent. Recent studies in Europe suggest that adding phytase can also improve feed conversion slightly, by 1 to 2 percent. One difficulty with phytase is its sensitivity to heat during feed processing.

**Poultry:** Hens use most of their P in bodily functions other than egg production. But adequate P is important to achieve a high rate of egg production.

Phosphorus deficiency causes lower body weight, reduced feed efficiency, skeletal problems, and reduced eggshell quality. Low diet P can depress egg hatchability, but P content of the egg is not altered.

Caged layer hens require high P, more than hens on litter. "Cage layer fatigue syndrome" is caused by low P levels in diet. There is a high death rate.

Much work on recommended P levels has found NRC recommendations to be sound and adequate.

**Horses:** The Ca and P requirements of horses have received considerable attention. Both nutrients are essential for strong bone development, proper mineralization of osteoid tissue, and adequate energy utilization.

The Ca:P ratio should be monitored when P intake is greater than Ca and when low Ca utilization from feedstuffs occurs. Calcium: P ratios of 6:1 do not appear detrimental to mature horses if P intake is adequate. Foals and yearlings have been fed Ca:P ratios of 3:1 with no problems.

**Goats:** Phosphorus is required for tissue and bone development. A deficiency will result in slow growth, "pica" appetite, and unthrifty appearance. Low levels of P in the blood often accompany it.

**Dogs and Cats:** Low P diets seldom occur in properly fed pets. However, animals require adequate Ca and P in their diets to ensure strong bones and teeth and good muscle development. A P deficiency in puppies causes rickets and poor growth. In cats, a high meat diet can cause an imbalance of Ca to P, because meat is high in P. BC

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**TABLE 1.** Amounts and estimated availability of P in selected feed materials for swine.

| | Corn | Barley | Wheat | Soybean meal | Dehulled canola meal | Meat and bone meal | Dicalcium phosphate | Monocalcium phosphate |
|---|---|---|---|---|---|---|---|---|
| | % | | | | | | | |
| P content (NRC-U.S.) | 0.28 | 0.36 | 0.37 | 0.65 | 1.01 | 4.98 | 18 | 25 |
| P availability (NRC-U.S.) | 13 | 27 | 45 | 28 | 19 | 81 | 87 | 90 |
| P availability (CVB-Europe) | 16 | 37 | 46 | 38 | 30 | 80 | 65 | 80 |