Animal Proteins Good Source

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Phosphorus, a component of several different types of chemical compounds found in feed ingredients, is an essential nutrient for fish and other animals. The phosphorus content of animal protein ingredients is highly variable (Table 1). In these ingredients, a significant amount of the phosphorus is derived from bone material and is referred to as bone or apatite phosphorus. Some of the phosphorus is also derived from, or bound to, several other chemical compounds, such as nucleic acids, proteins, fats, sugars, etc. This type of phosphorus is often referred to as organic or cellular phosphorus.

Animal protein ingredients are produced from a wide variety of raw materials and rendering equipment. Consequently, bone and organic phosphorus contents of animal proteins are highly variable, even for one given type of ingredient (e.g., meat and bone meal). In a recent study conducted at the University of Guelph, 32 animal protein ingredients were analyzed in order to quantify their bone and organic phosphorus contents. These included 10 fish meals, 14 meat and bone meals, and eight poultry by-product meals obtained from feed manufacturers and rendering plants across North America. Bone phosphorus accounted for 53 percent to 93 percent of total phosphorus in all the animal protein ingredients analyzed. This study indicated that total phosphorus (P) and bone phosphorus can be easily estimated based on ash content in animal protein ingredients using the following equations: total P (%) = 0.185 * ash (%) (R^2 = 0.88); and bone P (%) = 0.188 * ash (%) – 0.852 (R^2 = 0.94).

Table 1. Phosphorus Content of Animal Protein Ingredients (on dry matter basis)

Ingredient Types	P Content g/kg dry weight
Fish Meal	10.8 – 41.9
Meat and Bone Meal	24.9 – 70.8
Poultry By-product Meal	16.5 – 34.5
Blood Meal	0.8 – 17.1
Feather Meal	5.4 – 12.6

Digestibility of Phosphorus in Animal Proteins

In order to be of value to animals, nutrients, including phosphorus, must be digestible. The digestibility of phosphorus in animal proteins has been reported to be highly variable in scientific literature. In trout and salmon feeds, the digestibility of phosphorus has been found to range from 17 percent to 81 percent for fish meals, 22 percent to 45 percent for meat and bone meals, and 15 percent to 64 percent for poultry by-product meals (Table 2). These highly variable digestibility values present some challenges to feed formulators wanting to use animal proteins as digestible phosphorus sources in fish feeds.

The high variability in the digestibility of phosphorus in animal proteins in scientific studies is probably the result of differences in bone and organic phosphorus contents of the ingredients tested and the level of different chemical forms of phosphorus in the finished feeds.

Table 2. Phosphorus Digestibility of Animal Protein Ingredients Fed to Rainbow Trout

Ingredients Types	Phosphorus Digestibility %
Fish Meal	17 – 81
Meat and Bone Meal	22 – 67
Poultry By-product Meal	38 – 66
Blood Meal	70 – 104
Feather Meal	68 – 82

Accurate prediction of the digestible phosphorus content of fish feeds requires taking into account the levels of different phosphorus types. Therefore, a mathematical model to estimate digestible phosphorus content of fish feeds based on levels of different phosphorus types was recently developed (Figure 1). The types of phosphorus present in feed ingredients were classified into broad chemical categories: bone P; phytate P; organic P; calcium (Ca) monobasic/sodium (Na)/potassium (K) phosphate supplements; and Ca dibasic phosphate supplements.

The digestible phosphorus content of fish feeds could be accurately predicted using the following mathematical equation:

Digestible P = 0.68 bone P + 0 phytate P + 0.84 organic P + 0.89 Ca monobasic/Na/K phosphate supplements + 0.64 Ca dibasic phosphate supplements + 0.51 phytase/phytate – 0.02 (phytase/phytate)^2 - 0.03 (bone P)^2 - 0.14 bone P * Ca monobasic/Na/K phosphate supplements (probability < 0.0001, R^2 = 0.96)

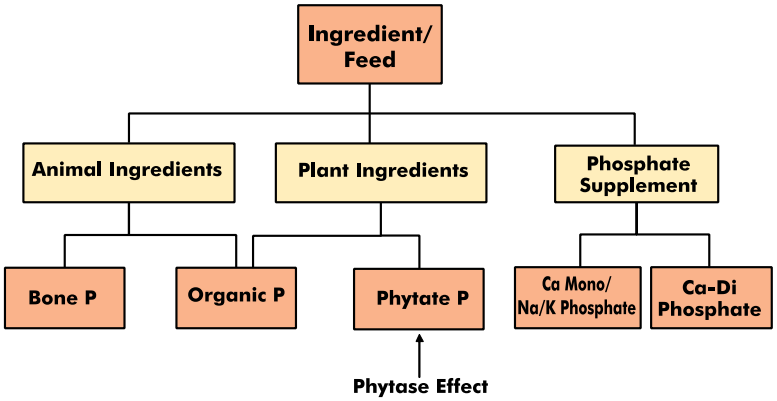
This model suggests that the digestibility of different phosphorus types differ significantly and the apparent digestibility of bone phosphorus decreases as its level increases. The model also suggests a negative interaction between monobasic phosphorus supplements and bone

# of Digestible Phosphorus for Fish

phosphorus. The model predicts that animal protein ingredients such as meat and bone meal and poultry by-product meal are effective sources of digestible phosphorus, notably in feeds formulated with high levels of plant protein ingredients.

The model was tested against the results of a digestibility trial with rainbow trout. There was a very good agreement between the values predicted by the mathematical model and the phosphorus digestibility values measured in the digestibility trial. The model therefore provides a simple means of estimating digestible phosphorus content of fish feeds and can be a useful tool for fish feed formulators. ❖

Figure 1. Schematic representation of a model estimating the digestible phosphorus content of fish feeds based on the levels of different phosphorus types in these feeds.



References

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