

## Evaluating feed phosphates

Evaluation of the suitability of a particular feed phosphate is normally based on biological values, such as availability or digestibility, followed by the product's physical and chemical properties. Methods for assessing biological value can broadly be categorised into three types:

- Bone measurements to give relative values of phosphorus availability.
- Balance trials to determine the digestibility (absorption) of phosphorus.
- In vitro tests of phosphate solubility to indicate the chemical structure of the product.

Variations in TAC of phosphorus in sheep and pigs				
Monocalcium phosphate				●●●●●●●●●●
Na Ca Mg phosphate				●●●●●●●●●●
Dicalcium phosphate				●●●●●●●●
Tricalcium phosphate CP			●●●●●●●●●●	
Bone meal			●●●●●●●●●●	
Natural tricalcium phosphate		●●●●●●●●●●	●●●●●●●●●●	
Ca-pyrophosphate	●●●●●●			
Al Fe Ca-phosphate	●●●●●●			
	0%	20%	40%	60%
Source: after Guéguen, 1988				

## Relative availability

Many early trials measured phosphorus availability using growth performance or bone parameters, such as breaking strength, tibia and toe ash content. Poultry were mainly used for this purpose.

Bio-assays based on bone parameters require comparison with a highly available reference source and only give a relative value of availability. The main purpose of this technique is that a ranking of test phosphates can be made fairly simply. However, results have varied quite widely between different researchers, due to differences in protocol, the reference phosphate and the origin of the test phosphates used.

Bone breaking strength can be a sensitive measure when applied to young rapidly growing animals, varying linearly with the quality and availability of the supplementary phosphorus.

However, this technique cannot replace balance trials in adult or slowly growing animals where there is no particular bone response.

## **Digestibility**

Balance trials, combined with radioactive markers to measure levels of endogenous phosphorus, enable true values of the digestibility of a feed phosphate to be determined.

Researchers at the French national agricultural research institute, INRA, determined the digestibility of a number of different feed phosphates in this way, expressing their result as a true absorption coefficient (TAC), defined as:

$$\frac{\text{P intake} - (\text{P faecal} - \text{P endogenous})}{\text{P intake}} \times 100\%.$$

However, although balance trials with radioactive markers are capable of giving reference values for phosphorus digestibility, their complexity, cost and concerns for animal welfare mean that similar trials have not been reproduced.

## **Apparent digestibility**

Environmental pressure and progress in livestock production resulted in the development of a more practical technique to evaluate the biological value of a phosphate. This also uses balance trials to measure the difference in ingested and excreted phosphorus, but does not take into account endogenous losses.

The phosphate's biological value is expressed as apparent digestibility, often in the form of an apparent digestibility co-efficient (ADC):

$$\frac{\text{P intake} - \text{P faecal}}{\text{P intake}} \times 100\%.$$

or for poultry: apparent absorbability (or apparent availability) (AAD):

$$\frac{\text{P intake} - (\text{P faecal} + \text{P urine})}{\text{P intake}} \times 100\%.$$

A review of recent trials to assess apparent digestibility of different feed phosphates for pigs and poultry shows a range of results. Differences can be found, even when comparing phosphates in the same chemical group. Nevertheless, although the absolute values differ, the relative ranking of the feed phosphates tested remains constant.

The trials also demonstrate that phosphorus availability has been significantly underestimated in earlier studies and that there are notable differences in the digestibility of different feed phosphates according to source and animal species.

## **In vitro solubility**

While the absolute and relative measurement of phosphate nutritional values involves balance trials, which are relatively difficult to reproduce, a combination of two simple solubility tests provides a straightforward method to assess product quality in the laboratory.

First, the solubility of a feed phosphate in 2% citric acid provides an indication to the level of phosphorus availability. Second, its solubility in alkaline ammonium citrate points to the chemical nature of the product and shows the presence of tricalcium phosphate. In vivo tests show that mono- and dicalcium phosphate are better absorbed by monogastric animals than the tricalcium form which is less soluble (Cromwell 1989, Guéguen 1988).

The relationship between the TAC of different phosphates and their solubility in citric acid and ammonium citrate has been determined by INRA. From its results, it can be observed that, apart from alumino-calcium phosphate, a phosphate's true absorption coefficient increases linearly in relation to its solubility in both media.

From this the conclusion can be drawn that if the solubility of a feed phosphate is greater than 95% in both tests, it can be considered to be of good quality. If this level is not achieved, further evaluation in vivo is necessary.

## **Physical and chemical properties**

In addition to its nutritional value, the application of a feed phosphate, whether in compound or mineral feed, dictates the physical characteristics required, such as particle size and density. For example, in mineral feeds, segregation is avoided by selecting ingredients with more or less the same density and particle size; whereas, in compound feeds, this is not as important.

From a chemical standpoint, the product's phosphorus and calcium content and its calcium to phosphorus ratio, are the most important evaluation criteria.

Use of different phosphates often depends on local practice and increasingly on the dietary space in a particular feed formulation. This factor is becoming more critical in "high density" feeds for broilers and young pigs, which have extremely limited dietary space.