

## Sources of phosphorus

The high chemical reactivity of phosphorus means that it only occurs in nature combined with oxygen or other elements in the form of phosphates. Main phosphate sources are of plant, animal and inorganic origin, containing varying quantities of phosphorus in several different chemical forms.

Digestibility of phosphorus of vegetable origin				
	P content	Phytate P	Digestible P	
			Pigs	Poultry
	g/kg	% total P	%	%
Barley	3.5	65	30	38
Maize	2.7	65	20	30
Wheat	3.1	65	26	38
Rape seed meal	10.8	75	27	33
Soya bean meal	6.5	70	39	42
Tapioca	1.0	15	10	66
Wheat middlings	10.6	85	20	27
Maize gluten feed	8.6	65	20	40

Source: Centraal Veevoeder Bureau (CVB), The Netherlands.

Although plant material invariably plays the largest role in animal nutrition, an animal's ability to benefit the phosphorus it contains differs substantially between ruminant and monogastric species.

Ruminants have the ability to digest the phytate phosphorus contained in plant material via microbial activity in the rumen, while monogastrics lack this mechanism, making this type of phosphorus virtually unavailable to them.

Even so, comparison of the requirements of ruminants with the levels of phosphorus provided by normal pasture and plant material shows that, to satisfy the needs of the animal even in maintenance state, additional phosphorus is necessary on a regular basis.

Similarly, the formulation of typical plant-based diets for monogastrics demonstrates that it is impossible to meet the animals' phosphorus requirements with these materials alone. Additional phosphorus supplementation is essential.

## **Plant material**

The phosphorus content of typically used plant materials ranges from 0.09% - 1.09%. As this is largely in phytate form, it is approximately 60% available to ruminants, whereas its digestibility varies from 10% - 39% for pigs and from 27% - 66% in poultry. The varying levels of total phosphorus, and differences in its digestibility, make it difficult to accurately estimate the actual amount of digestible phosphorus supplied to the animal, with the possibility of significant over- or underestimation.

## **Animal sources**

The amount of available phosphorus provided by animal sources - principally meat, fish and bone meals - varies from 59-74%, according to the material's origin and production process.

Despite higher digestibility, the total phosphorus content may also vary by as much as 30% and these sources run a greater risk of possible contamination.

*Important:* The use of meat and bone meals is currently prohibited in animal feeds throughout the European Union.

## **Inorganic sources**

High quality inorganic phosphates offer the combination of a consistently high total phosphorus content and excellent digestibility and are therefore widely used as supplemental phosphorus.

Most inorganic phosphates used for this purpose are derived from natural rock phosphates, principally found in Africa, northern Europe, Asia, the Middle East and the USA. However, in their natural form these are unsuitable for direct use in animal feed because the phosphorus they contain cannot be metabolised by animals.

Rock phosphates must therefore be chemically treated so that the phosphorus they contain is changed into the digestible orthophosphate form ( $\text{PO}_4^{3-}$ ). During this process, close control of the production parameters is essential to avoid deterioration of the orthophosphate molecule into other unavailable forms of phosphorus, such as pyro- and meta-phosphate, and to ensure a suitable calcium to phosphorus ratio for animal nutrition.

## **Product purity**

Furthermore, rock phosphates also contain impurities, such as fluorine, cadmium and arsenic which, if not removed in the production process, make them unsuitable for animal nutrition.

Research has shown that the maximum safe level of fluorine in the total diet is 60-100 ppm for cattle and 100-200 ppm for sheep (Phillips et al. 1960). In addition, current EU legislation stipulates that, for dairy cattle, a complete feed may only contain 30 ppm fluorine and a complementary feed 125 ppm.

Rock phosphates, however, can contain up to 40,000 ppm fluorine, therefore careful selection of products with a low fluorine content is essential in order that the amount of fluorine ultimately added to the feed is not higher than the legal limits.

Legal limits on undesirable elements in feed phosphates in the EU	
Fluorine	2000 ppm
Cadmium*	10 ppm
Arsenic	10 ppm
Mercury	0.1 ppm
Lead	15 ppm
Dioxins + dioxin-like PCBs	1.5ng (WHO-PCDD/F-TEQ/kg)
* or max. of 0.5mg per percent of phosphorus content Source: EU Directive 2002/32/EC, 2003/57/EC and 2006/13/EC	

Current EU legislation also limits the impurities allowed in feed phosphates. Quality feed phosphates produced by members of CEFIC's Inorganic Feed Phosphates Sector Group are randomly sampled and tested on a regular basis to ensure that they consistently conform to these standards. Group members are also in favour of adopting more stringent limits regarding impurities in feed phosphates used in all types of feed material.

### **Variable nutritional values**

Although it has been often assumed that most inorganic feed phosphates have a high phosphorus availability, research shows that there are significant differences in available phosphorus content between different types of phosphate, as well as between the same phosphates from different sources.

Investigation of 20 commercial dicalcium phosphates demonstrated differences in availability, compared to a highly available phosphorus source, of as much as 30% (Waibel et al. 1984). These variations were explained by the different compositions and chemical structures of the phosphates tested, demonstrating the importance of knowing these in order to be able to accurately predict phosphorus availability.