

MODERN FEED PHOSPHATES FOR MODERN ANIMAL HUSBANDRY

SUVREMENI KRMNI FOSFATI ZA SUVREMENI UZGOJ ŽIVOTINJA

K. De Bruyne, J. Zwart

Pregledno znanstveni članak
UDC: 636.085.12.087.72
Primljeno: 26. september - rujan 1997.

CONCLUSIONS

At the moment, there are two different concerns about phosphorus supplementation to the animal. Firstly there is the need for excellent bone mineralization. Secondly, pollution problems in regions with a none land bound animal husbandry emphasise even more the importance off feeds being highly digestible.

Environmental concerns in fact urge for the need of feed with a decreased total phosphorus content in combination with a high level of digestible phosphorus. In this way, uncontrolled output of phosphorus to the environment is avoided. The use of feed phosphates with a high and predictable phosphorus digestibility, together with the use of other raw materials with a high phosphorus digestibility (in combination with enzymes) will lead to a reduced phosphorus excretion.

Sufficient bone mineralization, in fact, requests for a critical (re-) view of the phosphorus requirements and the validation of the raw materials. The occurrence of broken drum sticks in the slaughterhouse is probably more expensive than the savings in the feed. This also urges for the need of using feed phosphates with a high and predictable phosphorus digestibility.

Recent research has demonstrated high levels of digestible phosphorus particularly in high quality monocalcium phosphate and dihydrate dicalcium phosphate. However, the knowledge is upto now not complete. Therefore, we strongly advise to develop a method for assessing the phosphorus digestibility of commercial feed phosphates as accurately as possible. By this we will obtain environment friendly husbandry without running the risk of endangering animal welfare or economic results by using ingredients which do not provide a predictable and stable phosphorus content, resulting in insufficient dietary phosphorus levels.

INTRODUCTION

Phosphorus is an essential element in the animal's body. The importance of phosphorus is reflected in a myriad of metabolic functions in which the element takes part. In addition to its vital role in

the metabolic processes, the main proporation of phosphorus is devoted to maintain and support the

Ir. Karl De Bruyne, Tessengerlo Chemie S.A. Troontstraat 130,
B 1050 Brussel Area Manager – Belgie, Ing. Jo Zwart,
Tessengerlo Chemie Rotterdam B. V. Maassluisdijk 103, 3130
AC Vlaardingen, Tecnical advisol, The Netherlands

skeleton. In fact, 80% of the animal's phosphorus is located there, co-precipitated with calcium in the hydroxy-apatite complex, in which it functions not only as a support system but also as a reservoir of phosphorus.

If insufficient phosphorus is supplied to the animal, predominantly the development of the skeleton will be affected. One could wonder if maximum bone development is really necessary for animals that are slaughtered before their mature weight. However, underdevelopment of the skeleton can give rise to welfare problems and economic losses. These are manifest in the breeding stock and in slaughter animals during the processing of the carcass.

BONE PROBLEMS

In a trial carried out by MORAN (1995.), the effects of sub-marginal phosphorus levels on carcass quality were studied. The exclusion of calcium phosphate had little impact on the live performances during the experiment. Carcass weight, abdominal fat, and percentage yield were all similar over the treatments. However, the nature of the quality affecting defects differed broken drum sticks and clavicles occurred more often when calcium phosphate had been omitted, most probably because of the increased susceptibility to processing traumas. Increased femur breakage during cone processing was obvious when calcium phosphates had been omitted.

Table 1. Performance and carcass quality of broilers in response to omitting calcium phosphate
Tablica 1. Proizvodna svojstva i kakvoća trupa tovnih pilića u odnosu na dodani kalcijev fosfat

Live performances; wk 6-7 – Proizvodna svojstva, 6-7 tj.			
	Weight at 7 Wk - Težina sa 7 tj.	g Gain – Prirast, g	Feed/Gain – Hrana/prirast
Control – Kontrola	2927	572	2.10
Without CaP – Bez CaP	2875	523	2.27
Carcass defects – Grješke trupa			
	% Broken Drums % Slomljeni batak	% Broken Clavicle % Slomljena klavikula	% Broken Femur % Slomljeni femur
Control – Kontrola	0.5	21.3	3.0
Without CaP – Bez CaP	3.5	29.0	19.4

The yield of untrimmed, skinless and boneless meat was not affected. However, the increasing incidence of carcass defects will have a negative cost effect because of the need for additional labour. Another remarkable conclusion drawn from this research was the reduced incidence of breast blisters and back bruising, most probably because of the fact that the birds had less resistance to catching and handling, and that their movements in coops prior to processing were minimal. This could be an indication that the exclusion of calcium phosphates had a negative impact on the welfare of the birds.

In the Netherlands there is an increasing number of reports on bone problems both with sows and broilers. Particularly in case of highly productive sows, phosphorus deficiency can be acute, which of course represents an economic loss to the

farmer. In case of broilers a less developed skeleton, resulting in bone fractures during processing, seems to become an increasing problem.

The incidence of bone problems is hard to quantify. However, from the MORAN report (1995.), it has become obvious that sub-optimal levels of phosphorus supplementation to broilers can easily lead to bone problems during slaughter, without affecting growth and yield. Therefore, a possible insufficient phosphorus supplementation could be (amongst others) a cause. Next to the under-supplementation with total phosphorus, there are three error sources which could possibly affect the level of digestible or available phosphorus in the feeds: the norms, the valuation of the raw materials (including feed phosphates) and the valuation of phytase effectiveness.

PHOSPHORUS NORMS

Recommendations for phosphorus requirements vary among different countries. In the NETHERLANDS the phosphorus requirements have recently been reviewed. These requirements are based on the factorial method allowing an accurate approach. One of the fundamentals in this system is based on obtaining (almost) maximum bone calcification. However, safety margins, which normally act as a safeguard for natural variations, have been decreased. Natural variations among animals can be caused by differences in breed and strain, herd uniformity, variation in feed intake (according to ROWAN, 5% to 10% of the animals consume too little phosphorus), environmental stress and differences in performances. Also improved breeding-techniques have resulted in faster growing, heavier, more efficient animals. The increased retention of protein at high growth rates results in higher requirements, therefore recommendations could easily be not in tune with the progress in live stock.

PHOSPHORUS SOURCES:

Phosphorus originates from three different sources: animal products vegetal raw materials and inorganic feed phosphates, all having their own advantages and disadvantages.

Animal products

The overall phosphorus content of rendered animal products is quite variable, variations of 30% are not uncommon. The phosphorus is considered to have a relative high availability. However, the rule of the thumb that the phosphorus availability is as high as 100% or at least similar to organic feed phosphates has not been confirmed in recent digestibility trials.

Another comment has to be made: rendered animal products may be subject to contamination with pathogenics.

Table 2. Digestibility of some selected animal products, results ID-DLO 1993

Tablica 2. Probavljivost pojedinih odabranih krmiva životinjskog podrijetla, rezultati ID-DLO, 1993.

Source	P-content g/kg Sadržaj P g/kg	St. deviation Standard. devijacija	Dig. Phosphorus % - Probavljivost fosfora %	
			pigs – svinje	poultry - perad
Meat and bone meal Mesno koštano brašno	59.4	6.0	69	66
Bone meal – Koštano brašno	74.4	4.3	64	59
Meat meal – Mesno brašno	31.1	2.6	59	65
Monocalcium phosphate Monokalcij fosfat	227	1.0	83	84

Vegetal raw materials

Most of the phosphorus present in vegetal material is in the form of phytate-phosphorus and since phytase is lacking in monogastric animals, this phytate-phosphorus is thought to be virtually unavailable to monogastric animals. As a rule of the thumb, the availability of phosphorus originating from vegetal materials has been set on 30%. However, the variation of digestible phosphorus content ranges from 6% to around 50%, because of the differences in phytate-phosphorus level and

since monogastric animals –particularly poultry- are at least partly capable to hydrolyse phytate-phosphorus.

Enzymes, i.e. phosphatases and phytases, are able to liberate phytate-bound phosphorus making it available for monogastric animals. Some vegetal raw materials, i.e. grain and grain by-products, contain significant quantities of natural phytase. However, the variation in the content is considerable. Moreover, pelleting operations will destroy the activity progressively. Also the activity is

inhibited at pH 3, the prevailing pH level in the stomach of monogastric animals.

Because of fluctuating phosphorus levels in the various vegetal raw materials and because of the susceptibility of endogenous phytase an over-estimation of the phosphorus digestibility is easily made. Which can lead to an sub-optimal phosphorus supply.

The content of digestible phosphorus of the plant raw materials can be increased by adding exogenous phytase to the feeds. Since 1990, microbial phytase preparations are commercially available. These microbial phytases contain high enzyme activity. In view of the sensitivity of phytase to temperature, humidity and other feed ingredients, like minerals and trace elements, a decrease in activity can be expected when it is included into animal feed. Particularly the thermostability during the pelleting process can be strongly affected by the degree of humidity and the conditioning circumstances.

The influence of process temperatures and storage on the stability of phytase

The INDUSTRIËLE HOGESCHOOL CTL in GENT studied the effect of pelleting conditions on the phytase activity. Besides, the effect of storage at increased temperature on the phytase activity was measured. The feeds used were standard commercial meal feeds and commercial phytase was added to obtain a level of 500 FTU. Hereafter the meals were split into two portions, one part was pelleted at different conditioning temperatures (increments of 10 °C), the other part was stored during four weeks at 40 °C. The (commercial meal feeds (piglet-, sow- and broiler feed) were mixed with (commercial) phytase. After this the feeds were conditioned, temperature and moisture content were increased by adding steam, and pelleted. Temperature and moisture content were measured after conditioning and at the die outlet. Enzyme activity was measured in the pellets, the remaining activity is expressed in relation to the activity measured in the meal before conditioning.

The results show that the phytase activity went down as temperatures were increased. At conditioning temperatures above 80 °C the phytase recovery was only around 20%. The outcome of this study is confirmed by several other researchers.

Table 3. Remaining activity (%) in the after conditioning and pelleting relative to the activity in the meal before pelleting

Tablica 3. Kretanje aktivnosti (%) u I poslije kondicioniranja I peletiranja u relativnom odnosu aktivnosti u krmnoj smjesi prije peletiranja

Feed Hrana	Conditioning temp. °C Temperatura	Moisture cont. * % Vlaga	Phytase recovery % Fitaza
Piglet	38	12	100
Prasad	60	14	53
	85	16.6	19
Sow Krmače	49	12.6	100
	59	16	64
	87	16.5	20
Broiler Brojleri	40	11.7	81
	60	13.6	63
	80.3	15.2	26

* after steam addition – poslije dodavanja pare

At farm, the temperature in silos can rise considerably during summer day time which of course can have a negative effect on the phytase activity in stored feed. Therefore, in the second part of the trial the loss in activity during storage was studied. The same meal feeds were used and stored at the temperature of 40 °C: the loss of activity was measured each week during a period of four weeks. After the period of four weeks storage at 40 °C, the loss in activity ranged between 26% and 44%.

Table 4. Remaining activity (%) in the feed (meal) during storage at 40 °C

Tablica 4. Kretanje aktivnosti (%) u krmnim smjesama u tijeku skladištenja pri 40 °C

Meal Smjesa	Week 1 1. tjedan	Week 2 2. tjedan	Week 3 3. tjedan	Week 4 4. tjedan
Piglet Prasad	83	64	62	56
Sow Krmače	72	78	59	-
Broiler Brojleri	85	78	78	74

If steam pelleting is used, the normal conditioning temperatures will be as high as 60 °C for pig feeds and 70 °C for broiler feeds. Taking in to account both effects, the loss in activity due to pelleting and storage, a total loss in activity, within four weeks, of almost 70% is most likely. Instead of a presumed activity of 500 FTU at the end, only 150 FTU is retrieved. In other words, more than 1650 FTU should have to be added to the feed in order to guarantee an activity of 500 FTU when fed to the animals.

Apart from the fact that phytase activity in ready made feed can not be guaranteed with any certainty, which endangers the phosphorus supplementation of farm animals, another remark has to be made on the effectiveness of phytase. Literature shows that in spite of the fact that the phosphorus liberated by phytase appears to be utilized as efficiently as the phosphate originating from inorganic phosphorus sources, it seems to be difficult to obtain maximum bone-strength or ash content (Seynave and Dewilde 1993, Sauveur, 1993, Simons and Versteegh, 1993, Huyghebaert and al., 1992). Taking in to account both effects, the possible loss due to stability problems and less than maximum bone calcification, this could most probably have a detrimental effect on the skeleton development and could negatively affect the welfare of animals.

Inorganic feed phosphates

Feed phosphates are used to balance the feeds to their content of available or digestible phosphorus and the total phosphorus content. Not only in view of economics but, even more important, in view of the impact on the environment, it is therefore of paramount importance to assess the availability of different feed phosphates as accurately as possible. In the NETHERLANDS, during the last decade, there have been quite a lot of animal trials for measuring the biological value of feed phosphates as accurately as possible.

Different ways exist to measure the availability of phosphorus. Because of the fact that phosphorus is for the greater part deposited in the skeleton, bone parameters (like bone strength or ash content) are used to measure the relative apparent phosphorus availability. However, these trials are quite complicated. Therefore, the apparent digesti-

bility is used at the moment to determine the biological availability of phosphorus sources.

Table 5. Apparent digestibility of different feed phosphates, CVB-values

Tablica 5. Stvarna probavljivost raznih krmnih fosfata, CVB-vrijednosti

	Pigs Svinje	Poultry Perad
Monocalcium phosphate – MCP	83	84
Dicalcium phosphate hydrated – DCP	69	77
Dicalcium phosphate anhydrous DCP bezvodni	66	57

Values may vary according to the origin
Vrijednosti variraju

The results show that between the two species there are some differences in the biological value of different feed phosphates. A possible explanation for this observation could be the fact that between pigs and poultry there are some anatomic and physiological differences. But also it could be caused by differences in the protocol.

To avoid undesirable interactions with phosphorus originating from the raw materials in the basal diet, it is important that, when carrying out a digestibility assay, the basal diet should be nearly phosphorus-free. Furthermore, the content of digestible phosphorus of the experimental diet should be below the phosphorus requirement of the animal.

Both protocols comply to the second starting point, however, only in case of poultry the researchers made use of virtual phosphorus free basal rations. Most probably this can also be partly an explanation of the differences of valuation of the feed phosphates between both species.

Apparent digestibility of some selected feed phosphates

During 1995 two trials were carried out in order to assess the biological value of our feed phosphates as accurately as possible, both with piglets and broiler chicks. The first one was carried out at THE GOVERNMENT RESEARCH INSTITUTE FOR ANIMAL NUTRITION, the second one at THE GOVERNMENT RESEARCH STATION FOR SMALL STOCK HUSBANDRY both in GENT,

BELGIUM. Since other papers will go further into these trials, only the results will be presented here and commented.

Piglets:

In the past a lot of trials were carried out to determine the phosphorus digestibility of different inorganic feed phosphates. There are, however, some differences between these trials and the trial presented here, both in the protocol and in the results. In the trial in question, a practically phosphorus free basal diet was used, in order to prevent the interference with endogenous phosphorus from other raw materials. In case a 'normal' basic diet is used (composed from standard feed ingredients) the level of endogenous phosphorus will be higher. Most probably this phosphorus will interfere with the one from the P-source to be checked, resulting in a digestible phosphorus value which will be an under-estimation of the real digestibility value.

Table 6. Apparent digestibility of some selected feed phosphates

Tablica 6. Stvarna probavljivost nekih probраниh krmnih fosfata

	Piglets Svinje	Broilers Brojleri
Aliphos monocal – MCP	92%	86%
Aliphos dical 18, dihydrated DCP - dihidrat	73%	83%
Dicalcium phosphate, anhydrous DCP – bez vode	63%	65%

The results clearly show that in the past the digestibility of the tested feed phosphates was under estimated. In particular the digestibility of monocalcium phosphate is according to this trial much higher; 92% vs. 83%. Such differences are not only of economic, but certainly also of environmental interest. Calculating with the correct digestible phosphorus values, the phosphorus excretion can be limited without affecting the level of digestible phosphorus in the feeds.

Broiler chicks

Although the digestibility of the tested feed phosphates was in general higher, the results (the ranking) of the trial in question are quite in line with earlier trials, carried out in THE NETHERLANDS. In those earlier trials virtually phosphorus free basal rations were already used. Between both trials pigs and poultry- there are notable differences in the digestibility of the different feed phosphates. Particularly dihydrate dicalcium phosphate scored a value (83%) which was almost as high as the value for monocalcium phosphate (86%). It seems that poultry is capable to utilize dihydrate dicalcium phosphate much better than in the case of pigs. These differences were already demonstrated in earlier trials.

The differences between the trial in question and the earlier ones clearly show the importance of phosphorus free basal rations. When using basal rations the digestibility of the feed phosphates can be assessed more accurate by. Therefore, we would like to emphasise the use of phosphorus-free basal rations in phosphorus digestibility trials. Considering the differences in digestibility between various feed phosphates, the use of phosphates which are not tested according to this method should be out of the question.

REFERENCES

1. Beers, S., P. A. Kemme, A. W. Jongbloed, V. B. J. Horsting – Apparent digestibility of phosphorus in products of animal origin. Rapport IVVO-DLO no. 249.
2. Bos, K. D., J. Jetten and al. (1994): Chemische achtergronden van fosforverbindingen in veevoedergrondstoffen, in vitro voorspelling van beschikbaar fosfor, analysemethode van microbieel fytase en in vitro onderzoek naar de werking van fytase. Produktschap voor veevoeder – kwaliteitsreeks, nr. 25, 81-97. VCB.
3. Cromwel, G. L., and al. (1993): Efficacy of phytase in improving the bioavailability of phosphorus in soybean meal and corn-soybean meal diets for pigs. Journal of animal science, July, 1831-1840.
4. Eekhout, M., M. De Schrijver, E. Vanderbeke (1995): The influence of proces parameters on the

- stability of feed enzymes during steam-pelleting. Proceedings of ESFE2, 163-169.
5. EMFEMA, (1996): Some considerations about the use of feed phosphates and phytase. Working document of the group major minerals.
 6. Huyghebaert, G., G. De Groot, R. Geerse (1992): Het effect van microbiële fytase op de P-benutting bij slachtkippen – Invloed op de skeletmineralisatie en op de zoötechnische prestaties. Landbouwtijdschrift, 45, 2, 225-237.
 7. Jongbloed, A. W., H. Everts, P. A. Kemme (1994): Verteerbaar fosfor normen voor varkens. CVB-documentatierapport nr. 10, september, centraal veevoederbureau.
 8. Kiishinen, Piironen (1990): Effect of phytase supplementation on utilization of phosphorus in chicken diets. WPSA.
 9. Lookeren Campagne van C.J., A. K. Kies (1995): Developments in feed enzymes, enzyme activity, application, efficacy and analysis. Proceedings of ESFE2, 260-268.
 10. Moran, E. T. (1995): Low phosphorus affects broiler carcass quality. FEED MIX, special issue on phosphates, 21-23.
 11. Roland A. D. (1995): Phosphorus recommendations for commercial leghorns, FEED MIX, special issue on phosphates, 21-23.
 12. Sauveur, B. (1989): Phosphore phytique et phytases dans l'alimentation des volailles. INRA Prod. Anim., 2,5, 343-351.
 13. Sauveur, B. (1993) – Les phytases fongiques dans l'alimentation des volailles. INRA Prod. Anim., 6, 265-267.
 14. Seynave, M. and Dewilde (1993): Rapport IRSIA.
 15. Simons, P. C., H. Versteegh (1993): Microbiële fytase in de voeding van slachtkuikens en leghennen. Produktschap voor veevoeder – Kwaliteitsreeks nr. 25, 125-135.
 16. Veevoedertabel (1996) – centraal veevoederbureau.
 17. Voorlopig systeem opneembaar fosfor pluimvee. CVB-reeks nr. 16, september 1994, centraal veevoederbureau.

SAŽETAK

Danas postoje dvije različite brige u svezi s dodavanjem fosfora životinjama. Prvo je potreba za dobrom mineralizacijom kostiju. Drugo, problemi zagađenja u područjima gdje se uzgajaju životinje koje nisu vezane za zemlju još više ističu važnost visoko probavljive hrane.

Briga za okoliš u stvari ističe potrebu hrane sa smanjenim ukupnim sadržajem fosfora u kombinaciji s visokom razinom probavljivog fosfora. Na taj se način izbjegava nekontrolirano ispuštanje fosfora u okoliš. Upotreba krmnih fosfata, visoke i predvidive probavljivosti fosfora zajedno s upotrebom drugih sirovina visoke probavljivosti fosfora (u kombinaciji s enzimima) dovest će do smanjenja ispuštanja fosfora.

Dovoljna mineralizacija kostiju u stvari zahtijeva kritično (pre-)ispitivanje potreba za fosforom i vrijednosti sirovina. Pojava slomljenih bataka u klaonici vjerojatno je skuplja od uštede na hrani. Ovo također ističe potrebu upotrebe krmnih fosfata visoke i predvidive probavljivosti fosfora.

Novija istraživanja pokazuju visoke razine probavljivog fosfora, osobito u monokalcij fosfatu visoke kakvoće i dikalcij fosfatu. Međutim saznanja su još nepotpuna. Stoga se preporuča razvijanje što točnije metode za procjenjivanje probavljivosti fosfora komercijalnih krmnih fosfata. Na taj će se način dobiti gospodarstva bez rizika ugrožavanja dobrobiti životinja ili ekonomskih rezultata primjenom sastojaka koji ne daju predvidiv i stabilan sadržaj fosfora, što će rezultirati nedovoljnim razinama fosfora.