



# Natuphos®





CONTENT/INTRO	02-03
PHOSPHORUS – AN ESSENTIAL MICRONUTRIENT FOR LIVESTOCK	04-05
THE KEY TO NATURAL PHOSPHORUS	06-07
MORE THAN JUST PHOSPHORUS RELEASE	08-09
THE PATH TO SUSTAINABLE ANIMAL NUTRITION	10-11
THE TOOL FOR EFFICIENT FEED FORMULATION	12-13
THE ANSWER TO RISING FEED COSTS	14-15
THE TOOL FOR ADDITIONAL COST SAVINGS	16-17
CONVINCING BENEFITS FROM ADDING MORE NATUPHOS®	18-19
THE RIGHT FORMULATIONS FOR ALL APPLICATIONS	20-21
SUPERIOR BIOEFFICACY – COMPARISON WITH PENIOPHORA PHYTASE	22-23
FAST NUTRIENT RELEASE MAKES THE SUCCESS	24-25
A TOP PLAYER – COMPARISON WITH E. COLI PHYTASE	26-27
THE MOST ENVIRONMENTALLY FRIENDLY ALTERNATIVE	28-29
THE NATUPHOS® PRODUCT PORTFOLIO	30
CONTACTS	31

#### ABBREVIATIONS

DCP	= Dicalcium phosphate
MCP	= Monocalcium phosphate
FTU	= Natuphos® phytase unit
P	= Phosphorus
avP	= Available phosphorus
dP	= Digestible phosphorus
iP	= Inorganic phosphorus
PP	= Phytate phosphorus
Zn	= Zinc

# OUR VALUABLE EXPERIENCE FOR YOUR VALUABLE ANIMALS.

#### AT A GLANCE

- Highly trusted and reliable phytase brand
- Excellent, long-proven quality
- More than 20 years of experience in safe feed formulation and phosphorus supply
- High-performing microbial 3-phytase
- Most cited database for phytase use in feed

A PIONEER – THE ORIGINAL PHYTASE!



# WHY THE ELEMENT PHOSPHORUS IS ELEMENTARY.

## AN ESSENTIAL MICRONUTRIENT

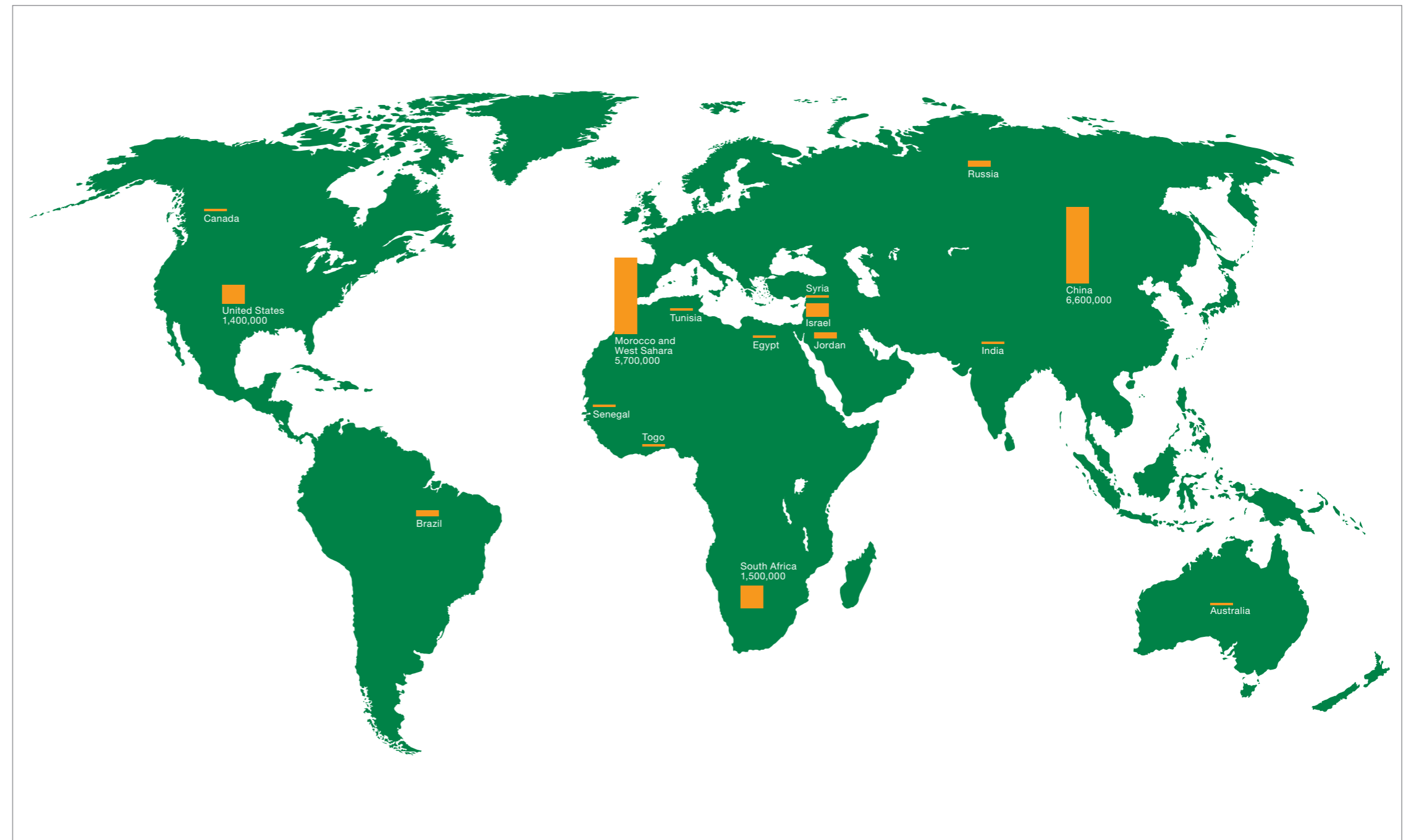
Phosphorus is an essential mineral for pigs and poultry, which require it for various biological functions. It plays a key role in bone formation and mineralization and is involved in many other metabolic processes like energy transfer as well as protein and nucleic acid assembly. Phosphorus is also one of the building blocks of cell membranes. Phosphorus deficiency causes poor bone mineralization and impairs important production parameters such as growth rate, carcass leanness and carcass quality. To ensure good animal health and performance, it is therefore essential to supply adequate amounts of phosphorus in the feed.

## SOURCES OF PHOSPHORUS

Feed ingredients contain varying amounts of phosphorus that is basically available for metabolic functions. However, phosphorus from feedstuffs of plant or animal origin is usually less digestible than inorganic phosphorus added to animals' diets. The cost of inorganic phosphorus feed supplements can be quite high, depending on the supply situation. Prices are expected to rise in the long-term because known global phosphorus reserves are limited (Figure 1). Phosphorus use is currently increasing at a rate of over 3.2 percent annually (FAO, 2008), mainly driven by a rising need for crop fertilization. So making use of plant phosphorus by adding phytase to feed will ensure a long-term, environmentally friendly supply.

## PHOSPHORUS USE IS INCREASING BY OVER 3.2% ANNUALLY (FAO, 2008)

FIGURE 1: KNOWN GLOBAL PHOSPHATE RESERVES (METRIC TONS)



Source: Potash Corp., 2005



# WHEN IT COMES TO UNLOCKING NATURAL PHOSPHORUS, NATUPHOS® IS A NATURAL.

## THE PHYTATE LOCK IN PLANT-BASED FEED

In plant-based feed like cereals and oilseeds, up to 80 percent or more of the total phosphorus can be locked up in phytate (Table 1). Phytate, which is the storage form of phosphorus for their seedlings, is practically indigestible by monogastric

animals (i.e., animals with a single stomach, including poultry and pigs). This causes them to excrete considerable amounts of undigested phosphorus from vegetable feed components, which also causes environmental problems (Figure 2).

TABLE 1: PHYTATE-BOUND PHOSPHORUS CONTENT OF MAJOR PLANT FEED COMPONENTS

INGREDIENT	PHYTATE P (g/100 g DM)	PHYTATE P (as % of total P)	INGREDIENT	PHYTATE P (g/100 g DM)	PHYTATE P (as % of total P)
<b>Cereals</b>			<b>Grain legumes</b>		
Maize	0.24	72	Field peas	0.24	50
Barley	0.27	64	Cowpeas	0.26	79
Wheat	0.27	69	Green gram	0.22	63
Oats	0.29	67	Pigeon peas	0.24	75
Sorghum	0.24	66	Chickpeas	0.21	51
Foxtail millet	0.19	70	<b>Oilseed meals</b>		
Finger millet	0.14	58	Soybean meal	0.39	60
Rice, unpolished	0.27	77	Cottonseed meal	0.84	70
Rice, polished	0.09	51	Peanut meal	0.48	80
<b>Cereal by-products</b>			Rapeseed meal	0.70	59
Rice bran	1.03	80	Sunflower meal	0.89	77
Wheat bran	0.92	71	Coconut meal	0.29	49
Rice polishings	2.04	89	Sesame meal	1.01	81
<b>Roots and tubers</b>			<b>Miscellaneous</b>		
Cassava root meal	0.04	28	Grass meal	0.01	2
Sweet potato tuber meal	0.05	24	Alfalfa meal	0.02	12
Taro corn meal	0.09	24	Cassava leaf meal	0.04	10
			Corn gluten meal	0.41	59
			Isolated soy protein	0.48	60

Source: Ravindran et al. 1995 (modified)

## NATUPHOS® MAKES BOUND PHOSPHORUS DIGESTIBLE

Natuphos®, the feed enzyme from BASF, is a highly efficient 3-phytase. It is produced by a non-pathogenic strain of *Aspergillus niger* in large-scale fermentation processes. Monogastric animals like poultry and swine lack sufficient intestinal phytase for breaking down phytate, which is present in cereal and soybean-based diets to varying extents. Hence, added to feed, Natuphos® joins the limited range of endogenous enzymes present in the gastrointestinal tract of pigs and poultry to ensure the efficient release of dietary phosphorus from phytate, thus making it readily digestible (Figure 3).

## QUALITY TO MEET YOUR NEEDS

Natuphos® is an important member of the extensive BASF family of animal nutrition products. All of BASF's enzyme products are subjected to stringent quality controls and continually developed further to create optimum solutions for your feed and animal production requirements.

FIGURE 2: FLOW OF PHOSPHORUS INGESTED BY GROWING-FINISHING PIGS

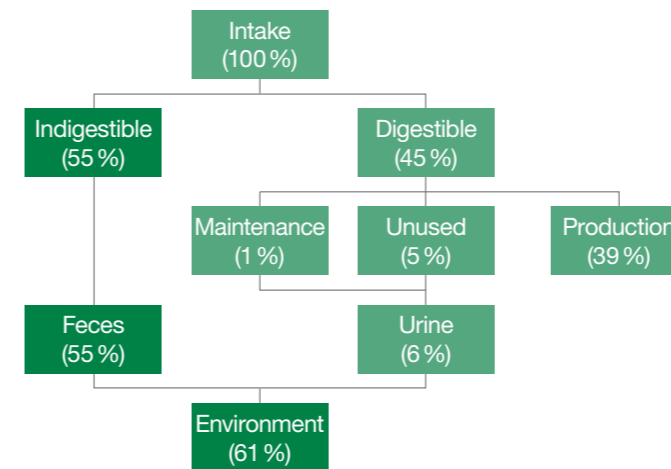
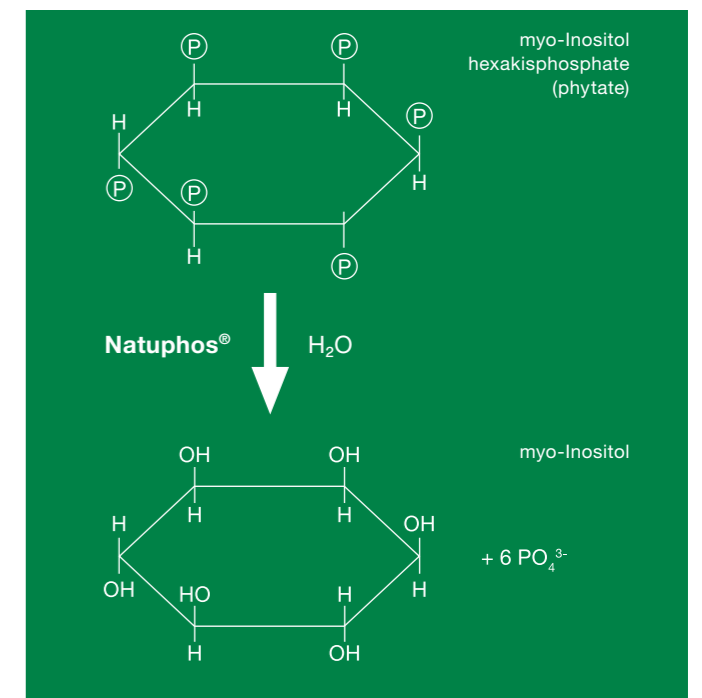


FIGURE 3: RELEASING PHOSPHORUS FROM PHYTATE WITH NATUPHOS®





# ONE GOOD IDEA. MANY GOOD REASONS.

## NATUPHOS® ALSO RELEASES OTHER PHYTATE-BOUND NUTRIENTS

Phosphorus is not the only valuable nutrient that is locked in the phytate complex. There are many others, including calcium, zinc, copper, magnesium and amino acids. When Natuphos® releases the phosphorus from phytate, it liberates it as well. It can then also be absorbed and utilized for physiological functions instead of being lost with the manure. Apart from phosphorus, it is mainly the absorption of calcium which can be improved by phytase supplementation (Figure 4). Improved absorption of phosphorus and calcium usually has a positive impact on bone mineralization. Enhanced absorption of minerals and trace elements results in various other benefits, e.g., improved egg shell thickness (Figure 5).

## MORE ENERGY AND BETTER PROTEIN UTILIZATION

Adding Natuphos® to feed not only allows animals to metabolize more energy (Figure 6). It also makes sure they get enough of the building blocks required to make protein, which is essential for all biological processes (Figure 7).

FIGURE 4: EFFECT OF NATUPHOS® ON PHOSPHORUS AND CALCIUM ABSORPTION IN PIGS

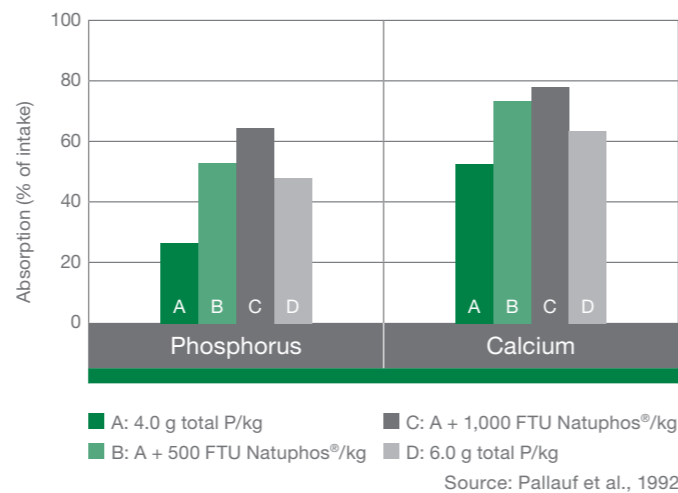


FIGURE 5: GRADED EFFECTS OF NATUPHOS® ON PHOSPHORUS DIGESTIBILITY AND EGG SHELL THICKNESS IN LAYERS (age: 70 weeks, period: 3 weeks)

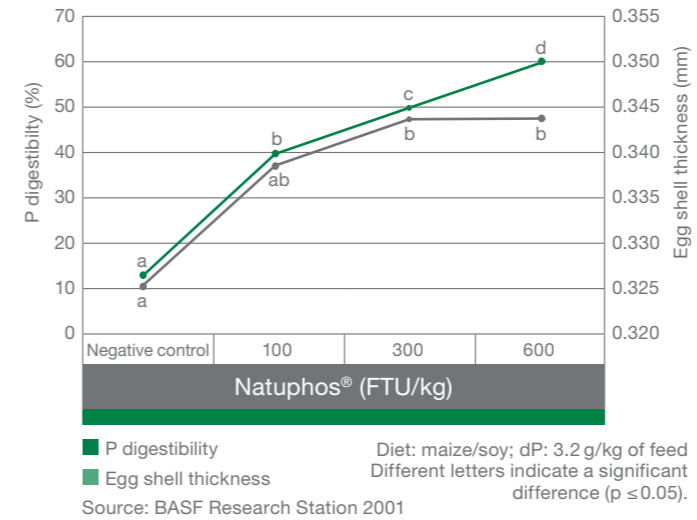


FIGURE 6: EFFECT OF NATUPHOS® ON APPARENT METABOLIZABLE ENERGY (AME) IN BROILERS

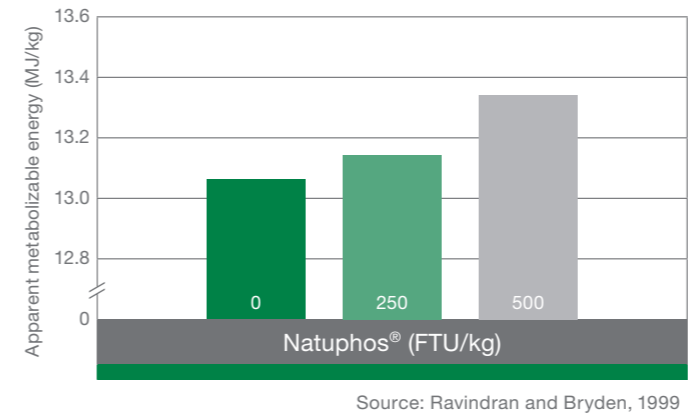
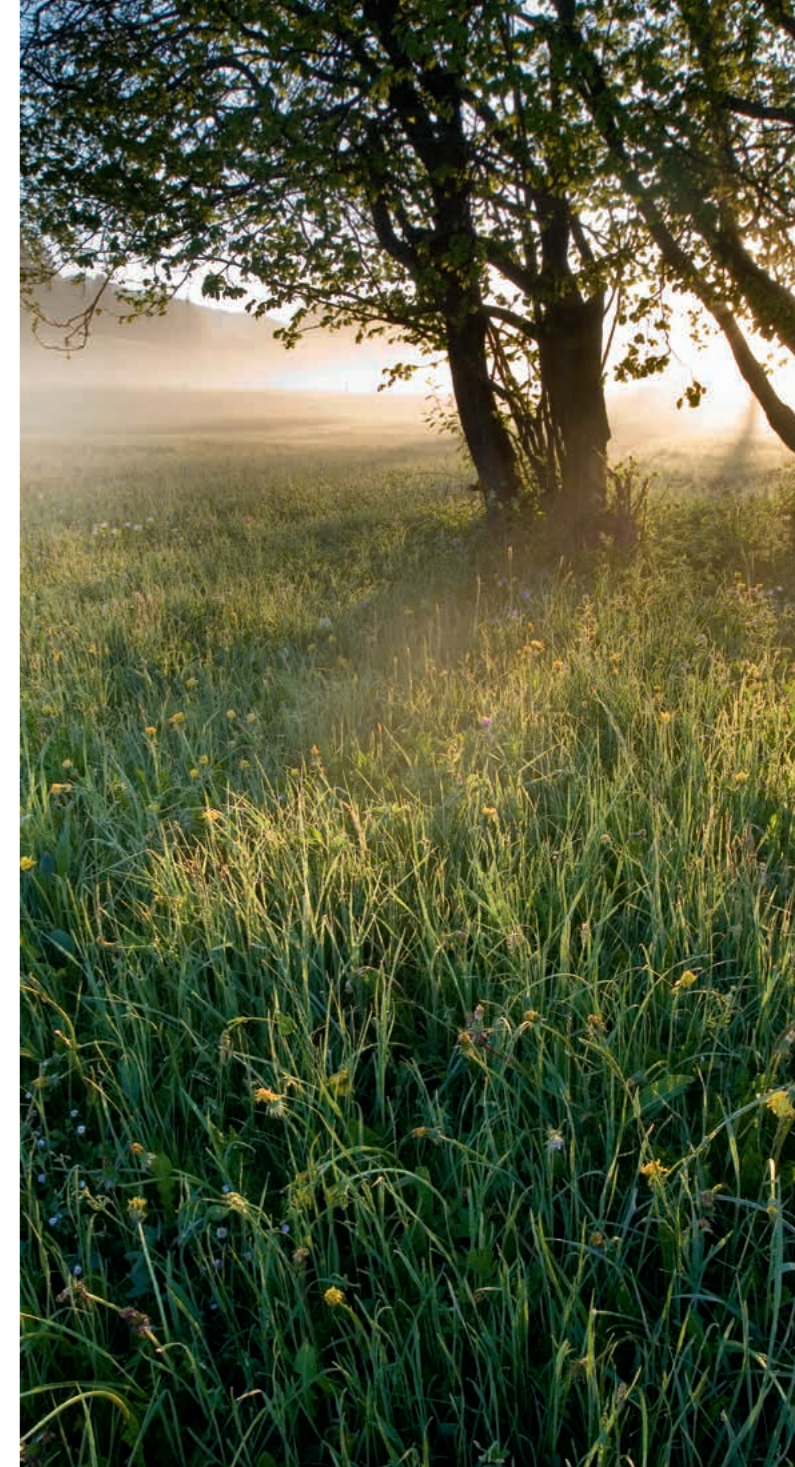
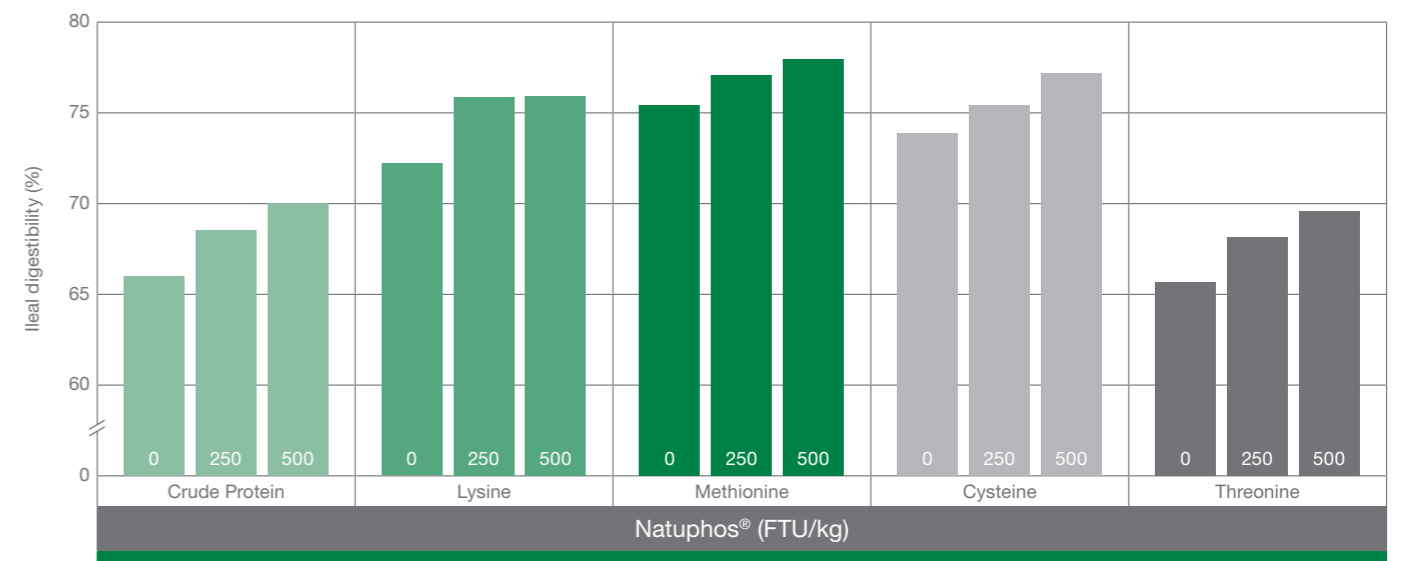


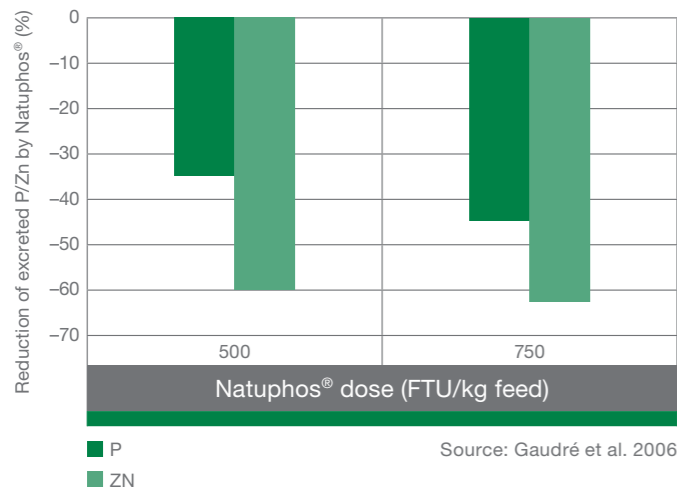
FIGURE 7: NATUPHOS® IMPROVES CRUDE PROTEIN AND AMINO ACID DIGESTIBILITY IN PIGS





# HOW NATUPHOS® CAN BE THE KEY TO PRODUCE MORE FROM LESS.

FIGURE 8: EFFECT OF NATUPHOS® ON PHOSPHORUS AND ZINC EXCRETION IN PIGS FROM 12 TO 110 KG BODY WEIGHT



## IMPROVE ANIMAL NUTRITION WHILE REDUCING FEED COSTS

Pig and poultry producers around the world add BASF's efficient phytase products to a variety of animal diets to improve the digestion of phytate-bound minerals and nutrients. Their experience has proven that this reduces the excretion of phosphorus and other environmentally critical substances such as zinc (Figure 8). The increased absorption of these nutrients also makes it possible to substitute some trace elements for Natuphos®, thus generating additional cost savings.

## NATUPHOS® REDUCES ENVIRONMENTAL IMPACTS

In many countries, intensive livestock production is concentrated in certain areas. Animal producers there are increasingly hampered by regulations on manure disposal that are designed to prevent excessive contamination of the soil with phosphorus, nitrogen and heavy metals. Natuphos®, the very first feed phytase, was developed in response to environmental problems of this type. A large number of laboratory and field trials have demonstrated that Natuphos® can help solve them.

Many feed producers now regard Natuphos® as a valuable tool for achieving more sustainable animal nutrition. It improves farms' phosphorus balance by tailoring feed phosphorus content more closely to their animals' requirements while minimizing losses through excretion (Table 2).

## NATUPHOS® - THE ECOFRIENDLY, ECONOMICAL SOLUTION

Pig and poultry feeds containing Natuphos® offer farmers economic benefits and also minimize ecologic burdens. The following benefits can be expected:

- Reduction of inorganic phosphorus supplementation
- Decrease of phosphorus excretion by up to 50 %
- Less land needed for manure disposal
- Lower disposal costs



TABLE 2: REDUCED PHOSPHORUS EXCRETION BY BROILERS

PHOSPHORUS		DIET WITHOUT NATUPHOS®	DIET WITH 300 FTU NATUPHOS®/KG AND -10 % avP	DIET WITH 600 FTU NATUPHOS®/KG AND -20 % avP
FEED PHOSPHORUS	TOTAL P CONTENT OF FEED (%)	0.67	0.57	0.47
	REDUCTION (%)		-14.90	-22.90
EXCRETION	TOTAL P CONTENT (% of dry matter)	1.43	1.21	0.97
	REDUCTION (%)		-15.40	-32.70
	TOTAL P CONTENT (g/kg live weight)	6.65	5.42	3.98
	REDUCTION (%)		-18.50	-40.10
	SOLUBLE P (mg/kg)	2,394	2,157	937
	REDUCTION (%)		-9.90	-60.90

Source: Simms et al. 1999



# ONE OF THE MOST EFFICIENT WAYS TO INCREASE EFFICIENCY.

## PROVEN EFFICACY

The ability of Natuphos® to release phytate-bound minerals and amino acids and its impact on the energy value of feed have been verified and quantified in numerous feeding trials with widely varying diets. You can take advantage of this by reducing nutrient constraints while still achieving high performance and carcass quality with feed based on maize, wheat, barley, sorghum, soybean meal, other protein sources or various by-products. BASF collected all of the results from trials with pigs and poultry in a comprehensive database.

## AN EASY-TO-USE GUIDE TO MORE EFFICIENT PRODUCTION

To facilitate the evaluation of the economic value of Natuphos® application, BASF has introduced the matrix. The standard Natuphos® matrix was created by merging results from a plethora of scientific and applied trials. It is generally known and used as “the standard phytase matrix”. This matrix precisely indicates the amounts of different nutrients that can be replaced per kg of Natuphos® up to a dosage of 500 FTU per kilogram of feed (in layer feed up to 300 FTU per kg). Standard matrix values for least-cost formulation for pig and poultry feed are shown in Table 3 a and 3b.

TABLE 3 A: STANDARD MATRIX VALUES FOR LEAST-COST FORMULATION OF PIG AND POULTRY FEED FOR ALL NATUPHOS® TYPES CONTAINING 5,000 FTU/G

	PIGS	BROILERS, TURKEYS AND DUCKS	LAYING HENS
Nutrient	Up to 500 FTU/kg of feed one kg of Natuphos® 5000 is equivalent to	Up to 500 FTU/kg of feed one kg of Natuphos® 5000 is equivalent to	Up to 300 FTU/kg of feed one kg of Natuphos® 5000 is equivalent to
Total phosphorus from DCP (P 70% digestible)	11,500 g	11,500 g	19,166 g
Total phosphorus from MCP (P 80% digestible)	10,000 g	10,000 g	16,667 g
Calcium	10,000 g	10,000 g	16,667 g
Lysine*	800 g	1,200 g	1,200 g
Methionine*	250 g	100 g	100 g
Cysteine*	300 g	300 g	300 g
Threonine*	500 g	1,300 g	1,300 g
Tryptophane*	300 g	300 g	300 g
Isoleucine*	500 g	1,200 g	1,200 g
Crude protein*	20,000 g	22,500 g	22,500 g
ME (metabolizable energy)	400 MJ/95,000 kcal	2,215 MJ/530,000 kcal	2,215 MJ/530,000 kcal

\*Apparent ileal digestibility.

TABLE 3 B: STANDARD MATRIX VALUES FOR LEAST-COST FORMULATION OF PIG AND POULTRY FEED FOR ALL NATUPHOS® TYPES CONTAINING 10,000 FTU/G

	PIGS	BROILERS, TURKEYS AND DUCKS	LAYING HENS
Nutrient	Up to 500 FTU/kg of feed one kg of Natuphos® 10000 is equivalent to	Up to 500 FTU/kg of feed one kg of Natuphos® 10000 is equivalent to	Up to 300 FTU/kg of feed one kg of Natuphos® 10000 is equivalent to
Total phosphorus from DCP (P 70% digestible)	23,000 g	23,000 g	38,332 g
Total phosphorus from MCP (P 80% digestible)	20,000 g	20,000 g	33,334 g
Calcium	20,000 g	20,000 g	33,334 g
Lysine*	1,600 g	2,400 g	2,400 g
Methionine*	500 g	200 g	200 g
Cysteine*	600 g	600 g	600 g
Threonine*	1,000 g	2,600 g	2,600 g
Tryptophane*	600 g	600 g	600 g
Isoleucine*	1,000 g	2,400 g	2,400 g
Crude protein*	40,000 g	45,000 g	45,000 g
ME (metabolizable energy)	800 MJ/190,000 kcal	4,430 MJ/1,060,000 kcal	4,430 MJ/1,060,000 kcal

\*Apparent ileal digestibility.

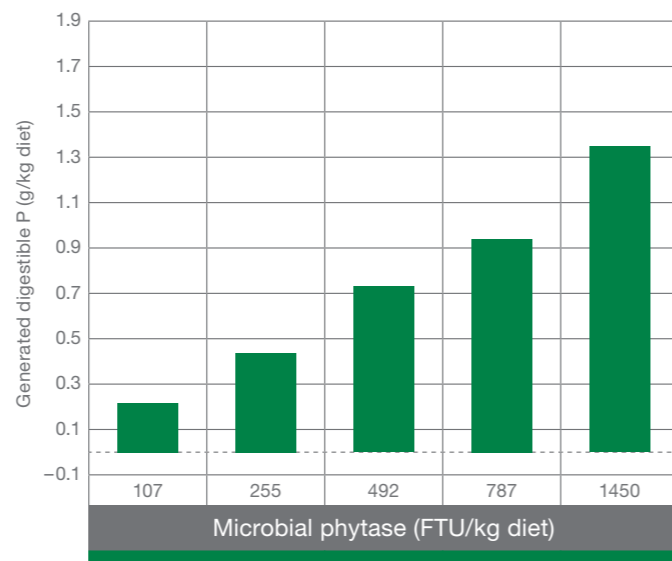


# MAKING YOUR FEED MORE VALUABLE CAN MAKE IT LESS EXPENSIVE.

## ADDITIONAL COST SAVINGS THROUGH EXTENDED MATRIX VALUES

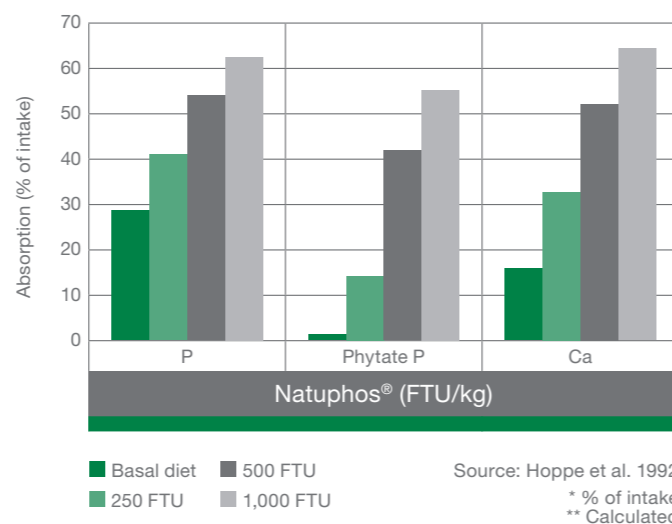
Steadily rising costs for feedstuffs – and especially those from inorganic sources – were the driver for BASF's research to develop extended matrix values for Natuphos® to enable additional cost savings in animal production. The large body of trial data that BASF has gathered from over 20 years of research and product development has been pooled in a matrix for the extended use of Natuphos®. With this matrix, BASF has made available a reliable tool for optimizing feed costs further. For example, as shown in the following Figures 9, 10 and Tables 4–6, increasing the doses of Natuphos® above 500 FTU per kg of feed gives a significant additional boost to the digestibility of phosphorus and other nutrients from pig and poultry diets.

FIGURE 9: EFFECT OF NATUPHOS® ON GENERATED DIGESTIBLE PHOSPHORUS IN GROWING PIGS (28 kg)



Source: Kies et al., 2005

FIGURE 10: UTILIZATION OF CALCIUM, PHOSPHORUS\* AND PHYTATE PHOSPHORUS\*\* BY PIGLETS



Source: Hoppe et al. 1992  
\* % of intake  
\*\* Calculated

TABLE 4: IMPROVEMENT OF PHOSPHORUS DIGESTIBILITY BY INCREASING NATUPHOS® DOSES GIVEN TO FATTENING PIGS

	TREATMENT 1	TREATMENT 2	TREATMENT 3	TREATMENT 4
Natuphos® addition/kg feed	0	250 FTU	500 FTU	750 FTU
P digestibility (%)	43 <sup>a</sup>	55 <sup>b</sup>	61 <sup>cd</sup>	66 <sup>d</sup>
Digestible P (g/kg)	1.9	2.3	2.7	2.9
Increase in digestible P (g/kg)		+0.5	+0.8	+0.1

Different superscripts indicate a significant difference (p ≤ 0.05).

Source: Poulsen et al. 2007

TABLE 5: USE OF INCREASING NATUPHOS® LEVELS ON PHOSPHORUS EQUIVALENCY IN PEKIN DUCKS VERSUS NEGATIVE CONTROL

	TREATMENT 1	TREATMENT 2	TREATMENT 3	TREATMENT 4	TREATMENT 5	TREATMENT 6	TREATMENT 7
Natuphos® addition/kg feed	100 FTU	200 FTU	300 FTU	400 FTU	500 FTU	600 FTU	700 FTU
Equivalency of added phytase units on available P	0.31	0.54	0.72	0.84	0.95	1.02	1.05
Equivalency of added phytase units on total P	0.37	0.64	0.84	1.00	1.15	1.20	1.26

Source: BASF 2004

TABLE 6: THE EFFECT OF DIETARY PHOSPHORUS AND MICROBIAL PHYTASE ON APPARENT ILEAL ABSORPTION OF PHOSPHORUS AND PHYTATE DEGRADATION IN LAYING HENS

	TREATMENT 1	TREATMENT 2	TREATMENT 3	TREATMENT 4
P from MCP (g/kg)	0	1	0	0
Phytase (FTU/kg)	0	0	250	500
P absorption (%)	26.2	40.6	47.7	54.5
Phytate degradation (%)	8.1	11.5	49.6	66.1

Source: Van der Klis et al., 1996







# HOW FEED CAN SAVE FEED COSTS.

The extended matrix values for least-cost formulation of pig and poultry feed are shown in Tables 7a and 7b.

## FOR PIG DIETS

At dosages above 500 FTU per kilogram of feed, the values of the extended matrix have to be added to the full value of the standard Natuphos® matrix to calculate the overall exchange rate.

## FOR BROILER, TURKEY AND DUCK DIETS

At dosages above 500 FTU per kilogram of feed, the values of the extended matrix have to be added to the full value of the standard Natuphos® matrix to calculate the overall exchange rate.

## FOR LAYING HEN DIETS

At dosages above 300 FTU per kilogram of feed, the values of the extended matrix have to be added to the full value of the standard Natuphos® matrix to calculate the overall exchange rate.



TABLE 7A: THE EXTENDED MATRIX VALUES FOR LEAST-COST FORMULATION OF PIG AND POULTRY FEED FOR ALL NATUPHOS® TYPES CONTAINING 5,000 FTU/G

	PIGS	BROILERS, TURKEYS AND DUCKS	LAYING HENS
Nutrient	For a dosage above 500 FTU/kg of feed one kg of Natuphos® 5000 is equivalent to	For a dosage above 500 FTU/kg of feed one kg of Natuphos® 5000 is equivalent to	For a dosage above 300 FTU/kg of feed one kg of Natuphos® 5000 is equivalent to
Total phosphorus from DCP (P 70% digestible)	5,750 g	3,450 g	5,750 g
Total phosphorus from MCP (P 80% digestible)	5,000 g	3,000 g	5,000 g
Calcium	5,000 g	3,000 g	5,000 g
Lysine*	400 g	360 g	360 g
Methionine*	125 g	30 g	30 g
Cysteine*	150 g	90 g	90 g
Threonine*	250 g	390 g	390 g
Tryptophane*	150 g	90 g	90 g
Isoleucine*	250 g	360 g	360 g
Crude protein*	10,000 g	6,750 g	6,750 g
ME (metabolizable energy)	200 MJ/47,250 kcal**	665 MJ/159,000 kcal	665 MJ/159,000 kcal

\* Apparent ileal digestibility.

\*\*Based on crude protein, calculated using the formula of the German Society for Nutritional Physiology (1987).

TABLE 7B: THE EXTENDED MATRIX VALUES FOR LEAST-COST FORMULATION OF PIG AND POULTRY FEED FOR ALL NATUPHOS® TYPES CONTAINING 10,000 FTU/G

	PIGS	BROILERS, TURKEYS AND DUCKS	LAYING HENS
Nutrient	For a dosage above 500 FTU/kg of feed one kg of Natuphos® 10000 is equivalent to	For a dosage above 500 FTU/kg of feed one kg of Natuphos® 10000 is equivalent to	For a dosage above 300 FTU/kg of feed one kg of Natuphos® 10000 is equivalent to
Total phosphorus from DCP (P 70% digestible)	11,500 g	6,900 g	11,500 g
Total phosphorus from MCP (P 80% digestible)	10,000 g	6,000 g	10,000 g
Calcium	10,000 g	6,000 g	10,000 g
Lysine*	800 g	720 g	720 g
Methionine*	250 g	60 g	60 g
Cysteine*	300 g	180 g	180 g
Threonine*	500 g	780 g	780 g
Tryptophane*	300 g	180 g	180 g
Isoleucine*	500 g	720 g	720 g
Crude protein*	20,000 g	13,500 g	13,500 g
ME (metabolizable energy)	400 MJ/95,000 kcal**	1,330 MJ/318,000 kcal	1,330 MJ/318,000 kcal

\* Apparent ileal digestibility.

\*\*Based on crude protein, calculated using the formula of the German Society for Nutritional Physiology (1987).



# IF THE BENEFITS DON'T CONVINCE YOU, YOUR ANIMALS WILL.

## CLEAR GAINS IN NUTRIENT UTILIZATION

Doubling the standard dose up to 1,000 FTU per kg of feed increases average utilization of the nutrients listed in the standard matrix table by 50 percent in pigs (Figure 11a) and by 30 percent in broilers, turkeys and ducks (Figure 11b). With laying hens, doubling the standard dose (300 to 600 FTU per kilogram of feed) also increases the available phosphorus by 30 percent (Figure 11c). For simplicity's sake, the increase of available phosphorus from 0–500 FTU/kg and from 500–1,000 FTU per kilogram of feed in pigs, broilers, turkeys and ducks are assumed to be linear. Likewise, the increase of available phosphorus from 0–300 and 300–600 FTU per kilogram of feed in laying hens is assumed to be linear.

FIGURE 11A: EFFECT OF NATUPHOS® AT FORTIFICATION LEVELS UP TO 500 FTU/KG AND ABOVE IN PIGS

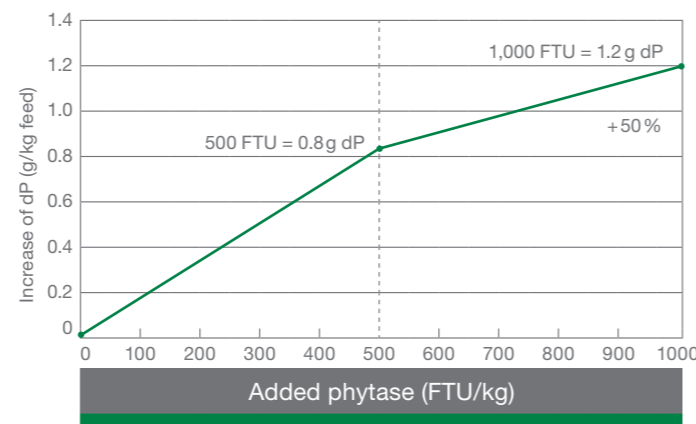


FIGURE 11B: EFFECT OF NATUPHOS® AT FORTIFICATION LEVELS UP TO 500 FTU/KG AND ABOVE IN BROILERS, TURKEYS AND DUCKS

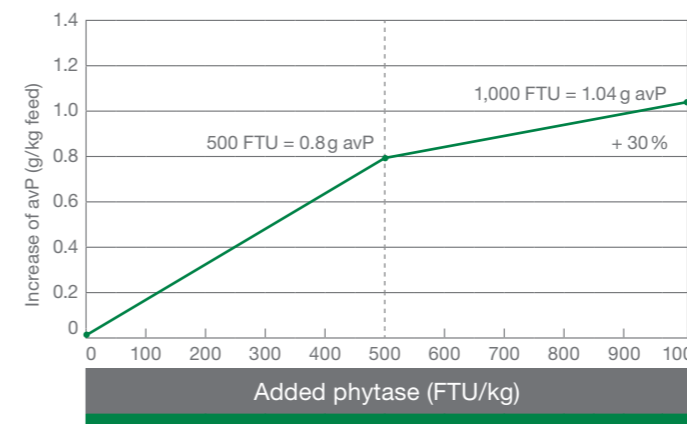
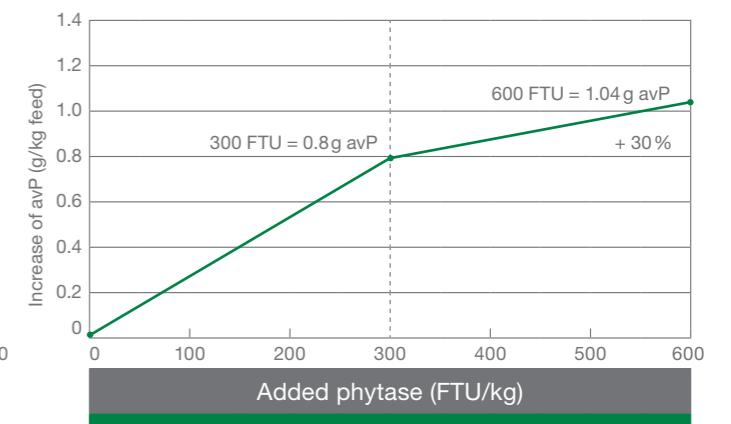


FIGURE 11C: EFFECT OF NATUPHOS® AT FORTIFICATION LEVELS UP TO 300 FTU/KG AND ABOVE IN LAYING HENS





# THERE'S ONLY ONE NATUPHOS®. BUT IT COMES IN THREE FORMULATIONS.

## NATUPHOS® GRANULE

This product has been continually developed and improved for years. Today this highly sophisticated formulation is able to adequately protect the phytase molecule at pelleting temperatures up to 85°C. Also under suboptimal storage conditions (>30°C), this formulation exhibits superior stability compared to competing products – both pure and in premixes (Figures 12–14).

## NATUPHOS® POWDER

The original, classic product is a freeflowing powder. It is thermostable and suitable for pelleting temperatures up to 70°C. It is well-known for its excellent properties, especially in mash feed but also in some base mixes.

## NATUPHOS® LIQUID

BASF has also developed a liquid formulation for applications involving very high pelleting temperatures. With appropriate equipment, you can spray this product onto the cooled pellets (Figure 15).

Pioneered by BASF, this approach has become standard practise around the world. Due to its excellent storability and stability after spraying, Natuphos® Liquid is the favorite product for applications in which the feed pelleting temperatures exceed 85°C.



FIGURE 12: SHELF LIFE WHEN STORED IN A CLOSED PACKAGE AT 35°C



FIGURE 13: PREMIX STABILITY WHEN STORED AT 35°C

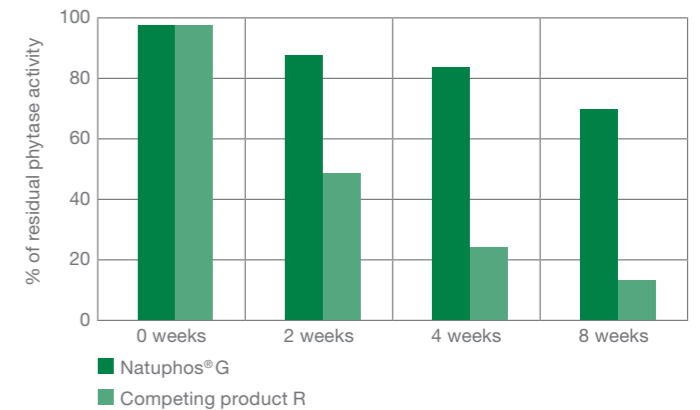


FIGURE 14: PREMIX STABILITY WHEN STORED AT 35°C

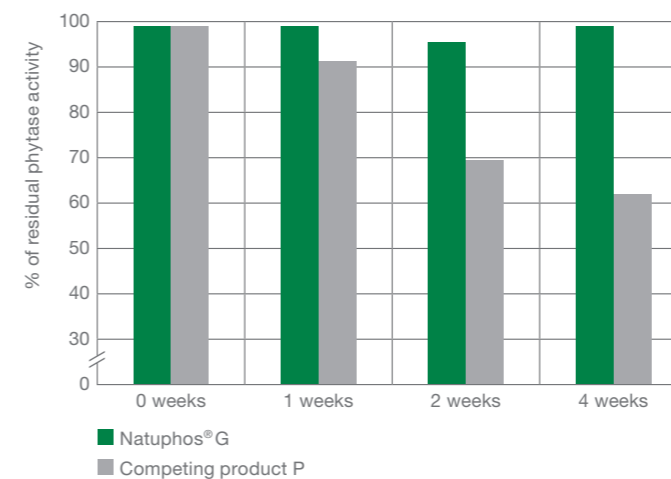
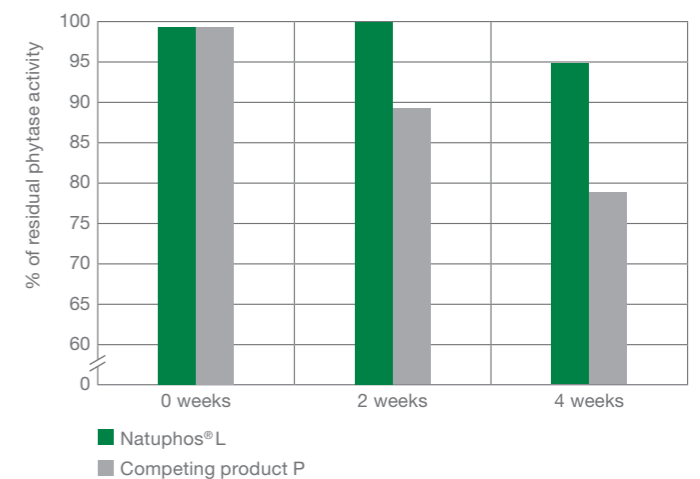


FIGURE 15: STABILITY OF LIQUID PHYTASE AFTER BEING SPRAYED ON PELLETS STORED AT 30°C



## THE NATUPHOS® PHYTASE UNIT

Natuphos® is measured in FTUs. An FTU is the amount of enzyme that releases 1µmol iP per minute from 0.0051 mol/l of sodium phytate at a pH of 5.5 and a temperature of 37°C. Sample preparation depends on whether Natuphos® is analyzed as a pure product or in a premix, a base mix or feed. BASF is intensively involved in further developing the popular AOAC and CEN methods used for determining these values.



# WHEN IT COMES TO BIOEFFICACY, THE ORIGINAL IS STILL THE BEST.

## RELATIVE BIOEFFICACY OF NATUPHOS® COMPARED TO COMPETING PRODUCTS

To produce cost-effective, high-quality feed it is important to carefully select the additives used. Both bioefficacy and application stability are major criteria for defining the value of a phytase product. Compared to competitors' products, Natuphos® is one of the top performers in terms of maximizing the release of phosphorus per phytase unit from plant sources.

## A REAL WINNER

As shown in Figure 16 and Table 8, feeding trials with broilers and pigs put the relative bioefficacy of Natuphos® (Aspergillus 3-phytase) versus Peniophora 6-phytase at 1:1.5.

## SUPERIOR TO OTHER PHYTASE PRODUCTS

It is evident that these equivalency values can only apply to Natuphos®. They cannot be transferred to other phytase products, which differ in terms of enzyme origin or formulations.

**EXCHANGE RATE:  
1 FTU NATUPHOS® = 1.5 FTU PENIOPHORA PHYTASE**

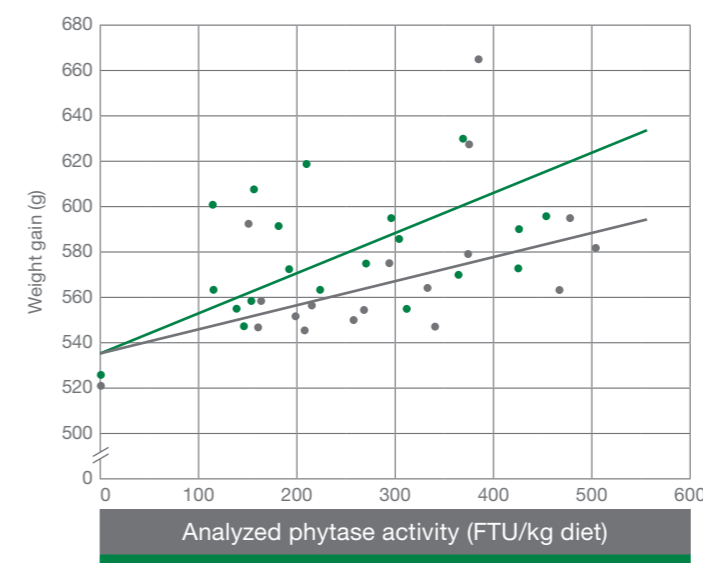
TABLE 8: IMPROVEMENT OF PHOSPHORUS DIGESTIBILITY BY INCREASING THE NATUPHOS® DOSES COMPARED TO PENIOPHORA PHYTASE IN FATTENING PIGS

	TREATMENT 1	TREATMENT 2	TREATMENT 3	TREATMENT 4	TREATMENT 5
Phytase addition/kg	0	250 FTU Natuphos® G	500 FTU Natuphos® G	375 FTU Coated Peniophora phytase	750 FTU Coated Peniophora phytase
P digestibility (%)	43 <sup>a</sup>	55 <sup>b</sup>	61 <sup>cd</sup>	54 <sup>b</sup>	60 <sup>c</sup>
Digestible P (g/kg)	1.9	2.3	2.7	2.3	2.6
Increase in digestible P (g/kg)	-	+0.5	+0.8	+0.5	+0.7

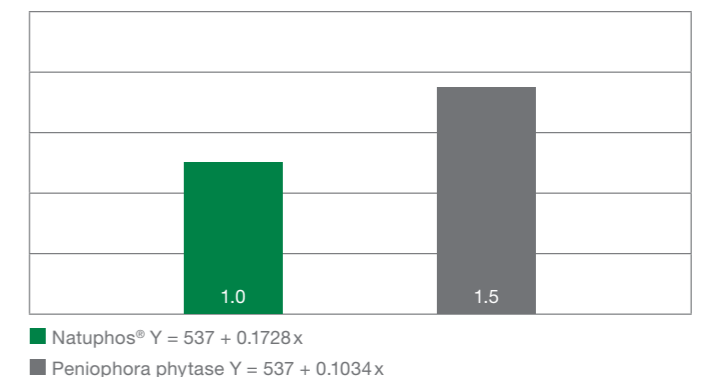
Different superscripts indicate a significant difference ( $p \leq 0.05$ ).

Source: Poulsen et al. 2006

FIGURE 16: GROWTH RESPONSE TO LIQUID PHYTASE IN BROILERS (SUMMARY OF 8 TRIALS)



EXCHANGE RATE OF NATUPHOS® VERSUS PENIOPHORA PHYTASE IN LIQUID PRODUCTS





# THE FASTEST WAY TO SUCCESS IS A FAST PHYTASE RELEASE.

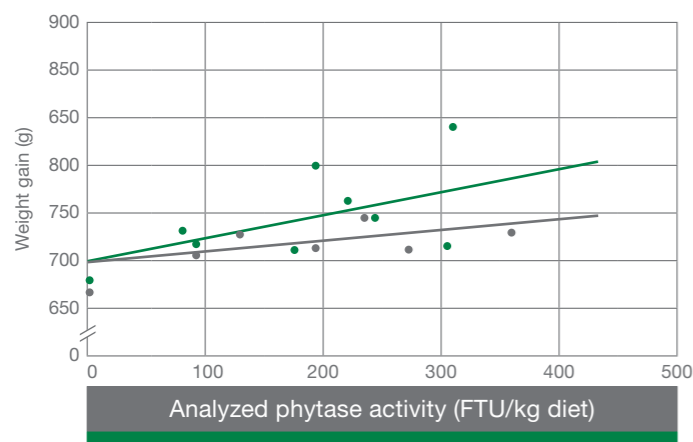
## THE INFLUENCE OF PRODUCT FORMULATION ON PHYTASE RELEASE AND PRODUCT BIOEFFICACY

As was said earlier, the formulation of a phytase – i. e., granule or coating – is chosen for the purpose of increasing its thermal and premix stability. It can significantly improve the bioefficacy of the final phytase product. For example, broiler feeding trials have shown that the bioefficacy per enzyme unit of granulated and/or coated Natuphos® G differs more clearly from that of a lipid-coated competing Peniophora phytase product (see Figure 17) than in feeding trials comparing the corresponding liquid products.

Granulated and coated products differ because of how much time they take to release the phytase. This is easy to demonstrate by dissolving different products in water and then measuring phytase release at various points in time (Figure 18). Natuphos® Granulate, which is highly water-soluble, liberates phytase within seconds; by comparison, the coating of the competing Peniophora phytase causes a significant delay. In order for a phytase to perform optimally, it must take effect as quickly as possible in the animal's digestive tract. A coating that retards phytase release can therefore be disadvantageous in animal species that have a short digestive tract and a fast rate of digesta passage.



FIGURE 17: GROWTH RESPONSE TO COATED/GRANULATED PHYTASE IN BROILERS (SUMMARY OF 8 TRIALS)



EXCHANGE RATE OF NATUPHOS® VERSUS PENIOPHORA PHYTASE IN COATED/GRANULATED PRODUCTS

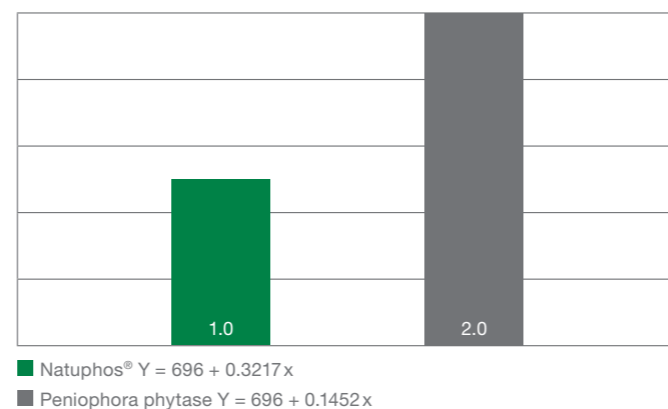
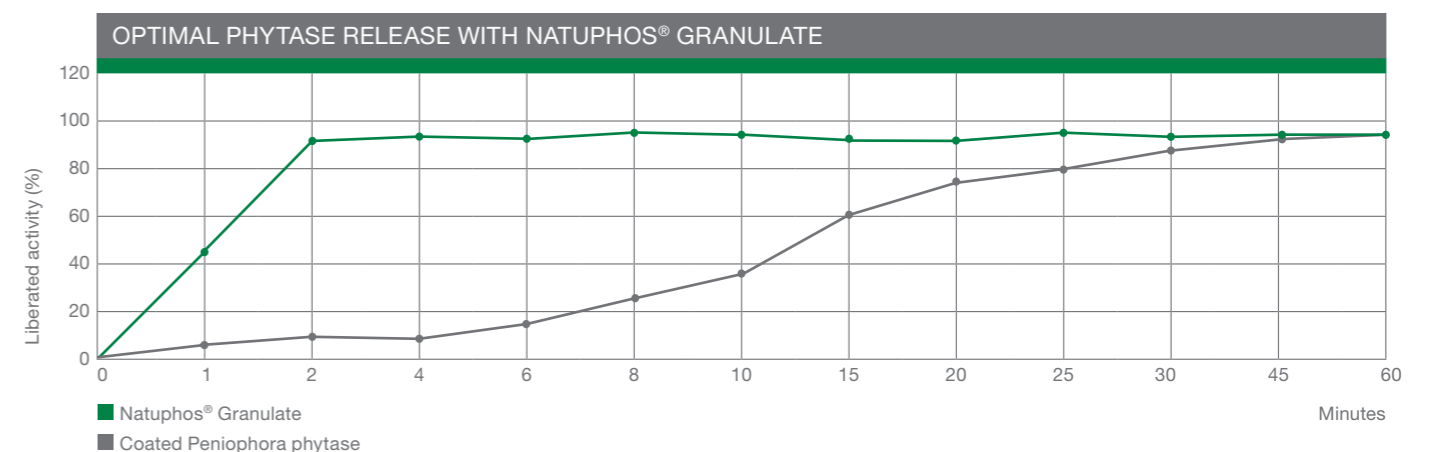


FIGURE 18: EXCHANGE RATES – THE IMPACT OF COATING ON PHYTASE RELEASE





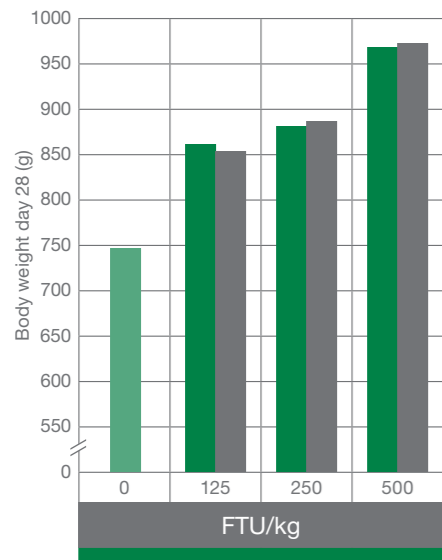
# WHEN YOU WANT TOP PERFORMANCE, GO FOR A TOP PERFORMER.

## A SIGNIFICANT FINDING

Comparison of Natuphos® (Aspergillus 3-phytase) and E. coli 6-phytases in pig and poultry feeding trials (Figures 19–22) shows an exchange rate for phosphorus release from phytate of 1:1. This means that, unless the product formulation impedes phytase release, one phytase unit of Natuphos® is equal to one FTU unit of an E.coli phytase (measured using the current FEFANA method).

Feeding trials are essential for evaluating and adjusting enzyme bioefficacy. Evaluating enzymes is not always a straightforward process, and a number of factors can influence the determined bioefficacy. Biochemical studies are important, but can be poor predictors of enzyme performance in poultry or swine under commercial conditions.

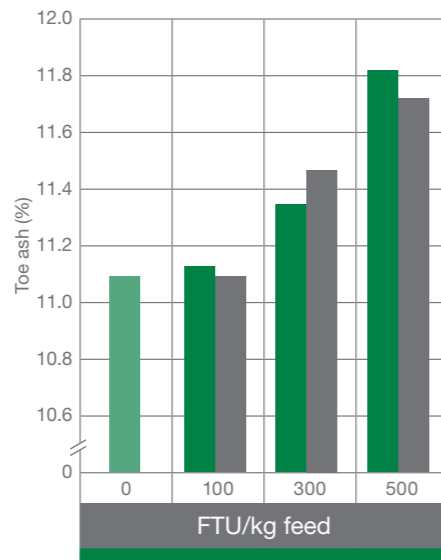
FIGURE 19: EFFECT ON BODY WEIGHT IN BROILERS FED INCREASING NATUPHOS® OR E. COLI 6-PHYTASE LEVELS IN A MAIZE/SOY-BASED DIET, FROM DAYS 7 TO 28



■ Neg. control (w/o inorganic P)  
■ Natuphos®  
■ E. coli 6-phytase

Source: BASF, 2008

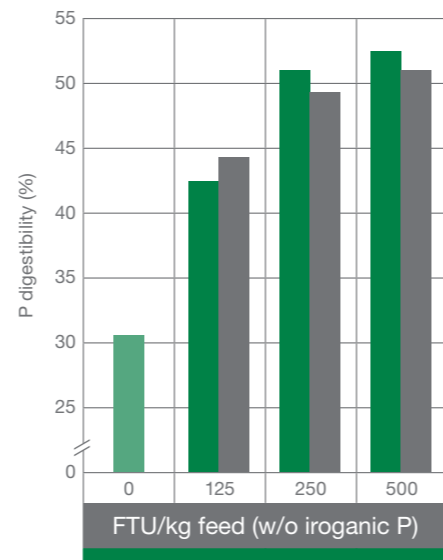
FIGURE 20: EFFECT ON TOE ASH CONTENT IN BROILERS FED INCREASING NATUPHOS® OR E. COLI 6-PHYTASE LEVELS IN A MAIZE/SOY-BASED DIET, FROM HATCHING TO DAY 21



■ Neg. control (0.25% nP)  
■ Natuphos®  
■ E. coli 6-phytase

Source: Purdue University, 2007

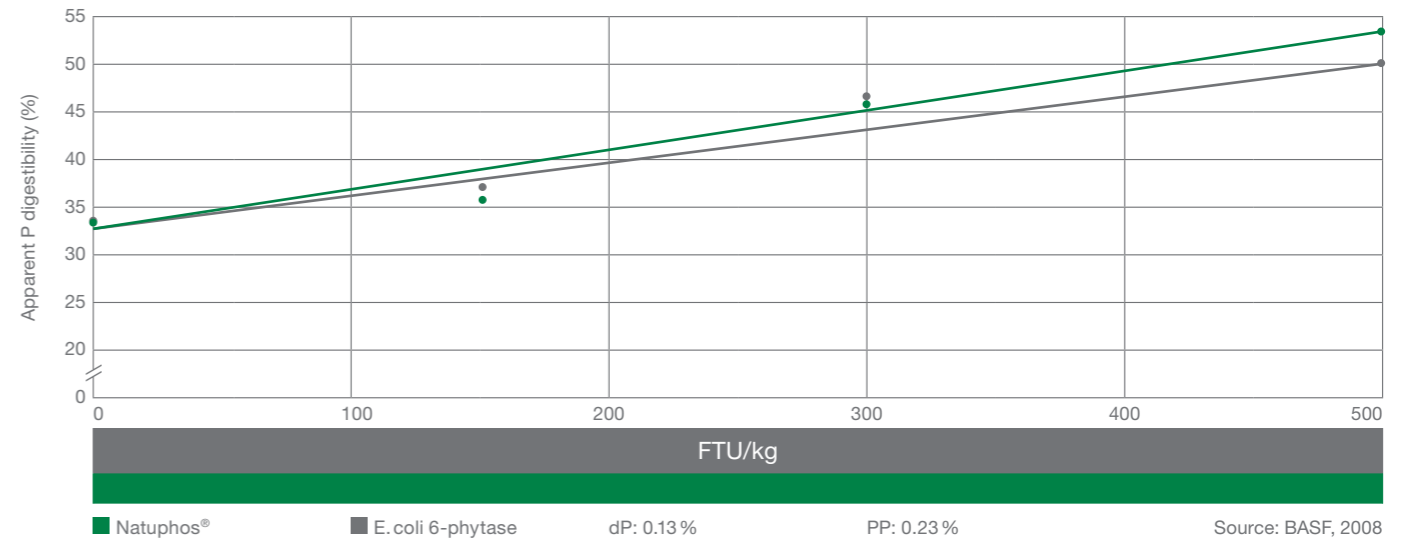
FIGURE 21: COMPARISON OF THE EFFECT ON PHOSPHORUS DIGESTIBILITY IN 45-KG FATTENING PIGS FED INCREASING NATUPHOS® OR E. COLI 6-PHYTASE LEVELS WITH A WHEAT/BARLEY/SOYBEAN MEAL-BASED DIET



■ Neg. control  
■ Natuphos®  
■ E. coli 6-phytase

Source: University of Aarhus, 2008

FIGURE 22: EFFECT ON PHOSPHORUS DIGESTIBILITY IN 16-KG PIGLETS FED INCREASING NATUPHOS® OR E. COLI 6-PHYTASE LEVELS WITH A MAIZE/SOYBEAN MEAL/SUNFLOWER MEAL-BASED DIET



EXCHANGE RATE: 1 FTU NATUPHOS® = 1 FTU E.COLI PHYTASE





# NATUPHOS<sup>®</sup>: AN ENERGY-SAVING AND SIMPLE DECISION.

## ADVANCED ECO-EFFICIENCY

BASF has developed an efficient tool for comparing products and processes by determining their environmental benefits in relation to the associated costs. It is a forwardlooking method for assessing various alternatives by balancing and validating environmental and economical aspects from the perspective of end users.

## USED TO COMPARE DIETS AND PHOSPHORUS SOURCES

This tool has been applied in Europe to compare different methods of phosphorus supply to monogastric animals. Effects in pig diets containing different amounts of dicalcium phosphate (DCP) with and without Natuphos<sup>®</sup> were compared over an entire fattening period. Both performance data and mineral loss via manure were measured. For monocalcium phosphate (MCP) diets, the DCP values were adjusted to reflect the differing amounts of digestible phosphorus.

MCP enhances the eco-efficiency of Natuphos<sup>®</sup> diets more than DCP does. There are two reasons for this. One is that actual production of MCP impacts the environment less than that of DCP, and the other is that the phosphorus contained in MCP is more digestible than that in DCP, so less is ultimately excreted along with the manure.

## NATUPHOS<sup>®</sup> DIETS CURB POLLUTION

The chief finding of the study, however, is that there are significant differences in the pollution caused via the manure. The contamination of surface waters with phosphorus and heavy metals that can result when manure is applied to fields is the most important consideration for assessing eco-efficiency.

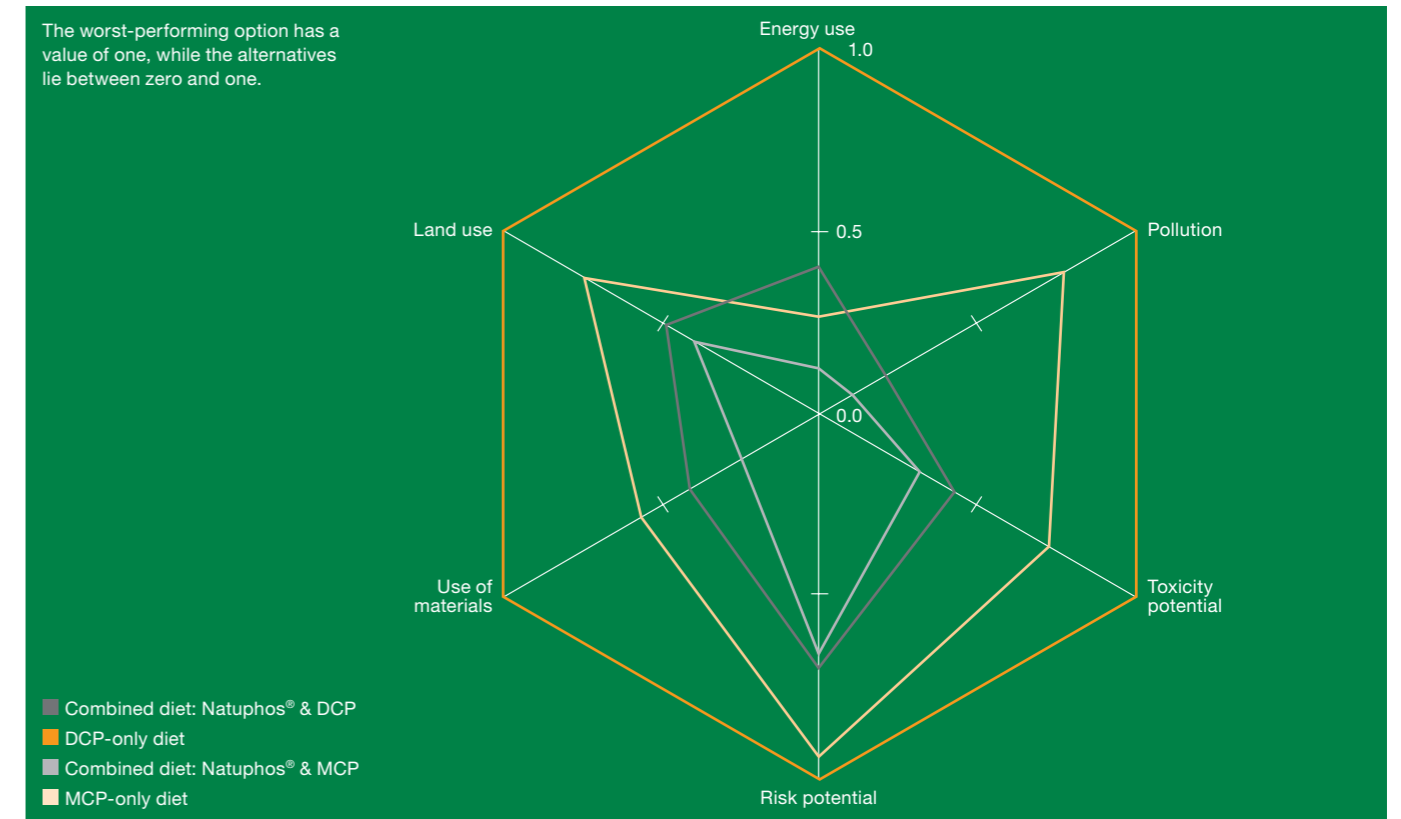
The environmental fingerprint shows the performance of the various options in all impact categories in standardized form (Figure 23). Combined Natuphos<sup>®</sup> and DCP diets perform better than non-Natuphos<sup>®</sup> diets in all impact categories except energy consumption. Especially in the pollution category, Natuphos<sup>®</sup> diets significantly outperform the alternatives.

Regarding the energy consumed to administer a Natuphos<sup>®</sup> diet, the contribution of the Natuphos<sup>®</sup> itself is negligible; most of the energy goes for the added mineral phosphates. MCP uses up less energy than DCP, because considerably smaller amounts of it are needed.

## CONCLUSION

The results of the study confirm that the use of Natuphos<sup>®</sup> for intensive animal production confers major benefits: both reduced emissions and significant energy savings. Natuphos<sup>®</sup> is thus clearly the most eco-efficient option for supplying phosphorus to monogastric animals.

FIGURE 23: ENVIRONMENTAL FINGERPRINTS OF DIFFERENT DIETS





# NATUPHOS®: THE PRODUCT PORTFOLIO.

## VARIED PORTFOLIO TO MEET YOUR NEEDS

Ever since launching our first spraydried product, Natuphos® 5,000, we have focused our research efforts on continuing to improve our phytase formulations. Today Natuphos® is available in powdered, granulated and liquid forms with different phytase concentrations to make sure to meet the requirements of your particular application and enable you to produce high-quality feed under different conditions.

## LIQUID APPLICATION

Postpelleting liquid application (PPLA) systems for feed additives point the way to the future of compound feed production. They help avoid hydrothermal stresses on heatsensitive substances and markedly reduce the loss of bioactive ingredients. The use of liquid Natuphos® formulations is a viable alternative when high pelleting temperatures are essential to ensure pellet quality, sufficient output or compliance with sanitary requirements.

PRODUCT	FORM	ADDITIONAL INFORMATION	PRODUCT NO.
Natuphos® 5000	Powder	Phytase (5,000 FTU/g), recommended for nonpelleted feed or pelleting below 70°C	30041116
Natuphos® 5000G	Granulate	Phytase (5,000 FTU/g), recommended for pelleting below 85°C	30060577
Natuphos® 5000G (EU)	Granulate	Phytase (5,000 FTU/g), recommended for pelleting below 85°C	30077741 (Sold in the EU only)
Natuphos® 5000L	Liquid	Phytase (5,000 FTU/g), recommended for postpelleting applications	30041121
Natuphos® 10000G	Granulate	Phytase (10,000 FTU/g), recommended for pelleting below 85°C	30069924
Natuphos® 10000G (EU)	Granulate	Phytase (10,000 FTU/g), recommended for pelleting below 85°C	30500879 (Sold in the EU only)
Natuphos® 10000L	Liquid	Phytase (10,000 FTU/g), recommended for postpelleting applications	30172646
Natuphos® 10000L (EU)	Liquid	Phytase (10,000 FTU/g), recommended for postpelleting applications	30500880 (Sold in the EU only)
Natuphos® 5000 Combi L	Liquid	Phytase (5,000 FTU/g) and Xylanase (5,600 TXU/g) and Glucanase (2,500 TGU/g); recommended for postpelleting applications	30487393

## CONTACTS

### North America

BASF Corporation  
Animal Nutrition, North America  
100 Park Avenue  
Florham Park, New Jersey 07932  
USA  
Phone: +1-800-527-9889  
Fax: +1-973-245-6766  
e-mail: nutrition-north-america@basf.com

### Europe, Africa, West Asia

BASF SE  
Animal Nutrition, Europe  
Chemiestrasse 22  
68623 Lampertheim  
Germany  
Phone: +49-621 60-28073  
Fax: +49-621 60-28363  
e-mail: nutrition-europe@basf.com

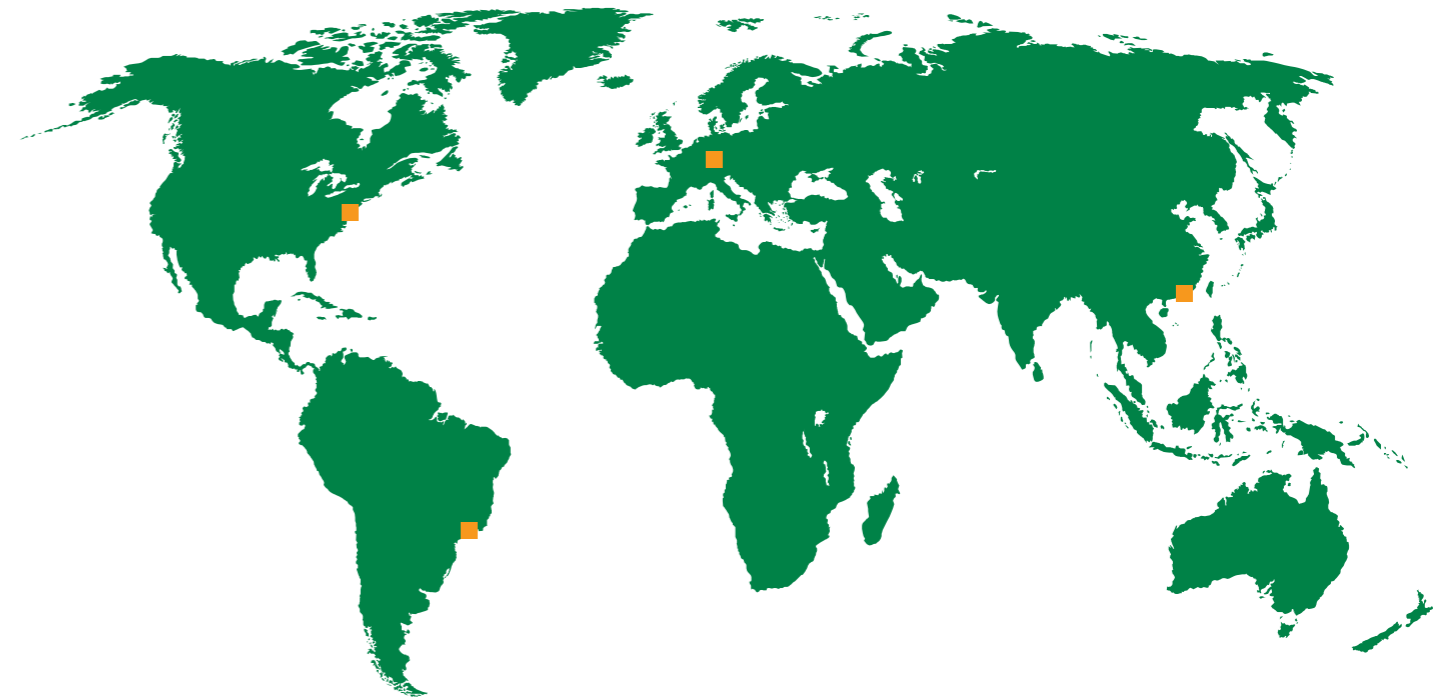
### Asia/Pacific

BASF East Asia Regional Headquarters Ltd.  
Animal Nutrition, Asia/Pacific  
45th Floor, Jardine House  
No.1 Connaught Place  
Central Hong Kong  
Phone: +852-273 11-238  
Fax: +852-273 15-637  
e-mail: nutrition-asia-pacific@basf.com

### South America

BASF S.A.  
Animal Nutrition, South America  
Avenida das Nações Unidas 14.171 – 10th floor  
04794-000 São Paulo SP  
Brazil  
Phone: +55-11-2039-2292  
Fax: +55-11-2039-2344  
e-mail: nutrition-south-america@basf.com

[www.animal-nutrition.basf.com](http://www.animal-nutrition.basf.com)



© Registered trademarks of BASF in several countries.

Published by BASF SE, Animal Nutrition, 67056 Ludwigshafen, Germany  
Note: National regulations may vary and need to be considered prior to product use.

This document, or any answers or information provided herein by BASF, does not constitute a legally binding obligation of BASF. While the descriptions, designs, data, and information contained herein are presented in good faith and believed to be accurate, it is provided for your guidance only. Because many factors may affect processing or application/use, we recommend that you make tests to determine the suitability of a product for your particular purpose prior to use. It does not relieve our customers from the obligation to perform a full inspection of the products upon delivery or any other obligation. No warranties of any kind, either express or implied, including warranties of merchantability or fitness for a particular purpose, are made regarding products described or designs, data, or information set forth, or that the products, designs, data, or information may be used without infringing the intellectual property rights of others. In no case shall the descriptions, information, data, or designs provided be considered a part of our terms and conditions of sale. (October 2014)





We create chemistry