

Danish nutrient standards

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Main conclusion

The nutrient standards now include an additional row for growers and finishers that have a particularly good feed conversion ratio. For gilts, phase feeding is now only recommended to obtain the correct balance between backfat thickness and normal behaviour. The minimum concentration of digestible protein in feed for sows in the gestation and insemination units is lowered, and the recommended weight intervals for when the different diets are used have been slightly adjusted. Finally, inclusion of 'Quantum Blue' phytase has been reduced from 400 to 325 FTU at a 100% concentration.

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The overall improvement in feed conversion ratio and the increase in the production of intact male pigs indicate a significant potential for optimal feed conversion in many herds. Consequently, the standards now also accommodate feed for growers and finishers with a particularly good feed conversion ratio.

Practical experiences and SEGES Innovation trials, as well as international studies, confirm that insufficient protein and lysine concentrations increase the risk of behavioural misconduct, such as tail and ear biting. For gilts, the optimal solution to this is phase feeding with a moderate amino acid deficiency, which results in a slight reduction in gain while still increasing backfat and maintaining a safe distance from the levels that may trigger tail and ear biting.

The amino acid standards for sows remain unchanged, but the minimum standards for digestible protein for gestating sows and for sows in the service unit have been lowered by 5-10 g/FUsow based on the results of a recent study. This has the dual benefit of reducing the cost of the feed and reducing the environmental impact of gestating sows.

Pig producers are now advised only to apply the lowest protective standard for weaned pigs up to 9 kg (previously 15 kg) due to the potential for behavioural issues in weaned pigs resulting from a low protein concentration.

Finally, a literature review has led to a reduction in the evaluation of the phytase 'Quantum Blue' from AB Vista from 400 FTU to 325 FTU at a 100% dosage.

The Danish feed evaluation system

The Danish feed evaluation system is based on the physiological energy value of nutrients and on the standardised digestibility of these nutrients. In 2002, the old feed unit was replaced by two new feed units: FU_{gp} (feed units for weaned pigs, growers and finishers) and FU_{sow} (feed units for sows).

Energy evaluation in Denmark is based on:

1. Chemical analyses of water, ash, crude protein and crude fat
2. In vitro digestibility at ileal level and faecal level

3. Energy values of nutrients based on 'potential physiological values'.

The protein evaluation system is based on the standardised ileal digestibility of each amino acid.

All recommendations are expressed per Danish Feed Unit. In order to calculate g per kg or per MJ in other evaluation systems, the below table can be used.

Energy content per kg diet of a conventional complete diet:					
	Feed unit	MJ ME	MJ NE (French)	EW (Dutch)	MJ physiological energy, DK
Lactation period	1.06 FUsow	13.0	9.9	1.06	8.2
Gestation period	0.99 FUsow	12.0	9.2	0.99	7.6
Weaned pigs, 6-9 kg	1.17 FUgp	13,8	10.3	1.17	8.6
Weaned pigs, 9-30 kg	1.12 FUgp	13,4	9.9	1.12	8.3
Finishers, 30-100 kg	1.05 FUgp	12,8	9.4	1.05	7.7

Amino acids, protein and macro minerals – weaned pigs

The standards for amino acids, protein and macro minerals for weaned pigs are shown in tables 1a and 1b. The amino acid standards do not include a safety margin as they are determined as the economic optimum level in diets containing conventional ingredients under normal price relations. Consequently, it is possible to improve productivity slightly by increasing amino acids and protein, but this will not be profitable as the increase in price exceeds the productivity improvements. Furthermore, an increase in protein levels may increase the risk of diarrhoea outbreaks.

The standards are recommended according to feed conversion, ie. raised in diets for a good FCR. In periods of increased incidence of diarrhoea, it is possible to use a lower set of standards to achieve optimal protection against diarrhoea. However, this may result in an increased risk of behavioural issues, such as ear and tail biting. Feeding the low standards will affect productivity negatively and should be employed only in the period when diarrhoea outbreaks peak. A protein level below the recommended minimum relative to a given lysine level will result in a deficiency of non-essential amino acids.

Calcium and phosphorus levels are also adjusted to FCR, and the remaining mineral standards are for now not adjusted to FCR. In feed for very small pigs, calcium content is lower as a high calcium concentration from calcium carbonate increases the risk of diarrhoea, and consequently calcium levels are a compromise between the risk of diarrhoea and maximum bone mineralization.

Table 1a. Nutrient standards – weaned pigs.

Diet	FCR good: < 1.65 FUgp / kg gain, 6-30 kg				% of lysine
	6-9 6-15	9-15	9-30	15-30	
Leucine, histidine & isoleucine, % of "ideal protein profile"	86	86	88	90	
Standards for digestible protein and amino acids, g per feed unit					
Lysine	11.5	11.5	12.0	12.0	
Methionine	3.7	3.7	3.8	3.8	32
Methionine + cystine	6.2	6.2	6.5	6.5	54
Threonine	7.1	7.1	7.4	7.4	62
Tryptophan	2.65	2.65	2.52	2.52	21-23
Isoleucine	5.2	5.2	5.6	5.7	46-48
Leucine	9.9	9.9	10.6	10.8	86-90
Histidine	3.2	3.2	3.4	3.5	28-29
Phenylalanine	6.2	6.2	6.5	6.5	54
Phenylalanine + tyrosine	10.9	10.9	11.4	11.4	95
Valine	7.2	7.2	7.6	7.6	62-64
Protein, min	135	137	145	148	
Protein, max	143	145	153	156	
Macro minerals, g per feed unit					
Digestible phosphorus	3.4	3.3	3.2	3.1	
Calcium, no phytase	7.2	8.2	8.7	8.7	
Calcium, 60-100 % phytase	6.7	7.7	8.2	8.2	
Calcium, 150-250 % phytase	6.4	7.4	7.9	7.9	
Calcium, 300-400 % phytase	6.2	7.2	7.7	7.7	
Sodium	2.5	2.1	2.0	1.9	
Chloride	4.0	3.5	3.4	3.2	
Potassium	2.5	2.5	2.5	2.5	
Magnesium*	0.9	0.9	0.9	0.9	
Vit. + micro., see table 5	6-9	9-15	9-30	15-30	

* Increase by 0.2 g, if phytase dosage (table 6) is 100% or less.

Table 1b. Nutrient standards – weaned pigs

Diet	Protective (> 1.8 FUgp / kg gain 6-30 kg)				Standard (1.65-1.8 FUgp / kg gain 6-30 kg)				% of lysine
	6-9	9-15 6-15	9-30	15-30	6-9 6-15	9-15	9-30	15-30	
Weight interval, kg ¹	6-9	9-15 6-15	9-30	15-30	6-9 6-15	9-15	9-30	15-30	
Leucine, histidine & isoleucine, % of "ideal protein profile"	86	86	88	90	86	86	88	90	
Standards for digestible protein and amino acids, g per feed unit									
Lysine	10.0	10.5	11.0	11.0	11.0	11.0	11.5	11.5	
Methionine	3.2	3.4	3.5	3.5	3.5	3.5	3.7	3.7	32
Methionine + cystine	5.4	5.7	5.9	5.9	5.9	5.9	6.2	6.2	54
Threonine	6.2	6.5	6.8	6.8	6.8	6.8	7.1	7.1	62
Tryptophan	2.30	2.42	2.31	2.31	2.53	2.53	2.42	2.42	21-23
Isoleucine	4.6	4.8	5.1	5.2	5.0	5.0	5.4	5.5	46-48
Leucine	8.6	9.0	9.7	9.9	9.5	9.5	10.1	10.4	86-90
Histidine	2.8	2.9	3.1	3.2	3.0	3.0	3.2	3.3	28-29
Phenylalanine	5.4	5.7	5.9	5.9	5.9	5.9	6.2	6.2	54
Phenylalanine + tyrosine	9.5	10.0	10.5	10.5	10.5	10.5	10.9	10.9	95
Valine	6.2	6.5	6.9	7.0	6.9	6.9	7.2	7.3	62-64
Protein, min	118	125	134	137	130	132	140	143	
Protein, max	126	133	142	145	138	140	148	151	
Macro mineral standards, g per feed unit									
Digestible phosphorus	3.2	3.1	3.0	2.9	3.3	3.2	3.1	3.0	
Calcium, no phytase	6.8	7.8	8.3	8.3	7.0	8.0	8.5	8.5	
Calcium, 60-100% phytase	6.3	7.3	7.8	7.8	6.5	7.5	8.0	8.0	
Calcium, 150-250% phytase	6.0	7.0	7.5	7.5	6.2	7.2	7.7	7.7	
Calcium, 300-400% phytase	5.8	6.8	7.3	7.3	6.0	7.0	7.5	7.5	
Sodium	2.5	2.1	2.0	1.9	2.5	2.1	2.0	1.9	
Chloride	4.0	3.5	3.4	3.2	4.0	3.5	3.4	3.2	
Potassium	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	
Magnesium ²	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	
Vit. + micro., see table 5	6-9	9-15	9-30	15-30	6-9	9-15	9-30	15-30	

¹⁾ The two lowest levels of protein and amino acids have a positive effect on diarrhoea, but increase the potential for behavioural misconduct, such as ear and tail biting, and should therefore be used for shortest period possible.

²⁾ Increase by 0.2 g, if phytase dosage (table 6) is 100% or less.

Amino acids, protein and macro minerals – growers

The standards for amino acids, protein and macro minerals for growers are shown in table 2. The recommended weight intervals depend on the feed conversion in the entire finisher period 30-115 kg. If, in the 30-115 kg period, feed conversion averages, for instance, 2.7 FUgp/kg gain, the diet used in the 30-60 kg period should contain 8.9 g digestible lysine per FUgp and include all nutrients listed in the column labelled '8.9 g lysine'.

As is the case for weaned pigs, the recommendations for growers aim to maximise protein utilization at the lowest protein level possible to reduce the risk of diarrhoea outbreaks. In order to comply with all recommendations at the minimum protein level with standard ingredients, it is necessary to add not only lysine, methionine and threonine, but also tryptophan and valine to the diets that include 9.2-10.2 g digestible lysine per FUgp. If this is not possible, protein levels must be increased slightly.

Table 2. Nutrient standards – growers.

Feed conversion, 30-115 kg	Weight interval, kg					
2.30-2.45 FUgp/kg gain	25-45	30-55	30-75	45-75 30-100	45-115	
2.45-2.6 FUgp/kg gain	20-45	30-45	30-60	30-75	45-75 30-115	
2.6-2.75 FUgp/kg gain		20-45	30-45	30-60	30-75	
2.75 FUgp / kg gain			20-45	30-45	30-60	
Leucine, histidine and isoleucine, % of old profile	94	95	96	100	100	
Standards for digestible protein and digestible amino acids, g per feed unit						% of lysine
Lysine	10.2	9.7	9.2	8.9	8.6	100
Methionine	3.2	3.0	2.8	2.7	2.6	30-31
Methionine + cystine	5.6	5.4	5.2	5.1	5.0	55-58
Threonine	6.4	6.1	5.9	5.7	5.6	63-65
Tryptophan	2.04	1.94	1.84	1.78	1.72	20
Isoleucine	5.1	4.9	4.7	4.7	4.6	50-53
Leucine	9.6	9.2	8.8	8.9	8.6	94-100
Histidine	3.1	2.9	2.8	2.8	2.8	30-32
Phenylalanine	5.5	5.2	5.0	4.8	4.6	54
Phenyl + tyrosine	10.2	9.7	9.2	8.9	8.6	100
Valine	6.5	6.2	5.9	5.7	5.5	64
Protein, minimum	135	132	129	128	125	
Macro mineral standards, g per feed unit						
Digestible phosphorus	2.8	2.7	2.6	2.5	2.4	
Calcium, no phytase	8.0	7.8	7.6	7.4	7.2	
Calcium, 60-100% phytase	7.5	7.3	7.1	6.9	6.7	
Calcium, 150-250% phytase	7.2	7.0	6.8	6.6	6.4	
Calcium, 300-400% phytase	7.0	6.8	6.6	6.4	6.2	
Sodium	1.8	1.7	1.7	1.6	1.6	
Chloride	3.0	2.8	2.8	2.7	2.7	
Potassium	2.5	2.5	2.5	2.5	2.5	
Magnesium*	0.8	0.8	0.8	0.7	0.7	
Vit. and micro., see table 5	Finishers					

* Increase by 0.2 g, if phytase dosage (table 6) is 100% or less.

Amino acids, protein and macro minerals – finishers

The standards for amino acids, protein and macro minerals for finishers are shown in table 3. The recommended weight intervals depend on the feed conversion in the entire finisher period 30-115 kg.

The amino acid standards represent the economic optimum level at a given potential for feed conversion in a specific herd. At a feed conversion of 2.6-2.75 FUgp per kg gain, the standard recommends 8.2 g digestible lysine per FUgp – and all nutrients in the column labelled '8.2 g digestible lysine'. Should this pig producer opt to increase the content of digestible lysine to 8.6 g, productivity will marginally improve, but feed costs will increase slightly beyond the value of the enhanced productivity. Should the digestible lysine content be reduced to 7.9 g, the value of the lost productivity will exceed the benefit of the lower feed costs.

The minimum standards for digestible protein will typically ensure that only lysine, methionine, threonine and tryptophan need to be added; however, tryptophan can be omitted from diets containing less than 5% sunflower meal. If both tryptophan and valine are added, it would be possible to comply with all standards at a lower protein level. However, this is not recommended for pig producers, as it would not result in a reduction in feed costs and as low protein levels lead to a drop in lean meat percentage. The standards for calcium and digestible phosphorus are sufficient to ensure maximum productivity and a good bone mineralization.

The standards for calcium and digestible phosphorus represent the recommended content, taking into account productivity, the environment and the economy.

Table 3. Nutrient standards - finishers.

Feed conversion, 30-115 kg	Weight interval						
	45-115	55-115	75-115				
2.30-2.45 FUgp/kg gain	45-115	55-115	75-115				
2.45-2.60 FUgp/kg gain	30-115 45-75	45-115	60-115	75-115			
2.6-2.75 FUgp//kkgain	30-75	30-115 45-75	45-115	60-115	75-115		
2.75 FUgp/kg gain	30-60	30-75	30-115 45-75	45-115	60-115	75-115	
Standards for digestible protein and digestible amino acids, g per feed unit							% of lysine
Lysine	8.6	8.2	7.9	7.6	7.3	7.1	100
Methionine	2.6	2.5	2.4	2.3	2.2	2.1	30
Methionine +cystine	5.0	4.7	4.6	4.5	4.3	4.3	58-61
Threonine	5.6	5.4	5.2	5.0	4.9	4.8	65-67
Tryptophan	1.72	1.64	1.58	1.52	1.46	1.42	20
Isoleucine	4.6	4.3	4.2	4.0	3.9	3.8	53
Leucine	8.6	8.2	7.9	7.6	7.3	7.1	100
Histidine	2.8	2.6	2.5	2.4	2.3	2.3	32
Phenylalanine	4.6	4.4	4.3	4.1	3.9	3.8	54
Phenyl+tyrosine	8.6	8.2	7.9	7.6	7.3	7.1	100
Valine	5.5	5.2	5.1	4.9	4.7	4.5	64
Protein, minimum	125	120	116	112	108	105	
Macro mineral standards, g per feed unit							
Digestible phosphorus	2.4	2.3	2.2	2.1	2.0	2.0	
Calcium, no phytase	7.2	7.0	6.8	6.7	6.6	6.6	
Calcium, 60-100% phytase	6.7	6.5	6.3	6.2	6.1	6.1	
Calcium, 150-250% phytase	6.4	6.2	6.0	5.9	5.8	5.8	
Calcium, 300-400% phytase	6.2	6.0	5.8	5.7	5.6	5.6	
Sodium	1.6	1.5	1.5	1.4	1.3	1.3	
Chloride	2.7	2.5	2.5	2.3	2.2	2.2	
Potassium	2.5	2.5	2.5	2.5	2.5	2.5	
Magnesium*	0.7	0.7	0.7	0.6	0.6	0.6	
Vit. and micro., see table 5	Finishers						

* Increase by 0.2 g, if phytase dosage (table 6) is 100% or less.

Amino acids, protein and macro minerals – sows and gilts

The standards for amino acids, protein and macro minerals for sows and gilts are shown in table 4.

It is recommended that gilt feed contains less digestible protein and amino acids than finisher feed to prevent gilts from becoming too fat and to ensure that they develop sufficient back fat. Experimental and practical evidence indicate that insufficient protein and amino acids may trigger tail and ear biting. It is therefore recommended that pig producers apply phase feeding, as this will result in a slight slowing of growth without the onset of behavioural issues during the initial growth period. Calcium and phosphorus standards for gilts are slightly higher than for finishers in order to obtain the greatest deposition of bone mineral.

It is anticipated that the standards for sows and gilts in the service unit and for gestating sows will result in maximum productivity and bone strength. The standards for lactating sows are estimated to be the economic optimum in herds with a high litter gain.

In feed for gestating sows, it is recommended that free lysine constitute max 30% of digestible lysine if the pigs are fed only once a day, as the utilization of free amino acids drops as the inclusion rate increases when pigs are only fed once a day. However, if the pigs are fed twice a day or more, a high inclusion of free lysine does not constitute a problem. Other amino acids rarely reach 30% free amino acid when the minimum standards for protein are being met.

Table 4. Nutrient standards – sows and gilts (parenthesis: possible use, but not primary recommendation).

Primary use	Gilts	Lactating sows	Gilts	Empty sows, gilts and gestating sows	Gestating sows and gilts		
Lactating sows		X					
Farrowing unit to d 2 after farrowing		(X) ⁴	X	(X)			
Gilts, weight interval kg	30-60	(30-60)	60-110	85-110	100-150	110-150	(120+)
Weaning to service			(X)	X	(X)		
Gestating incl. gilts, day			110-117	90-114	(0-114) ⁴	0-114 ⁴	0-90
Gestating excl. gilts, day			110-117	90-114		0-114 ⁴	0-110 ⁴
Standards for digestible protein and digestible amino acids, g per feed unit							
Lysine	7.7	7.7	6.0¹	5.0²	4.5²	4.0²	3.5²
Methionine	2.3	2.4	1.9	1.5	1.4	1.2	1.1
Methionine + cystine	4.5	4.5	3.5	3.3	2.9	2.6	2.3
Threonine	5.0	5.0	3.9	3.6	3.2	2.9	2.5
Tryptophan	1.54	1.54	1.2	1.0	0.9	0.8	0.7
Isoleucine	4.1	4.3	3.4	3.0	2.7	2.4	2.1
Leucine	7.7	8.3	6.5	5.1	4.6	4.1	3.6
Histidine	2.5	2.8	2.2	1.8	1.6	1.4	1.2
Phenylalanine	4.2	4.2	3.3	2.9	2.6	2.3	2.0
Phenylalanine + tyrosine	7.7	8.7	6.8	5.1	4.6	4.1	3.6
Valine	5.0	5.3	4.1	3.7	3.3	3.0	2.6
Protein, minimum	114	118	100	90	85	80	75
Macro mineral standards, g per feed unit (g per feed unit if only used for gilts below 110 kg)							
Digestible phosphorus	2.5	3.0	2.3 ⁵	2.3 ⁵	2.1	2.0	2.0
Calcium, no phytase	7.4	8.0	7.0	7.0	7.0	7.0	7.0
Calcium, 60-100% phytase	6.9	7.5	6.9	6.5	6.5	6.5	6.5
Calcium, 150-250% phytase	6.6	7.2	6.6	6.2	6.2	6.2	6.2
Calcium, 300-400% phytase	6.4	7.0	6.4	6.0	6.0	6.0	6.0
Sodium	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Chloride	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Potassium	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Magnesium ³	0.7	1.0	0.7	0.6	0.6	0.5	0.5
Vit. and micro., see table 5	Lactating (only for gilts= finishers)			Gestating sows (only for gilts= finishers)			

¹) Amino acid profile for gilts at 6.0 g digestible per FU/sow is here equal to lactation profile to allow for potential use as a transition diet in the farrowing unit. ²) Of this, max 30% free lysine with one daily feeding as free amino acids are not fully utilized with only one daily feeding. ³) Increase by 0.2 g if phytase dosage (table 6) is 100% or less.

⁴) Sows and gilts should be fed minimum 5 g digestible lysine/feed unit (20-22 g dig. lysine/day) the last 5-7 days before farrowing to stimulate udder development and subsequent milk performance. ⁵) If these two diets are used in the farrowing unit until 1-2 days after farrowing, it is recommended to use the mineral standards shown in the first column to the left.

Vitamins and micro minerals

Table 5. Vitamin and micro mineral standards – all pigs.

	Gestating sows Gilts > 110 kg Service unit	Lactating sows	Weaned pigs			Finishers and gilts 30-110 kg
			6-9 kg	9-15 kg	15-30 kg	
Vitamins = added per feed unit						
Vitamin A, i.u.	8000	8000	8000	5000	5000	4000
Vitamin D ₃ , i.u.	800*	800*	800	500	500	400
Vitamin E, i.u.	40	165	140	140	60	40
- as <i>dl-alpha-tocopherol</i> , mg	36	150	130	130	54	36
- corresponding to vitamin E (all-rac acetate), mg	40	165	140	140	60	40
- corresponding to vitamin E (RRR), mg	27	111	94	94	40	27
- corresponding to vitamin E (RRR acetate), mg	29	121	103	103	44	29
Vitamin K ₃ , mg	2	2	2	2	2	2
Thiamine (B ₁), mg	2	2	2	2	2	2
Riboflavine (B ₂), mg	5	5	4	4	4	2
Pyridoxine (B ₆), mg	3	3	3	3	3	3
Niacine, mg	20	20	20	20	20	20
Biotin, mg	0.2	0.2	0.2	0.2	0.2	0.05
D-Pantothenic acid, mg	15	15	10	10	10	10
Folic acid, mg	1.5	1.5	0	0	0	0
Vitamin B ₁₂ , mcg	20	20	20	20	20	20
Micro minerals = total content in feed, ie. added + natural content per feed unit						
Iron, mg	80	80	150**	150**	150**	80
Copper, mg	6	6	6	6	6	6
Manganese, mg	40	40	40	40	40	40
Zinc, 0-150% phytase, mg***	100	100	100	100	100	100
Zinc, 200-400% phytase, mg***	100	100	100	100	100	70
Iodine, mg****	0.5	1.0	0.3	0.3	0.3	0.3
Selenium, mg****	0.2	0.2	0.35	0.35	0.35	0.2

* The active part of vitamin D is 25-OH D3 vitamin. Vitamin D can be added to feed either as regular vitamin D3 (cholecalciferol) or as 25-OH D3 vitamin (HyD®). 1 microgram HyD® corresponds to 40 i.u. vitamin D3. Danish studies show that when added to feed in identical concentrations, 25-OH D3 vitamin content in blood is more than twice as high when using HyD® compared with regular vitamin D3, and that HyD® has a positive effect on sow productivity – in particular in pigs' weaning weight, as HyD® is more easily transferred to foetuses and sow milk than regular vitamin D3-vitamin.

** Of this min. 100 mg easily soluble iron salt

*** Feed contains approx. 30 mg natural zinc per FUgp, which is why the added dose is 30 mg lower than the standard. Consequently, if finisher feed contains minimum 200% phytase, only 40 mg zinc per FUgp is added.

**** According to the Danish Feedstuff Act, diets must not contain more than 0.5 mg selenium per kg complete diet. Depending on the composition of the diet, ie. it is allowed to add 0.2-0.35 mg selenium per feed unit.

***** If the feed contains more than 10% rapeseed product (> 1.5 mmol glucosinlates/kg), it is recommended to increase iodine by 50%.

Phytase and recommended minimum content of total-phosphorus

The majority of phytase products are subject to the same official analysis method, whereby the activity is analysed at pH 5.5. Table 6 below only includes phytase products that have been analysed using this method. Given that phytase must function in the stomach at pH 3.0-4.5, the activity recorded at this pH combined with resistance to the pig's enzymes and other enzyme traits determines the effect in the pigs. Table 6 shows the levels at which the relevant enzymes generate the same effect. These levels can all be employed in the Danish phytase analysis system, provided that the feed contains the stated amount of phytase, also after pelleting.

It is important to highlight that in pelleted feed, analyses should reveal 150-300 FTU more than the amount added, as 150-300 FTU of grain phytase is typically capable of surviving the pelleting process. Correspondingly, analyses of home-mixed feed will typically reveal 400-800 FTU more phytase than the amount added, as this is the amount of grain phytase that originates from grain that has not been subject to heat treatment. The challenge arises from the fact that 500 FTU grain phytase have a significantly lower effect than 500 FTU phytase from the enzymes added as grain phytase is not as effective in the low pH of the stomach.

Table 6. Phytase units/kg feed in different phytase products; inclusion rates ranging from 100 to 400%.

Inclusion	Natuphos ¹ Ronozyme HiPhos (FYT) Optiphos Plus (FTU)	Axtra Phy (FTU)	Axtra Phy Gold (FTU)	Quantum Blue (FTU)	Natuphos E (FTU)	Enzy ³ Phostar (FTU)
100%	500	300	(260) ²	325 ⁴	350	750
150%	750	450	(390) ²	488	525	1,125
200%	1,000	600	520	650	700	1,500
300%	1,500	900	780	975	1,050	2,250
400%	2,000	1,200	1,040	1,300	1,400	3,000

1) 500 FTU inclusion of Natuphos is original reference for 100% inclusion, but Natuphos is not commercially available today.

2) Minimum allowed inclusion is 500 FTU as this is the lowest tested inclusion in the EFSA approval.

3) Enzy Phostar is not pelleting-resistant and can only be used in meal-based feed.

4) Quantum Blue minimum inclusion in feed for sows and finishers: 250 FTU. Minimum inclusion in feed for weaned pigs: 500 FTU.

As it is not possible to analyse the content of digestible phosphorus in feed, it can be assessed to some degree on the basis of the total content of phosphorus. Table 7 illustrates the recommended minimum content of total phosphorus in diets containing phytase.

Table 7. Guiding minimum content of total phosphorus¹ in complete diets with phytase, g per feed unit.

Phytase, % of standard ²	Dig. P	Min. content of total P when adding phytase					
		100		200		300	400
Complete diet (CD) / Home-mixed (HM)		CD	HM	CD	HM	Both	Both
Weaned pigs, 9-30 kg	3.1	5.4	5.1	5.1	5.0	4.9	4.8
Finishers, 30-115 kg	2.5	4.50	4.25	4.20	4.05	3.95	3.90
	2.4	4.35	4.10	4.05	3.90	3.80	3.75
	2.3	4.20	3.95	3.90	3.75	3.65 ³	3.60 ³
	2.2	4.05	3.80	3.75	3.60 ³	3.50 ³	3.45 ³
Gestating sows	2.0	3.8	3.5	3.4	3.3	3.3	3.2
Lactating sows	3.0	5.2	5.0	4.9	4.8	4.75	4.7

1) Prerequisites of minimum recommendations: conventional diets based on grain and soybean meal without extracted rapeseed meal and extracted sunflower meal, in which wheat constitutes approx. 50% of the grain in feed for sows and minimum 2/3 of the grain in feed for weaned pigs and finishers. Phosphorus source: monocalcium phosphate. In other types of diets, the content of total phosphorus often needs to be slightly higher to meet the standards for digestible phosphorus. Minimum standard for finisher feed: Four standards for digestible phosphorus corresponding to four levels of feed conversion ratio.

2) Phytase units in different phytase products in different inclusion rates are shown in table 7.

3) Such a low level of phosphorus is difficult to reach as the feed's natural content of phosphorus is usually higher even when only grain and soybean meal are used – depending on P content in the harvest of the year in question.

Revision of the standards

The standards are routinely revised. Revisions are made by experts from Aarhus University, the University of Copenhagen, pig production advisors and SEGES Innovation.

Amino acids and protein:

1990:	The standards for the first five amino acids were revised according to new weaner trial results.
1991:	The standards for male pigs were reduced by 10% on the basis of new trial results. Consequently, this set of standards does not include specific standards for male pigs.
1996:	Standards were determined for the remaining six amino acids.
1998:	Standards were incorporated applicable to phase feeding.
2001:	<ul style="list-style-type: none"> The standards for methionine, methionine + cystine, and threonine for sows were revised. The standards for leucine for weaned pigs and growers, and for methionine for finishers were revised.
2002:	<ul style="list-style-type: none"> The standards for threonine and tryptophan for weaned pigs were revised. New amino acid standards and recommendations for minimum content of crude protein were incorporated. This applies to the new feed evaluation system introduced in the summer of 2002. The amino acid standards were changed from apparent faecal digestible to standardised ileal digestible. The standards for histidine and leucine for growers (20-45 kg) were changed in the new feed evaluation system, as there was no agreement between the standards for the different weight intervals for these two amino acids.
2004:	<ul style="list-style-type: none"> The threonine standard for finishers was increased and the standards for several of the amino acids were adjusted slightly, as the composition of the ideal protein for certain weight intervals was deemed illogical. The weight intervals were standardized, which means that 30-100 kg is used in all tables for unity mixes for finishers.
2005:	Standards were introduced for heavy pigs (slaughter weight: 110-115 kg) in the weight interval 65-110 kg.
2006:	The standard for tryptophan for weaned pigs was revised.
2008:	<ul style="list-style-type: none"> The amino acid standards for weaned pigs were revised and recommendations were incorporated for amino acid content in feed on farms with diarrhoea problems. A maximum content of digestible protein per FUgp was introduced in weaner feed. The standards for methionine, tryptophan, valine and leucine for finishers were changed. The rule-of-thumb for the importance of amino acid deficiency was deleted.
2010:	The standard for valine for weaned pigs was revised.
2012:	<ul style="list-style-type: none"> The standard for lysine for weaned pigs was revised. Weight intervals in the weaner period were revised. Ideal protein composition was revised (isoleucine, histidine and tryptophan) for weaned pigs. Guiding minimum and maximum content of digestible protein per feed unit was reduced. Phase feeding standards for growers/finishers were revised.
2013:	Amino acid standards for lactating sows and for finishers were revised.
2014:	Amino acid standards for gilts were incorporated.
2015:	The ideal protein profile for weaner and finisher feed was revised. For weaned pigs, the revision concerned leucine, phenylalanine and phenylalanine+tyrosine. For finishers, the revision concerned methionine, isoleucine, phenylalanine, phenylalanine+tyrosine, and valine. Furthermore, a standard

	for specialised production was introduced focusing on lean meat %, relevant for, for instance, producers delivering pigs for the British markets.
2015:	The standard for digestible lysine for lactating sows was raised to 7.7 g per feed unit and the amino acid profile in per cent of lysine was maintained, ie. all amino acids standards were raised by 16-17%. The minimum standard for digestible crude protein for lactating sows was raised from 110 to 125 g per feed unit.
2016:	The lysine standard was raised to 8.8 and 8.5 g per feed unit for growers in the weight intervals 30-45 kg and 30-55 kg. The remaining amino acids for growers were revised according to the current amino acid profile with the exception of isoleucine, leucine and histidine. These three amino acids were lowered to the same percentage of lysine as in the weaner standards for all weight intervals for growers and finishers, ie. 53, 100 and 32% of lysine. The standards for amino acids and protein for finishers in all weight intervals were raised by 2.5% for each time FCR improves by 0.1 with on a point of departure of 2.8 feed units per kg gain.
2017:	The tryptophan standard for weaned pigs is increased to 21% of lysine. The standards for digestible methionine, methionine+cystine, leucine, histidine, valine and protein in lactation feed were lowered.
2018:	The amino acid standards for weaned pigs are adjusted to 10.6 g digestible lysine per FUgp for the entire period 6-30 kg. A fourth step for improved FCR was introduced in the finisher standards, and a slightly greater effect of feed consumption is now included: 0.3 g digestible lysine and 4 g digestible protein per 0.1 FUgp/kg gain improved FCR. The effect of production for the UK market is increased to 0.3 g digestible lysine and 8 g digestible protein per FUgp in diets used up to slaughter.
2019:	Amino acid standards for weaned pigs are adjusted: in the 6-15 kg period, leucine, isoleucine and histidine only constitute 90% and valine only 95% of lysine. Consequently, the minimum protein standards are lowered in diets for pigs below 15 kg. For pigs above 15 kg the standards for lysin, methionine, threonine and tryptophan are raised by approx. 4% and the standards for leucine, isoleucine and histidine are lowered by 1%. Thereby leucine, isoleucine and histidine constitute 95% and valine approx. 98% of the previous standard. It is now possible to select a protective diet for all weight intervals. Amino acid standards for growers and finishers are adjusted slightly as there are now amino acid standards for three levels of feed conversion. For small growers, the standards for leucine, isoleucine and histidine are lowered to 96-98% of the precious profile to avoid a high protein level. The standards for protein and amino acids for specialised productions are specified in a separate table. The lysine standard for gestating sows in the entire period is raised to 4.0 g digestible lysine per FU _{sow} and standards are provided for phase feeding of gestating sows with 3.5 g digestible lysine per FU _{sow} until day 85 after service followed by 5.0 g digestible lysine per FU _{sow} until transfer to the farrowing unit. The amino acid profile for the service unit and for gestating sows is also adjusted, so that the profile is now met based on theoretical calculations of requirement for growth and maintenance.
2021:	Standards for weaned pigs are adapted (inclusion and profile) to three levels of FCR. The standards recommended in cases of poor FCR can also be applied for 'protective' diets for prevention of diarrhoea. Lysine, methionine, threonine, tryptophan and valine are raised by approx. 5% to a given protein level (leucine level). Consequently, in the growth intervals 6-15, 9-30 and 15-30 kg, leucine, isoleucine and histidine only constitute 86, 88 and 90%, respectively, of the previous (pre-2019) percentage of lysine. Valine constitutes 93, 94 and 95% of lysine in the growth intervals 6-15, 9-30 and 15-30 kg. For finishers, protein minimum standards are lowered – in particular in the 'UK standards' – while the amino acid standards remain unchanged.

2023:	Tryptophan standards for pigs up to 15 kg are raised from 21 to 23% of lysine. Lysine standards for growers and finishers are raised by 0.2 g digestible lysine/FUgp, and valine standards are lowered from 67 to 64% of lysine. This has permitted a reduction in digestible protein by 2 g/FUgp for all standards below 9.5 g digestible lysine/FUgp.
2024:	The phase-feeding standards replace the unity standard of 6.0 g digestible lysine in feed for gilts in the 30-110 kg period. This is done in order to prevent behavioural issues during the initial growth period. The minimum standards for digestible protein in feed for empty sows and gilts are lowered by 5-10 g per feed unit to fulfil the necessary requirements in order to comply with all amino acid standards (safety margin eliminated). In addition, footnotes in table 4 stipulate that sows must be provided with a minimum of 5 g digestible lysine per feed unit in the final week prior to farrowing to stimulate milk production. The weight interval for the use of the lowest protective standard is modified from 6-15 to 6-9 due to the risk of behavioural issues associated with long-term use.

Minerals:

1991:	The selenium standard was revised.
1995:	Standards for digestible phosphorus for growers and finishers were incorporated in the standards.
1997:	The standards for calcium and digestible phosphorus for sows and weaned pigs were revised.
1998:	Phase feeding standards for phosphorus were incorporated in the standards.
2000:	Calcium standards for sows and weaned pigs were revised.
2002:	<ul style="list-style-type: none"> The recommendations for total-P in the feed including phytase were revised. A calcium standard was incorporated for the use of phytase.
2005:	The standard for digestible phosphorus was made a minimum standard.
2006:	<ul style="list-style-type: none"> The standard for digestible phosphorus for weaned pigs was revised. The guiding minimum content of total-P was revised. Recommendations for double dosage of phytase were introduced.
2008:	The standards for digestible phosphorus were revised for all animal groups.
2010:	<ul style="list-style-type: none"> The standards for digestible phosphorus for growing pigs and finishers were revised, and the guiding levels of total phosphorus were revised. A recommendation for increased phosphorus content was introduced when a high zinc inclusion is applied (2,500 ppm).
2012:	Efficiency of a new phytase product (Ronozyme NP) was determined.
2014:	Mineral standards for gilts and recommendation for calcium content in feed for weaned pigs suffering from diarrhoea were incorporated.
2015:	The standard for digestible phosphorus for lactating sows was raised from 2.7 to 3.0 g per feed unit.
2016:	Optiphos phytase – efficiency estimated at 250 OTU for 100% inclusion (standard inclusion).
2016:	Axtra Phy and Quantum Blue efficiency estimated at 400 FTU for 100% inclusion (standard inclusion). Recommendations added on the addition of zinc to feed for finishers with normal and high inclusion of phytase.
2017:	Calcium standard is graduated in relation to phytase dose, and the calcium standard for weaned pigs 9-15 kg is lowered to 0.5 g.
2018:	<p>Sodium and chloride standard were raised for weaned pigs, particularly in starter diets, and lowered for finishers.</p> <p>Standards for digestible P are adapted to finishers' FCR and calcium standards are adapted to the new P standards for finishers. For gilts, calcium and phosphorus standards are now equal to finisher standards at an FCR of 2.55-2.65.</p>

2019:	Specification of individual minerals in connection with new tables, but no principal changes to mineral levels.
2020:	Revision of phosphorus and calcium standards following an overall assessment of recent trial results. Aextra Phy efficiency revised from 400% to 300% FTU for 100% inclusion.
2021:	Calcium and phosphorus standards for weaned pigs are adjusted according to FCR. Standard recommendations remain unchanged, whereas calcium and digestible phosphorus are lowered by 0.2 and 0.1, respectively, in protective diets, and correspondingly raised in diets for a good FCR. The efficiency of two new phytases is assessed: Optiphos Plus requires 500 FTU and Enzy Phostar 750 FTU for a standard dose.
2021:	Magnesium standards for all pigs are increased and are determined according to theoretical calculation of amount required for normal deposit.
2023:	Iodine standards are raised from 0.2 mg/FUgp for all pigs to 0.3 mg/FUgp for growers and to 0.5 and 1.0 mg/FU _{sow} for gestating sows and lactating sows, respectively. A footnote introduces a 50% increase in iodine in feed containing more than 10% rapeseed products.
2023:	Efficiency of Aextra Phy Gold is estimated at 260 FTU for 100% inclusion. Ronozyme NP, Phyzyme and Optiphos are removed from the table as they are longer commercially available. 60% inclusion is also eliminated from the table as such a low inclusion is no longer relevant.
2024:	Gilt standards are adapted to phase feeding and the recommendation for the Quantum Blue phytase is reduced from 400 FTU to 325 FTU at a 100% dosage.

Vitamins:

1990:	The vitamin standards were revised.
2004:	The vitamin E standard for lactating sows was revised.
2005:	The vitamin E standard for weaned pigs was revised.
2012:	The vitamin E standard is presented in IU and supplemented with conversion to mg when using different vitamin E products.
2014:	Vitamin standards for gilts were incorporated.
2018:	Recommendation of Hy-D® for sows is added.
2019:	Implementation of a vitamin E standard of 60 i.u. in the 15-30 kg period in connection with harmonization of weight intervals in all tables.