

DANISH NUTRIENT STANDARDS

This is the 29th edition of the standards.

INSTITUTION: SEGES DANISH PIG RESEARCH CENTRE

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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: FUgp (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.

Energy content per kg diet of a conventional complete diet:				
	Feed unit	MJ ME	MJ NE	MJ physiological energy
Lactation period	1.06 FU _{sow}	13.3	9.6	7.9
Gestation period	0.99 FU _{sow}	12.6	8.8	7.4
Weaned pigs, 6-9 kg	1.18 FU _{gp}	14.4	10.5	8.7
Weaned pigs, 9-30 kg	1.17 FU _{gp}	14.1	10.4	8.6
Finishers, 30-100 kg	1.07 FU _{gp}	13.4	9.6	7.9

Amino acids, protein and macro minerals – weaned pigs

The standards for amino acids, protein and macro minerals for weaned pigs are shown in Table 1. 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 productivity improvements. Furthermore, a protein increase will increase the risk of diarrhoea outbreaks.

Diets for weaned pigs are, as a point of departure, based on the standard recommendations as they are designed to generate the optimum economy. However, pig producers who experience periodic outbreaks of diarrhoea in their herds may try feeding the pigs according to the 'protective' standards matching the period in question as lower protein levels may alleviate diarrhoea problems. Note, however, that this will lower productivity. The minimum protein standard depends on the ingredients of the feed: with, for instance, 5-10% maize and 1-4% potato protein it is possible to meet the standards for leucine, isoleucine and histidine at a low protein level.

Calcium levels are lower in feed for very small pigs and in protective diets 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 1. Nutrient standards – weaned pigs.

Type of diet	Protective diet				Standard diet				% of lysine
Weight interval, kg	6-9 6-15	9-15	9-30	15-30	6-9 6-15	9-15	9-30	15-30	
Leucine, histidine and isoleucine, % of old profile	90	90	93	95	90	90	93	95	
Standards for digestible protein and digestible amino acids, g per feed unit									
Lysine	9.5	10.0	10.5	10.5	10.5	10.5	11.0	11.0	100
Methionine	3.0	3.2	3.4	3.4	3.4	3.4	3.5	3.5	32
Methionine + cystine	5.1	5.4	5.7	5.7	5.7	5.7	5.9	5.9	54
Threonine	5.9	6.2	6.5	6.5	6.5	6.5	6.8	6.8	62
Tryptophan	2.0	2.1	2.2	2.2	2.2	2.2	2.3	2.3	21
Isoleucine	4.5	4.8	5.2	5.3	5.0	5.0	5.4	5.5	49-51
Leucine	8.6	9.0	9.8	10.0	9.5	9.5	10.2	10.5	90-95
Histidine	2.7	2.9	3.1	3.2	3.0	3.0	3.3	3.3	29-31
Phenylalanine	5.1	5.4	5.7	5.7	5.7	5.7	5.9	5.9	54
Phenyl + tyrosine	9.5	10.0	10.5	10.5	10.5	10.5	11	11	100
Valine	6.0	6.4	6.8	6.9	6.7	6.7	7.1	7.2	63-65
Protein, min. possible	118	125	135	138	130	130	141	144	
Protein, min. typical diet	121	128	138	141	133	134	144	148	
Protein, max	131	138	148	151	143	144	154	158	
Macro mineral standards, g per feed unit									
Digestible phosphorus	3.3/3.6*	3.2	3.1	3.0	3.3/3.6*	3.2	3.1	3.0	
Calcium, no phytase	7.0	7.5	8.0	8.5	7.0	8.0	8.5	8.5	
Calcium, 60-100% phytase	6.5	7.0	7.5	8.0	6.5	7.5	8.0	8.0	
Calcium, 150-250% phytase	6.2	6.7	7.2	7.7	6.2	7.2	7.7	7.7	
Calcium, 300-400% phytase	6.0	6.5	7.0	7.5	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	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	
Vit. + micro., see table 6	6-9	9-15	9-15	15-30	6-9	9-15	9-15	15-30	

*3.6 for prescribed zinc oxide as high zinc levels reduce the effect of phytase.

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, the pigs have a feed conversion of, for instance, 2.7 FU_g/kg gain, the diet used in the 30-60 kg period should contain 8.7 g digestible lysine per FU_g and include all nutrients listed in the column with 8.7 g lysine.

As is the case for weaned pigs, the recommendations for growers aim at maximising protein utilization at the lowest protein level possible to reduce the risk of diarrhoea outbreaks. To be able to comply with all recommendations at minimum protein with standard ingredients, it is necessary to add not only lysine, methionine and threonine, but also tryptophan and valine to the diets with 8.7-10.0 g digestible lysine per FU_g. If this is not possible, protein levels must be increased slightly.

Table 2. Nutrient standards – growers.

Feed conversion, 30-115 kg	Weight interval, kg					
	20-45	30-45	30-60	30-75*	45-75 (30-115)*	
< 2.6 FU _g / kg gain						
2.6-2.75 FU _g / kg gain		20-45	30-45	30-60*	30-75*	
2.75 FU _g / kg gain			20-45	30-45*	30-60*	
Leucine, histidine and isoleucine, % of old profile	96	97	98	100	100	
Standards for digestible protein and digestible amino acids, g per feed unit						% of lysine
Lysine	10	9.5	9	8.7	8.4	100
Methionine	3.1	2.9	2.7	2.6	2.5	30-31
Methionine + cystine	5.5	5.3	5.1	5.0	4.9	55-58
Threonine	6.3	6.0	5.8	5.6	5.5	63-65.5
Tryptophan	2.0	1.9	1.8	1.75	1.68	20
Isoleucine	5.1	4.9	4.7	4.6	4.5	51-53
Leucine	9.6	9.2	8.8	8.7	8.4	96-100
Histidine	3.1	2.9	2.8	2.8	2.7	31-32
Phenylalanine	5.4	5.1	4.9	4.7	4.5	54
Phenyl + tyrosine	10.0	9.5	9	8.7	8.4	100
Valine	6.6	6.3	6.0	5.8	5.6	66-67
Protein, minimum	135	132	130	130	128	
Macro mineral standards, g per feed unit						
Digestible phosphorus	2.9	2.8	2.7	2.6	2.5	
Calcium, no phytase	8.2	8.0	7.8	7.6	7.4	
Calcium, 60-100% phytase	7.7	7.5	7.3	7.1	6.9	
Calcium, 150-250% phytase	7.4	7.2	7.0	6.8	6.6	
Calcium, 300-400% phytase	7.2	7.0	6.8	6.6	6.4	
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	0.4	0.4	0.4	0.4	0.4	
Vit. and micro., see table 6	Finishers					

*Specialised productions, for instance for the UK market, see table 4. Small growers with standard 9-10 g dig. lysine per FU_g follow the same standard for standard production and UK production.

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 are the economic optimum level at a given potential for feed conversion in a specific herd. At a feed conversion of 2.6-2.75 FU_g per kg gain, the standard recommends 8.0 g digestible lysine per FU_g – and all nutrients in the same column as 8.0 g digestible lysine. If this pig producer decides to increase the content of digestible lysine to 8.4 g, productivity will increase marginally, but feed costs will increase beyond the value of the improved productivity. If, on the other hand, the content of digestible lysine is lowered to 7.7 g, the value of lost productivity will exceed the benefit of a drop in feed costs.

The minimum standards for digestible protein will normally ensure that only lysine, methionine, threonine and tryptophan need to be added – though tryptophan can be left out in diets containing less than 5% sunflower meal. If both tryptophan and valine are added, it will be possible to comply with all standards at a lower protein level, but pig producers are not recommended to do so, as it will not lower the 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. Recent studies indicate that the phosphorus standards include a small safety margin – at least in diets with a high phytase content. The standards for digestible phosphorus constitute the recommended content taking into account productivity, environment and economy.

Table 3. Nutrient standards - finishers (for UK and specialised productions, see table 4).

Feed conversion, 30-115 kg	Weight interval						
	30-115 45-75	45-115	60-115	75-115			
< 2.6 FE _{sv} / kg gain							
2.6-2.75 FE _{sv} / kg gain	30-75	30-115 45-75	45-115	60-115	75-115		
> 2.75 FE _{sv} / 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	8.4	8.0	7.7	7.4	7.1	6.9	100
Methionine	2.5	2.4	2.3	2.2	2.1	2.1	30
Methionine +cystine	4.9	4.6	4.5	4.4	4.2	4.2	58-61
Threonine	5.5	5.3	5.1	4.9	4.7	4.6	65.5-67
Tryptophan	1.68	1.6	1.54	1.48	1.42	1.38	20
Isoleucine	4.5	4.2	4.1	3.9	3.8	3.7	53
Leucine	8.4	8.0	7.7	7.4	7.1	6.9	100
Histidine	2.7	2.6	2.5	2.4	2.3	2.2	32
Phenylalanine	4.5	4.3	4.2	4.0	3.8	3.7	54
Phenyl+tyrosine	8.4	8.0	7.7	7.4	7.1	6.9	100
Valine	5.6	5.4	5.2	5.0	4.8	4.7	67
Protein, minimum	128	124	120	115	111	108	
Macro mineral standards, g per feed unit							
Digestible phosphorus	2.5	2.4	2.3	2.2	2.1	2.1	
Calcium, no phytase	7.4	7.2	7.0	6.9	6.8	6.8	
Calcium, 60-100% phytase	6.9	6.7	6.5	6.4	6.3	6.3	
Calcium, 150-250% phytase	6.6	6.4	6.2	6.1	6.0	6.0	
Calcium, 300-400% phytase	6.4	6.2	6.0	5.9	5.8	5.8	
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	0.4	0.4	0.4	0.4	0.4	0.4	
Vit. and micro., see tabel 6	Finishers						

Amino acids, protein and macro minerals – pigs for the UK market and production with focus on lean meat percentage

Pig producers producing pigs for the British market (UK) and other specialised productions are paid a bonus provided the pigs are approved. Approval requires minimum 58% meat for each pig. By increasing the amino acid levels, but in particular the protein level, lean meat percentage increases leading to a higher approval rate. Put differently, pig producers supplying pork to the UK market will benefit from increasing protein and amino acids.

Table 4 provides an outline of the recommended standards for growers and finishers for which the bonus is conditional upon a minimum lean meat percentage. If table 4 is compared with tables 2 and 3, it is clear that the standards for amino acids and protein are raised in a given weight interval. Mineral standards are the same as for standard pigs.

Table 4. Nutrient standards – finishers, UK and specialised productions.

Feed conversion, 30-115 kg	Weight interval							
	30-75 30-60	30-115 45-75	45-115	60-115	75-115			
< 2.6 FUgp / kg gain								
2.6-2.75 FUgp / kg gain	30-60 30-45	30-75	30-115 45-75	45-115	60-115	75-115		
> 2.75 FUgp / kg gain	30-45 20-45	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	9.0	8.7	8.4	8.0	7.7	7.4	7.1	100
Methionine	2.7	2.6	2.5	2.4	2.3	2.2	2.1	30
Methionine + cystine	5.1	5.0	4.9	4.6	4.5	4.4	4.2	57-61
Threonine	5.8	5.6	5.5	5.3	5.1	4.9	4.7	64-67
Tryptophan	1.8	1.75	1.68	1.6	1.54	1.48	1.42	20
Isoleucine	4.7	4.6	4.5	4.2	4.1	3.9	3.8	53
Leucine	8.8	8.7	8.4	8.0	7.7	7.4	7.1	100
Histidine	2.8	2.8	2.7	2.6	2.5	2.4	2.3	32
Phenylalanine	4.9	4.7	4.5	4.3	4.2	4.0	3.8	54
Phenyl + tyrosine	9	8.7	8.4	8.0	7.7	7.4	7.1	100
Valine	6.0	5.8	5.6	5.4	5.2	5.0	4.8	67
Protein, minimum	132	132	132	128	124	119	116	
Macro mineral standards, g per feed unit								
Digestible phosphorus	2.6	2.5	2.4	2.3	2.2	2.1	2.1	
Calcium, no phytase	7.6	7.4	7.2	7.0	6.9	6.8	6.8	
Calcium, 60-100% phytase	7.1	6.9	6.7	6.5	6.4	6.3	6.3	
Calcium, 150-250% phytase	6.8	6.6	6.4	6.2	6.1	6.0	6.0	
Calcium, 300-400% phytase	6.6	6.4	6.2	6.0	5.9	5.8	5.8	
Sodium	1.6	1.6	1.5	1.5	1.4	1.3	1.3	
Chloride	2.7	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	2.5	
Magnesium	0.4	0.4	0.4	0.4	0.4	0.4	0.4	
Vit. and micro., see table 6	Finishers							

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 5.

It is recommended that gilt feed contains less protein and amino acids than finisher feed to prevent gilts from becoming too fat and to ensure that they develop sufficient back fat. Calcium and phosphorus are expected to generate maximum bone mineral deposition.

The standards for sows and gilts in the service unit and for gestating sows are expected to generate 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 inclusion rate increases when pigs are only fed once a day. If the pigs are fed twice or several times a day, 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 5. Nutrient standards – sows and gilts (parenthesis: possible use, but not primary recommendation).

Applies to	Farrowing unit	Gilts	Service unit, gilts and gestating sows		Gestating sows and gilts	Gestating sows	% of lysine* at lysine g/FU _{sow} 6-7.7 3.5-5	
Lactating sows	X							
Farrowing unit to d 2 after farrowing	X	(X)						
Gilts, weight interval kg	(30-65)	30-110	65-110	90-150	110-150			
Weaning to service		(X)	X	(X)				
Gestating, one diet, day			85-114	(0-114)	0-114	0-84		
Gestating, phase, day								
Standards for digestible protein and digestible amino acids, g per feed unit								
Lysine	7.7	6.0	5.0**	4.5**	4.0**	3.5**	100	100
Methionine	2.4	1.9	1.5	1.4	1.2	1.1	31	31
Methionine +cystine	4.5	3.5	3.3	2.9	2.6	2.3	58	65
Threonine	5.0	3.9	3.6	3.2	2.9	2.5	65	72
Tryptophan	1.54	1.2	1.0	0.9	0.8	0.7	20	20
Isoleucine	4.3	3.4	3.0	2.7	2.4	2.1	56	60
Leucine	8.3	6.5	5.1	4.6	4.1	3.6	108	102
Histidine	2.8	2.2	1.8	1.6	1.4	1.2	36	35
Phenylalanine	4.2	3.3	2.9	2.6	2.3	2.0	55	58
Phenyl + tyrosine	8.7	6.8	5.1	4.6	4.1	3.6	113	102
Valine	5.3	4.1	3.7	3.3	3.0	2.6	69	74
Protein, minimum	118	100	95	92	90	85		
Macro mineral standards, g per feed unit								
Digestible phosphorus	3.0	2.5	2.3	2.1	2.0	2.0		
Calcium, no phytase	8.0	7.4	7.0	7.0	7.0	7.0		
Calcium, 60-100% phytase	7.5	6.9	6.5	6.5	6.5	6.5		
Calcium, 150-250% phytase	7.2	6.6	6.2	6.2	6.2	6.2		
Calcium, 300-400% phytase	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		
Chloride	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		
Magnesium	0.4	0.4	0.4	0.4	0.4	0.4		
Vit. and micro., see table 6	Lactating	Gestating sows Finisher standards are sufficient, if the feed is only used for gilts below 110 kg						

*Amino acid profile for gilts at 6.0 g digestible per FU_{sow} is here equal to lactation profile to allow for possible use as a transition diet in the farrowing unit.

**Of this, max 30% free lysine with one daily feeding as free amino acids are not fully utilized with only one daily feeding

Vitamins and micro minerals

Table 6. 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	0.2	0.2	0.2	0.2	0.2	0.2
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, this means that it is allowed to add 0.2-0.35 mg selenium per feed unit.

Phytase and guiding minimum content of total-phosphorus

Most phytase products are recorded with the same official method where the activity is recorded at pH 5.5. Optiphos is the exception as this product has other times and enzyme concentrations in the manufacturer's original method where the result is shown as OUT. As phytase must work in the stomach at pH 3.0-4.5, in particular, it is the activity recorded at this pH combined with resistance to the pig's enzymes and other enzyme traits that determine the effect in the pigs. Table 7 shows at which levels the relevant enzymes generate the same effect, and that can all be equally used in the Danish phytase analysis system as long as the feed contains the stated amount of phytase, also after pelleting.

In this connection it is important to note that in pelleted feed, analyses should reveal 150-300 FTU more than the amount added as 150-300 FTU grain phytase usually survive 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 not-heat-treated grain. The challenge here is 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 7. Phytase units in different phytase products; inclusion rates ranging from 60 to 400%.

Inclusion	Natuphos (FTU)	Ronozyme NP (FYT)	Optiphos ³		Axtra Phy (FTU)	Natuphos E (FTU)
	Phyzyme XP (FTU)		OTU	FTU	Quantum Blue (FTU)	
60%	300 ¹	Below allowed inclusion rate	150 ⁴	400	250 ⁶	210
100%	500	1,500 ²	250	670	400 ⁶	350
150%	750	1,875	375	1,005	600	525
200%	1,000	2,500	500	1,340	800	700
300%	1,500 ⁵				1,200	1,050
400%	2,000 ⁵				1,600	1,400

1) Minimum inclusion allowed of Ronozyme HiPhos is 500 FYT.

2) 1,250 FYT are required to obtain an effect corresponding to 100%, but the approved inclusion rate is 1,500-3,000 FYT per kg feed.

3) Optiphos is approved in the EU according to a different analysis method, the OTU. In practice, Optiphos can be verified with the standard method (FTU/FYT), and an EU test made at multiple laboratories revealed that 2.68 as many analysed FTU/FYT than declared OUT are required.

4) Optiphos minimum inclusion in feed for sows and finishers: 125 OTU. Minimum inclusion in feed for weaned pigs: 250 OTU (100%). Max inclusion rate: 500 OTU.

5) Phyzyme is approved in inclusion rates up to 1,000 FTU in feed for weaned pigs and finishers, and 500 FTU in feed for sows.

6) Axtra Phy minimum inclusion: 250 FTU. 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 must be assessed on the basis of the total content of phosphorus. Table 8 shows the guiding minimum content of total phosphorus in diets containing phytase.

Table 8. Guiding minimum content of total phosphorus¹ in complete diets with phytase, g per feed unit.

Phytase, % af 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, 30-110 kg	2.3	4.2	3.95	3.9	3.75	3.65	3.6
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: 2.3 g dig. P per FU_g (>2.75 per kg gain).

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

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 Pig Research Centre.

Amino acids:

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 FU_gp 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.

	<ul style="list-style-type: none"> 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:	<p>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.</p> <p>It is now possible to select a protective diet for all weight intervals.</p> <p>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 previous profile to avoid a high protein level. The standards for protein and amino acids for specialised productions are specified in a separate table.</p> <p>The lysine standard for gestating sows in the entire period is raised to 4.0 g digestible lysine per FUsow and standards are provided for phase feeding of gestating sows with 3.5 g digestible lysine per FUsow until day 85 after service followed by 5.0 g digestible lysine per FUsow until transfer to the farrowing unit. The amino acid profile for the service</p>

	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.
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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 dosis, 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.

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.

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