

Nutrient standards

The Danish feed evaluation system

In 2002, a new feed evaluation system was introduced in Denmark. This system is based on the physiological energy value of the nutrients and on their standardised digestibility. The new system introduced two new feed units replacing the old feed unit: FUgp (feed units for weaners, growers and finishers) and FUsow (feed units for sows).

In practice, the Danish energy evaluation is based on:

1. Chemical analyses of water, ash, crude protein and crude fat
2. In vitro digestibilities at ileal and faecal levels
3. Energy values of nutrients based on "potential physiological values".

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

A typical complete diet has the following energy content per kg diet:

	Feed unit	MJ ME	MJ NE	MJ physiological energy
Lactation diets	1.06 FUsow	13.3	9.6	7.9
Gestation diets	0.99 FUsow	12.6	8.8	7.4
Weaner diets, 6-9 kg	1.18 FUgp	14.4	10.5	8.7
Weaner diets, 9-30 kg	1.17 FUgp	14.1	10.4	8.6
Finisher diets, 30-100 kg	1.07 FUgp	13.4	9.6	7.9

Amino acids

The standards for amino acids are shown in tables 1-4. A safety margin is not included in the amino acid standards. The standards for weaners, growers and finishers are based on ad lib feeding or on approximate ad lib. Feed for gilts must comply with the amino acid standards for lactating sows from they weigh approx. 60 kg. Until they weigh 60 kg they must follow the standards for weaners/growers. The sperm production of boars is not affected by the protein content of the feed, and feed for boars can thereby follow the standards for gestating sows.

The standards in tables 3 and 4 denote the minimum content estimated to be necessary to ensure a maximum production. However, "maximum production" does not apply to the amino acid standards for weaners (table 1). Here, the standards are based on an economically optimum standard, as a standard for maximum productivity will increase the feed costs more than can be justified by the improvement in productivity.

Table 1. Amino acid standards for weaners, g digestible per feed unit (Fuggp)

Interval, kg	6-9 kg	9-20 kg	9-30 kg	20-30 kg	% of lysine*
Lysine	11.0	10.6	10.4	10.0	100**
Methionine	3.5	3.4	3.3	3.2	32
Methionine + cystine	5.9	5.7	5.6	5.4	54
Threonine	6.7	6.5	6.3	6.1	61
Tryptophan	2.15	2.07	2.03	1.95	19.5**
Isoleucine	6.4	6.1	6.0	5.8	58
Leucine	11.2	10.8	10.6	10.2	102
Histidine	3.7	3.6	3.5	3.4	34
Phenylalanine	6.3	6.0	5.9	5.7	57
Phenylalanine + tyrosine	12.2	11.8	11.5	11.1	111
Valine	7.4	7.1	7.0	6.7	67
Crude protein, min.	158	153	150	145	-
Crude protein, max.	170	165	162	157	-

*: Always ensure that the composition of the ideal protein is met in case of lysine levels / weight intervals different from those stated above.

** : The amino acid standards show the level that under normal price conditions will guarantee maximum gross margin in herds with good health status. Trials have demonstrated that maximum productivity is obtained by increasing the standard by approx. 5% (all amino acids) resulting in a better feed conversion ratio and an increase in daily gain by 1-2%. The current tryptophan standards for weaners are established on the basis of an optimum gross margin, ie. the evaluation includes the price of adding tryptophan. Trials have demonstrated that maximum productivity is obtained when the standard is increased from the current approx. 19.5% to 22% of the lysine standard (corresponding to approx. 0.25 g digestible tryptophan more than stated in the table). By increasing the content from 19.5% to 22%, an increase in daily gain of approx. 1.5% is expected, whereas feed conversion is not affected. It is recommended to increase the tryptophan content to this level, provided that the increase in feed price does not reach a level where there is no room on the bottom line for a profit on the basis of the expected productivity.

Recommendations in case of diarrhoea problems in weaners

Experiences from trials and practice have shown that the risk of diarrhoea increases when the protein content in the feed increases.

In herds where feeding according to the standards results in a diarrhoea frequency that is too high, the content of protein and amino acids can be reduced, but it is recommended to maintain the same amino acid profile in per cent of lysine as in the standards.

It is only recommended to go below the standard in the period in which it is necessary in the individual herd. In table 2, the recommendations for amino acid content is shown in cases of diarrhoea problems.

Table 2. Recommendations for amino acid content* in case of diarrhoea problems, g digestible per feed unit

Interval, kg	6-9 kg	9-20 kg	9-30 kg	20-30 kg	% of lysine*
Lysine	10.0	10.0	9.8	9.5	100
Methionine	3.2	3.2	3.1	3.0	32
Methionine + cystine	5.4	5.4	5.3	5.1	54
Threonine	6.1	6.1	6.0	5.8	61
Tryptophan	1.95	1.95	1.9	1.85	19.5
Isoleucine	5.8	5.8	5.7	5.5	58
Leucine	10.2	10.2	10.0	9.7	102
Histidine	3.4	3.4	3.3	3.2	34
Phenylalanine	5.7	5.7	5.6	5.4	57
Phenylalanine + tyrosine	11.1	11.1	10.9	10.5	111
Valine	6.7	6.7	6.6	6.4	67
Crude protein, min.	145	145	142	138	-
Crude protein, max.	157	157	154	150	-

*: These recommendations are expected to reduce gain and feed conversion ratio by approx. 3% compared with the standards, provided that all amino acids comply with the recommendation. If this is not the case, further reductions in productivity must be expected.

Table 3. Amino acid standards for growers and finishers, g digestible per feed unit (FUgp)

Interval, kg	20-45	30-45	30-55	30-105 45-65	45-105 55-75	55-105	65-105	75-105 65-110	% of lysine*
Lysine	8.7	7.9	7.7	7.4	7.1	6.9	6.7	6.4	100
Methionine	2.7	2.4	2.4	2.3	2.2	2.1	2.1	2.0	31
Met+cyst	4.9	4.5	4.4	4.3	4.2	4.1	4.0	3.8	56-60
Threonine	5.5	5.1	5.0	4.9	4.7	4.6	4.5	4.4	63-67
Tryptophan	1.7	1.5	1.45	1.4	1.35	1.3	1.3	1.25	19
Isoleucine	5.0	4.6	4.5	4.3	4.1	4.0	3.9	3.8	58
Leucine	8.9	8.1	7.9	7.5	7.2	7.0	6.8	6.5	102
Histidine	3.0	2.8	2.8	2.7	2.6	2.6	2.5	2.4	35-37
Phenylalanine	5.1	4.7	4.6	4.5	4.3	4.2	4.1	3.9	59-61
Phen+tyrosine	10.0	9.2	9.0	8.6	8.3	8.1	7.9	7.6	115-118
Valine	6.1	5.5	5.4	5.2	5.0	4.8	4.7	4.5	70
Crude prot., min	140	135	133	130	127	125	122	118	-

*: It is recommended to use the standards and profile stated (per cent of lysine) for the various weight intervals.

Tables 1 and 3 denote the minimum content of crude protein. If this is met, a sufficient supply of all amino acids is generally guaranteed if only lysine, methionine, threonine and tryptophan are added. Tables 1 and 2 furthermore denote a limit for maximum content of digestible protein in weaner feed to ensure that no more protein than necessary is used out of regard for the risk of diarrhoea.

Table 4. Amino acid standards for sows, g digestible per feed unit (FU_{sow})

Lysine	3.3	6.0
Methionine	1.6	1.9
Methionine + cystine	3.2	3.6
Threonine	3.0	3.9
Tryptophan	1.0	1.2
Isoleucine	3.0	4.2
Leucine	2.6	7.0
Histidine	1.2	2.5
Phenylalanine	1.9	3.6
Phenylalanine + tyrosine	3.6	7.0
Valine	3.5	5.0
Crude protein, min.	90	110

*: If it is impossible to reach an average feed intake during lactation of min. 6 FU_{sow} a day, it may be necessary to increase the amino acid content per FU_{sow} by 8% for all amino acids.

Minerals

The standards are stated as the pigs' requirements plus a safety margin. In general, it cannot be recommended to add minerals beyond the standard. This particularly applies to calcium, as calcium interacts with some of the micro minerals, which means that a high content of calcium may inhibit the absorption of these micro minerals.

The standard for digestible phosphorus is a minimum standard, and does thus not include a safety margin.

The mineral standards in tables 5 and 6 are denoted as total amount in the feed.

Gilts and boars follow the mineral standards for finishers up to 100 kg, and then they follow the standards for gestating sows.

Table 5. Mineral standards for sows and weaners, total amount per feed unit

	Sows		Weaners			
	Gestating	Lactating	6-9 kg	9-20 kg	9-30 kg	20-30 kg
Calcium, g	7.0	8.0	7.0	8.5	8.5	8.5
Calcium + add. of phytase, g	6.5	7.5	6.5	8.0	8.0	8.0
Dig. phosphorus, g	2.0	2.7	3.3 ³	3.2	3.1	2.9
Sodium, g	1.5	1.5	1.5	1.5	1.5	1.5
Chloride, g	2.5	2.5	2.5	2.5	2.5	2.5
Potassium, g	2.5	2.5	2.5	2.5	2.5	2.5
Magnesium, g	0.4	0.4	0.4	0.4	0.4	0.4
Iron, mg	80	80	150 ¹	150 ¹	150 ¹	150 ¹
Copper, mg	6	6	6	6	6	6
Manganese, mg	40	40	40	40	40	40
Zinc, mg	100	100	100	100	100	100
Iodine, mg	0.2	0.2	0.2	0.2	0.2	0.2
Selenium, mg ²	0.2	0.2	0.35	0.35	0.35	0.35

¹ Of this, at least 100 mg easily soluble iron salt.

² 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 0.2 to 0.35 mg selenium can be added per feed unit.

³ When a high dosage of zinc oxide is used (2,500 ppm zinc), it is recommended to add 0.3 g digestible phosphorus more per feed unit than stated in the standard. It is also recommended to keep adding phytase in weaner feed when additional zinc is added.

Table 6. Mineral standards for growers and finishers, total amount per feed unit (FUgp)

	20-45 kg	30-45 kg	30-105 kg	45-105 kg	65-105 kg
Calcium, g	8.0	7.5	7.0	7.0	6.5
Calcium + add. of phytase, g	7.5	7.0	6.5	6.5	6.0
Dig. phosphorus, g	2.8	2.6	2.5	2.4	2.3
Sodium, g	1.5	1.5	1.5	1.5	1.5
Chloride, g	2.5	2.5	2.5	2.5	2.5
Potassium, g	2.5	2.5	2.5	2.5	2.5
Magnesium, g	0.4	0.4	0.4	0.4	0.4
Iron, mg	80	80	80	80	80
Copper, mg	6	6	6	6	6
Manganese, mg	40	40	40	40	40
Zinc, mg	100	100	100	100	100
Iodine, mg	0.2	0.2	0.2	0.2	0.2
Selenium, mg ¹	0.2	0.2	0.2	0.2	0.2

¹ 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 0.2 to 0.35 mg selenium can be added per feed unit.

Digestible phosphorus

As the content of digestible phosphorus in the feed cannot be analysed, the feed's content of digestible phosphorus must be assessed on the basis of the total content of phosphorus. In table 7, the guiding minimum content of total phosphorus in diets with phytase is shown.

Table 7. Guiding minimum content of total phosphorus in complete diets with addition of phytase, g/feed unit

	Complete diet with normal dosis phytase*	Complete diet with double dosis phytase*
Weaners, 9-30 kg	5.2 g	4.9 g
Growers and finishers, 30-105 kg	4.4 g	4.1 g
Gestating sows	3.8 g	3.4 g
Lactating sows	4.8 g	4.4 g

*: A normal dosis of phytase corresponds to the addition of 500 FTU (Natuphos or Phyzyme XP) or 750 FYT (Ronozyme-P) to heat-treated feed. In meal feed that is not heat-treated, a normal dosis of phytase corresponds to the addition of 300 FTU or 300 PPU or 450 FYT (please note, the smallest legal dosage is 500 FYT). Double dosis corresponds to the double level of a normal dosis in complete diets.

The prerequisites of the minimum recommendations are that traditional diets based on grain and soybean meal are used in which wheat constitutes approx. 50% of the grain for sows and min. 2/3 of the grain for weaners and finishers, and that monocalcium phosphate is used as phosphorus source. In other types of diets, the content of total phosphorus often needs to be slightly higher to meet the standards for digestible phosphorus.

Vitamins

Besides the pigs' minimum requirements, the standards include a safety margin to ensure maximum productivity and reproduction. The standards for certain vitamins also take into consideration maximum health to the extent that this is documented. The standards were revised in 1990. However, the standard for vitamin E for lactating sows was revised in May 2004, and the standard for weaners was revised in June 2005.

Contrary to the standards for minerals, the vitamin standards are denoted in amounts added without regard to the vitamin content of the basis feed (cf. table 8). This is due to the fact that the natural vitamin content of the feedstuffs varies greatly simultaneously with a generally low availability. It is not recommended to add vitamins beyond the standard.

Table 8. Vitamin standards for pigs, added amount per feed unit

	Gestating sows	Lactating sows	Weaners, 3-5 weeks, approx. 6-9 kg	Weaners, 5-10 weeks, approx. 9-30 kg	Finishers, 30-100 kg
Vitamin A, i.e.	8000	8000	8000	5000	4000
Vitamin D3, i.e.	800	800	800	500	400
Vitamin E, mg*	36	150	130	130**	36
Vitamin K3, mg	2	2	2	2	2
Thiamine (B ₁), mg	2	2	2	2	2
Riboflavin (B ₂), mg	5	5	4	4	2
Pyridoxine (B ₆), mg	3	3	3	3	3
Niacin, mg	20	20	20	20	20
Biotin, mg	0.2	0.2	0.2	0.2	0.05
D-pantothenic acid, mg	15	15	10	10	10
Folic acid, mg	1.5	1.5	0	0	0
Vitamin B ₁₂ , mcg	20	20	20	20	20

*: As dl-alpha-tocopherol.

** : When using a diet from 20 to 30 kg, vitamin E can be reduced to 36 mg per FUgp. The 130 mg per FUgp were documented in the period 6-20 kg.

Revision of the standards

The standards are routinely revised. Evaluations are made by representatives from The Faculty of Agricultural Sciences, Aarhus University, pig production advisors and Pig Research Centre.

The amino acid standards were revised in:

1990:	The standards for the first five amino acids were revised on the basis of the latest weaner trials.
1991:	The standards for male pigs were reduced by 10% on the basis of the latest Danish trials. Therefore, there are no specific standards for male pigs.
1996:	Standards were established for the remaining six amino acids.
1998:	Standards were incorporated for use in phase feeding.
2001:	The standards for methionine, methionine + cystine, and threonine for sows were revised. Furthermore, the standards for leucine for weaners and grow-ers, and for methionine for finishers were revised.
2002:	The standards for threonine and tryptophan for weaners were revised. New amino acid standards and recommendations for minimum content of crude protein were incorporated that apply 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:	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 was illogical for certain weight intervals. Furthermore, 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 heavier pigs (slaughtered at 110-115 kg) in the weight interval 65-110 kg.
2006:	The standard for tryptophan for weaners was revised.
2008:	The amino acid standards for weaners were revised and recommendations were incorporated for amino acid content in feed in herds with diarrhoea problems. Furthermore, 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 de-

	leted.
2010:	The standard for valine for weaners was revised.

The mineral standards were revised in:

1991:	The selenium standard was revised.
1995:	Standards for digestible phosphorus for growers and finishers were incorporated.
1997:	The standards for calcium and digestible phosphorus for sows and weaners were revised.
1998:	Phase feeding standards for phosphorus were incorporated.
2000:	The calcium standards for sows and weaners were revised.
2002:	The recommendations for total-phosphorus content in the feed with addition of phytase were revised, and a calcium standard was incorporated for the use of phytase.
2005:	The standard for digestible phosphorus became a minimum standard.
2006:	The standard for digestible phosphorus for weaners was revised. Furthermore, the guiding minimum content of total-P was revised, and recommendations for double dosage of phytase were introduced.
2008:	The standards for digestible phosphorus were revised for all animal groups.
2010:	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 dosage of zinc is used (2,500 ppm).

The vitamin standards were revised in:

1990:	The vitamin standards were revised.
2004:	The vitamin E standard for lactating sows was revised.
2005:	The vitamin E standard for weaners was revised.

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