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3-phase feeding of finishers with differentiated phosphorus standard

Report no. 471
May 25, 2000

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The National Committee for Pig Production
DANISH BACON AND MEAT COUNCIL

Abstract

A test of 3-phase feeding compared to feeding with one diet throughout the entire growth period (the unit mix for finishers 30-100 kg) has been carried out. The test was carried out in three herds with pigs in the growth interval 32 to 100 kg. Dry feeding was used ad libitum. The test comprised 121 blocks (replicates) and a total of 4,845 produced finishers.

The feed analyses showed 3-6% surplus content of crude protein in herds A and B, and deviations in mineral content in all herds in the interval –7 to +43%.

The results showed that for all herds in general there was no significant difference in the production value between the control group and the phase feeding group when average prices of 5 years were used. However, phase feeding resulted in a significant decrease in the lean meat percentage of 0.4 percentage units.

In herd A, phase feeding had a significantly negative effect (4%) and in herd B a significantly positive effect (4%) on the production value, whereas in herd C there was no evident effect of phase feeding on the production value. It is likely that the higher production value of phase feeding in herd B may partly be due to a deficiency of calcium and phosphorus in the control group, and partly to the concentration of energy being graduated – as opposed to herds A and C – into the lowest level in the final diet. This may improve the lean meat percentage, especially for the castrates when fed ad libitum.

In this test, 3-phase feeding resulted in a reduction of 4.5% in discharge of nitrogen, and of 2.5% in discharge of phosphorus per produced finisher compared to the unit mix (control).

It is problematic to attempt phase feeding when the aim is to reduce protein and phosphorus by 4-5% if or rather when the mixing uncertainty is 5-6% or above. This creates a great risk of a deficiency of nutrients of the pigs.

On the basis of this test, phase feeding for finishers is only recommended when it can be conducted without any or only few extra investments as a consequence eg. at multisite and certain liquid feeding systems. Furthermore, thorough analyses of the ingredients and a good mixing certainty are perquisites for phase feeding.

Background

In Denmark, one diet is traditionally used in the finisher period, but several conditions make it relevant to study the effect of using several diets:

- Discharge of nitrogen end phosphorus may be reduced
- It has not been finally established if the pigs can compensate for the deficiency in the beginning of a weight interval when they reach the last part of a weight interval. If this ability for compensatory nutrients utilization is sufficiently large – and this study may shed light on that – phase feeding is in principle is financially less attractive.
- It will be possible to add copper to the feed for young pigs, and thereby reduce the problems with diarrhoea after penning.
- Results from a Danish test (Report no. 408, The National Committee for Pig Production) showed that a scraped end diet used from approx. 65 kg to slaughter in which phosphorus, growth promoters, micro minerals and vitamins among others were excluded reduced production economy more than the achieved savings on feed costs.
- Increased use of batch operation makes it easier to use several diets so that it is possible to achieve a reduced feed price without having to increase investments significantly.

When using phase feeding, the feed is adjusted to the pigs' average requirement for short growth intervals (phases), eg. 30-49 kg, 50-69 kg, and 70-100 kg. We have here chosen to study 3-phase feeding instead of 2-phase feeding as this provides the possibility of a larger graduation of copper and phosphorus. If phase feeding is to be performed, 2- or 3-phase feeding should be used. More phases (and thereby diets) than this pose two central problems: (1) the standards have not been very well studied or described within short weight intervals, and (2) several diets cause greater risk of mixing uncertainty. The prevalent strategy in Denmark is feeding with one diet for finishers in the weight interval 30-100 kg adjusted to the pigs' average requirement for nutrients (hereafter called the unity mix). As the requirement for among others amino acids per FUp is largest when the pigs are little, we will have deficiency in the first part and over-supply in the last part of the weight interval. This applies to both phase feeding and the unity mix. This is shown in figure 1.

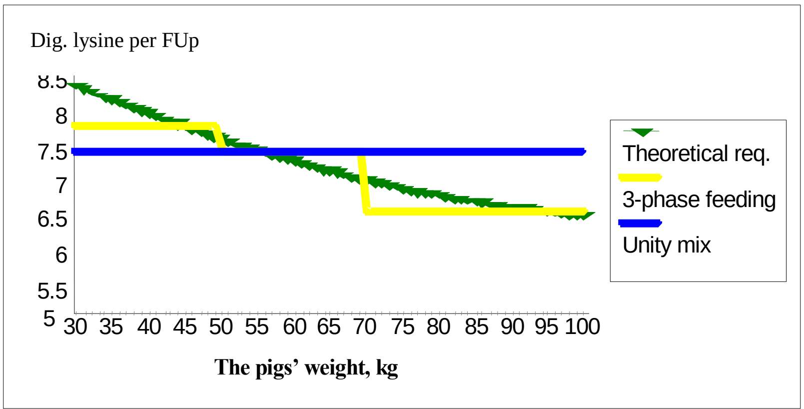

Figure 1. Outline of the relationship between the theoretical amino acid requirement (represented by lysine) and allocation either via the unity mix or 3-phase feeding

Phase feeding has been studied previously (Report no. 282, The National Committee for Pig Production). That study took its point of departure in reducing the nitrogen content. No significantly reduced production results were found in this study probably because the reduction in the amino acid supply towards the end of the growth period was too large. In a test by the Danish Institute of

Agricultural Sciences (842, report) unchanged production results were found, but the discharge of nitrogen was reduced on phase feeding.

In multisite production systems, it will be possible to employ phase feeding without any additional investments.

The purpose of the test was to study if phase feeding according to present standards can improve the financial results simultaneously with reducing the consumption of nitrogen and phosphorus.

Materials and methods

The test was carried out in three herds. Appendix 1a provides a description of the herds. The pigs were transferred at 30-34 kg and fed dry feed ad libitum. At transfer, the pigs were randomly distributed on to similar groups, evenly divided between sex and average weight on transfer. Table 1 shows the test design.

Table 1. Test design and planned nutrients content of the feed mixes

Group	Unity mix (Control group)	3-phase feeding (Test group)		
Diet	Control feed (=Middle)	Start	Middle	End
Weight interval	30-100	30-49	49-70	70-100
Mixing consumption, % of FUp*	100	22	31	47
Dig. crude protein, g/FUp	130	135	130	118
Dig. lysine, g/FUp	7.3	7.7	7.3	6.5
Dig. methionine, g/FUp	2.3	2.5	2.3	2.0
Dig. threonine, g/FUp	4.8	5.1	4.8	4.4
Calcium, g/FUp	7.0	7.5	7.0	6.0
Dig. phosphorus, g/FUp	2.2	2.3	2.2	1.9
Copper added, mg/kg	20	90	20	20
Vitamins and micro minerals	Standard	Standard	Standard	Standard

* One FUp equals the energy-value of 1 kg barley, basis 86% DM. FUp is determined by in vitro analysis.

In herd A, one block (replicate) consisted of two pens: one pen with control pigs, and one pen with test pigs. In herd B, one block consisted of 12 pens in a section: six pens in each group. In herd C, one block consisted four pens in a section: two pens in each group.

In each pen, gain, feed consumption, lean meat percentage, percent dead and rejected, and disease treatments were registered. In both groups within a block, intermediate weighing took place when the test group switched to the end diet.

The pigs in each block were transferred for slaughter over two to four times with an average slaughter weight of approx. 76 kg, corresponding to approx. 100 kg live weight.

In herds A and C, that used home-mixed feed, random samples of grain and soyabean meal were analysed for contents of crude protein, calcium and phosphorus. On each delivery of mineral feed mixes, samples were collected for establishing any deviations in the ready-mixed feed. The nutrients content of the ready-mixed feed was checked in all herds every two weeks by collecting random samples of the feed from all dispensers or from intake pits. A full feedstuff analysis was made on all the samples and a determination was made of calcium, phosphorus and all the essential amino acids.

The planned composition of the diets can be seen in appendices 1b, 1c and 1d.

Discharge of nitrogen and phosphorus expressed and kg N and P ex animal was calculated as an average for each group via the following formula (Report no. 736, the Danish Institute of Agricultural Sciences, 1997):

Kg N ex animal	=	N in feed – gain/pig x N discharged per kg gain
	=	(FUp per produced pig x g crude protein per FUp / 6250) – ((slaughter weight x 1.31 – weight on penning) x 0.028 kg N per kg gain)
Kg P ex animal	=	FUp per produced pig x g P/FUp/1000 g/kg – ((slaughter weight x 1.31 – weight on penning x 0.0055 kg P per contained kg gain)

Statistical analysis

The test was designed to show differences down to 4% of the production value. Daily gain, feed conversion and lean meat percentage were for each test unit (= the pigs at one feed valve) used for calculating production value in the form of a gross margin (GM) per place unit per year using the same feed prices. Gain and feed consumption were adjusted to the same weight on penning. As price and feed price was used the last five years' average (September 1, 1994 to August 31, 1999): price of 30 kg pigs: DKK360, kg adjustment of DKK4.95, settlement price, incl. bonus payment of DKK10.10 per kg, and feed price: DKK1.28 per FUp.

Production value was calculated as follows:
GM/place unit/year = GM/pig x 365 x 0.95 (pen utilization) / feeding days.

GM/pig is calculated as follows:
Sales price – purchase price – feed costs – various costs (kept constant at DKK26.30).

The difference between the groups in production value was analysed as primary parameter, and disease registrations as secondary parameter under the GLM procedure in SAS with weight on penning as co-variable, and with herd, block number within herd, the interaction link herd x group and group as explaining variables.

Furthermore, the current gross margin with average of the last five weeks' average (week 15-19, 2000) incl. the current difference in feed price between the groups was calculated. The following prices were used: Purchase price for 30 kg pigs of DKK354, kg adjustment of DKK4.83, and settlement price, incl. bonus payment (DKK9.18 + DKK0.61)/kg. The price per FUp for the three herds averaged DKK1.07 for the unity mix (=control), and DKK1.06 as weighted average of the phase feeding.

Results and discussion

Table 2 shows the significant deviations of the feed's nutrients content compared to the planned levels.

Table 2. Deviation of analysed nutrients values compared to planned level in the present product and per FUp

	Herd A, Home-mixed		Herd B, Purchased ready-mixed feed		Herd C Home-mixed	
Group	Control	Phase feed.*	Control	Phase feed.*	Control	Phase feed.*
FUp per kg product	- 1%	- 1%	+ 2%	+ 1%	- 3%	- 2%
Crude protein in product	+ 3%	+ 5%	+ 4%	+ 6%	0%	+ 1%
Calcium in product	+ 43%	+ 39%	- 1%	+ 2%	+ 2%	+ 11%
Phosphorus in product	+ 10%	+ 9%	- 7%	- 5%	+ 8%	+ 8%
Lysine in product	+ 3%	+ 3%	+ 4%	+ 3%	0%	+ 1%
Planned and analysed average content of nutrients per FUp (calculated on the basis of analyses)						
Dig. crude protein, plan	130	125	130	125	130	125
Dig. crude protein, analyses	135	132	132	131	133	129
Deviation from plan	4%	6%	2%	5%	3%	3%
Phase feed. comp. to control (planned: -4%)		**- 2%**		**- 1%**		**- 4%**
Calcium, plan	7.00	6.64	7.00	6.64	7.00	6.64
Calcium, analyses	10.11	9.32	6.79	6.71	7.35	7.52
Deviation from plan	44%	40%	- 3%	1%	5%	13%
Phase feed. comp. to control (planned: -5%)		**- 8%**		**- 1%**		**2%**
Dig. phosphorus, plan	2.20	2.09	2.20	2.09	2.20	2.09
Dig. phosphorus, analyses	2.44	2.30	2.01	1.97	2.45	2.30
Deviation from plan	11%	10%	- 9%	- 6%	11%	10%
Phase feed. comp. to control (planned: -5%)		**- 6%**		**- 2%**		**- 6%**
Dig. lysine, plan	7.30	7.01	7.30	7.01	7.30	7.01
Dig. lysine, analyses	7.59	7.29	7.44	7.15	7.52	7.22
Deviation from plan	4%	4%	2%	2%	3%	3%
Phase feed. comp. to control (planned: -4%)		**- 4%**		**- 4%**		**- 4%**

Number of analyses per diet: Herd A: 10, herd B: 8, and herd C: 4.
* As the phase feeding group was given three diets, the figures shown are weighted average for each diet. The weighting was made compared to consumed kg feed.

The other analysed nutrients did not show any significant deviations from the planned content. Lysine is only included in the table as a representative for the other essential amino acids that were all analysed, and deviations in the magnitude showed for amino acids cannot be said to be significantly different from the planned level with the present number of analyses per diet.

Note the bold figures in table 2 in the sections showing the calculated nutrients content in the feed of the phase feeding group compared to that of the control group. In each line is stated which difference was planned. In herd B, the saving was not so large on protein, calcium and phosphorus in the phase feeding group as planned, and the control group had a deficiency of 3% and 9%, respectively, of calcium and phosphorus compared to the standard. It is therefore estimated that the achieved production results were affected by this to the benefit of the phase feeding group.

In herds A and B, that both used home-mixed feed, the added minerals and amino acids originated from one mineral diet per diet type (start, middle, and end). Random samples of the mineral diets showed good agreement with the guaranteed content.

When calculating the consumption of mineral diets, it was seen that in herd C, with a mixing system from 1998, 2%-3% too much was dosed, while in herd A, with a mixing system from 1988, 8%-10% too much was dosed. Overdosing took place despite the supplier's attempts to correct the error. On the basis of a recalculation of the diets in herd A with an 8% overdose at the expense of wheat, the following over-content is expected: calcium 7%, phosphorus 4%, and lysine 2%. Table 2 shows that the measured relations did not reach that. This illustrates how difficult it is to avoid segregation and collect a representative random sample of meal feed.

It can be concluded that there were problems with achieving protein and mineral contents for both herd A and the feedstuff company that delivered to herd B.

Production results

Average figures from the three herds can be seen in table 3d. The effect of test treatment (control or 3-phase feeding) differed in the three herds, and therefore the production results are shown for each of the three herds in tables 3a-3c. Production value was calculated as gross margin per place unit per year using the same price per FUp for both groups.

Table 3a. Herd A: Production results, adjusted to the same weight on penning

Group	**Control**	**3-phase feeding**
No. replicates/produced pigs	43/835	41/808
From penning to slaughter (32-100 kg live weight)		
Daily feed intake per pig, FUp	2.52	2.53
Daily gain, g	891	888
Feed conversion, FUp/kg gain	2.83	2.85
Lean meat %	59.8	59.3
Nitrogen ex animal per produced pig, index	100	96
Phosphorus ex animal per produced pig, index	100	92
Production value, 5 years' prices:		
DKK/place unit/year, converted to index[1]	100 **a**	96 **b**
DKK/pig, converted to index	100	96
Current gross margin, last 5 weeks' prices:		
DKK/place unit/year, converted to index[2]	100 **a**	98
DKK/pig, converted to index	100	98

[1] Smallest significant difference: 3.1 index points.
[2] Statistics are not calculated on current prices.

Table 3b. Herd B: Production results, adjusted to the same weight on penning

Group	**Control**	**3-phase feeding**
No. replicates/produced pigs	68/999	64/936
From penning to slaughter (32-101 kg live weight)		
Daily feed intake per pig, FUp	2.41	2.43
Daily gain, g	894	912
Feed conversion, FUp/kg gain	2.70	2.66
Lean meat %	60.8	60.6
Nitrogen ex animal per produced pig, index	100	94
Phosphorus ex animal per produced pig, index	100	101
Production value, 5 years' prices:		
DKK/place unit/year, converted to index[1]	100 **a**	104 **b**
DKK/pig, converted to index	100	104
Current gross margin, last 5 weeks' prices:		
DKK/place unit/year, converted to index[2]	100	105
DKK/pig, converted to index	100	104

[1] Smallest significant difference: 3.0 index points.
[2] Statistics are not calculated on current prices.

Table 3c. Herd C: Production results, adjusted to the same weight on penning

Group	Control	3-phase feeding
No. replicates/produced pigs	16/632	16/635
From penning to slaughter (32-101 kg live weight)		
Daily feed intake per pig, FUp	2.33	2.27
Daily gain, g	832	819
Feed conversion, FUp/kg gain	2.80	2.77
Lean meat %	60.5	60.1
Nitrogen ex animal per produced pig, index	100	95
Phosphorus ex animal per produced pig, index	100	93
Production value, 5 years' prices:		
DKK/place unit/year, converted to index[1]	100	97
DKK/pig, converted to index	100	98
Current gross margin, last 5 weeks' prices:		
DKK/place unit/year, converted to index[2]	100	98
DKK/pig, converted to index	100	99

[1] Smallest significant difference: 6.9 index points.
[2] Statistics are not calculated on current prices.

There was no significant difference in the number of disease treatments (3.5% for both groups in the three herds) or in mortality (on average 1.2% dead and rejected in both groups in the three herds) neither within a herd or in all herds in general.

Table 4 shows that for all herds seen as one there was no significant difference in production value between the control group and the phase feeding group when 5 years' prices were used, but phase feeding did result in a significant reduction in lean meat percentage of 0.4 percentage units as can be seen in table 3d.

Table 3d. Production results for all three herds, adjusted for weight on penning and interaction

Group	**Control**	**3-phase feeding**
No. replicates/produced pigs	127/2,466	121/2,379
From penning to slaughter (32-101 kg live weight)		
Daily feed intake per pig, FUp	2.42	2.40
Daily gain, g	871	872
Feed conversion, FUp/kg gain	2.77	2.76
Lean meat %	60.4	60.0
Nitrogen ex animal per produced pig, index	100	95.5
Phosphorus ex animal per produced pig, index	100	97.5

Table 4. Production value and actual gross margin using current prices (all three herds)

Group	**Control**	**3-phase feeding with differentiated phosphorus standard**
Production value using 5 years' prices:		
DKK/place unit/year at DKK128 per 100 FUp[1]	637	632
Index	100	99
Gross margin using current feed prices and the last 5 weeks' prices:[2]		
Feed prices, DKK per 100 FUp (analysed FUp)	107	106
GM/place unit/year	745	745
GM/pig	168	168

[1] There was no significant difference on comparing the groups for all herds seen as one. The smallest significant difference was: GM/place unit/year: min. DKK41. Index: min. 6.5 index points. The set of prices used was the average of the last five years.
[2] No statistical calculation was made of differences in gross margin using current prices.

The production value per pig (calculated with the same feed price in both groups) and gross margin per pig (calculated on the basis of a current feed price for each group) are included to show the results cleared of value of daily gain. In certain situations, gain is not of great importance, eg. where there is not enough space to produce more pigs just because gain is higher.

In herd A, phase feeding had a significantly negative effect and in herd B a significantly positive effect on the production value per place unit per year, whereas there was no evident effect of phase feeding on production value in herd C.

It is likely that the higher production value of phase feeding in herd B may partly be due to a smaller reduction than planned of both protein, calcium and phosphorus in the feed for the phase feeding group compared to the control group as can be seen in table 2. It may also be because the energy concentration was graduated with the lowest level in the end diet, as opposed to herds A and C, which may improve feed conversion and lean meat percentage especially in castrates when feed ad libitum (Report from The National Committee for Pig Production, soon to be published). If a lower energy concentration in the end diet is introduced, the possibility for cheaper feeding with phase feeding can easily be eliminated for home-mixers. This is because normally only a limited number of ingredients is available, and use of wheat, triticale, rye and fat will be financially attractive and at the same time increase the energy content in the mix.

Looking at figure 1 in which the relation between the theoretical amino acid requirement (represented by lysine) and allocation either via the unity mix or 3-phase feeding is shown, it seems that on the basis of this test the pigs have a certain ability for compensatory nutrients utilization. Seen from a financial point of view, phase feeding is therefore not particularly attractive as the small gain, which is cheaper feed, is be counterbalanced by more explicit negative consequences of mixing uncertainty and possibly an extra investment in feeding equipment.

One characteristic for all the tests made of phase feeding in Denmark is that the average lean meat percentage was reduced on phase feeding. See table 5.

Table 5. Results of Danish phase feeding tests in % of unity mix for finishers

Institution, year	**SH, 1993 Report 842**	**Nat. Com. for Pig Production, 1994, Report 282 --Multiphase--**		**Nat. Com. for Pig Prod., 1998, Report 408**	**Nat. Com. for Pig Prod., 1998, Exp. 9811**	**This test**
Type	**Multiphase**	**Herd A**	**Herd B**	**Scraped end mix**	**End mix = wheat**	
No. replicates	20	10	12	75	8	121
Daily gain, %	-0.5	-2.8*	-1.7*	-2.9*	-14.3*	+0.1
FUp/kg gain, %	+0.8	+3.5*	+0.4	+1.4*	+18.9*	-0.7
Lean meat %, %-point	-0.3	-0.6*	-0.3*	-0.3	-2.9*	-0.4*
Current GM/place unit/year, %[1]	-2	-11	-3	-2	-59	0
Discharged nitrogen, %	-4	-11	-14	-4	-3	-5
Discharged phosphorus, %	?	?	?	-22	-5	-3

* Signifcant difference

[1] Using current feed prices: saving of DKK1 per 100 FUp in sources 1, 2 and 5. Saving of DKK3 in source 3, and of DKK19 in source 4.

One explanation may be that the small pigs (esp. female pigs) in a pen will experience a deficiency of amino acids compared to their requirement as they reach the weight later that fits the mix, and when it happens, the mixes are changed to a less concentrated mix that again causes deficiency in the pigs compared to their requirement. This problem is illustrated in figure 2. Especially these female pigs might achieve better results if they are carefully sorted according to size before they are penned.

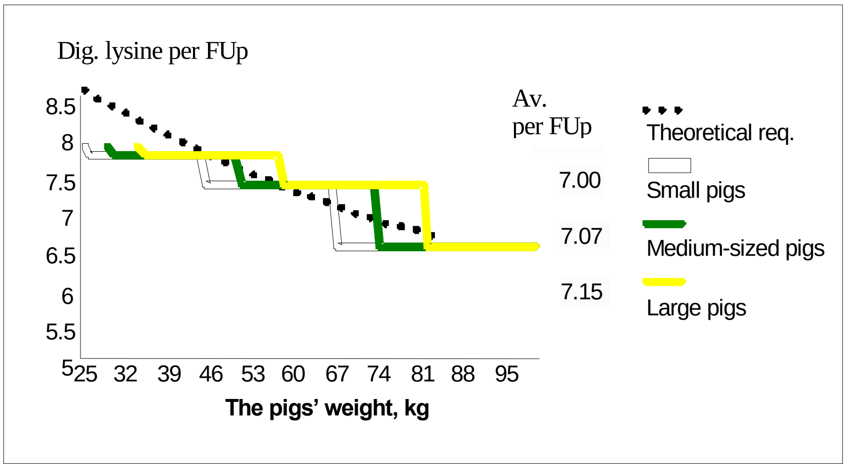

Figure 2. Problems concerning deficiency of nutrients of the smallest pigs in the pen

An impending revision of the Danish energy and protein assessment might be part of the explanation of the reduced lean meat percentage in phase feeding as the energy is underestimated and the amino acid availability overestimated in the present system in a mix with low crude protein level. Thus, according to this new knowledge, a larger amount of free amino acids could have been added to the end mixes. The results from herd B indicate that in phase feeding it could be sensible with a high level of energy in the start mix, lower in the middle mix and lowest in the end mix.

For comparison, phase feeding strategies from Holland, France and North Carolina, USA, are briefly described in appendix 2.

Discharge of phosphorus and nitrogen

One of the purposes of phase feeding is to reduce the discharge of nitrogen and phosphorus. As table 3 shows, the discharge of nitrogen was reduced by 4.5% (corresponding to 0.14 kg ex animal) with phase feeding in this test in which on average 3.6 mg less digestible crude protein per FUp was added. With phase feeding, the discharge of phosphorus was reduced by 2.5% (corresponding to 0.02 kg P ex animal).

In a test comparing levels of 110, 120 and 130 g digestible crude protein with each other (Report no. 467, The National Committee for Pig Production) it was discovered that when the feed's content of digestible crude protein dropped by 10 g per FUp in the interval 130-110 g digestible crude protein per FUp, the discharge of nitrogen dropped by 0.35 kg N ex animal, and that is comparable with this test.

If the feed conversion is unchanged, the discharge of nitrogen is reduced by approx. 1.6% if the crude protein is reduced by 1% in approx. 130 g digestible crude protein.

Conclusion

It is problematic to attempt phase feeding when the aim is to reduce protein and phosphorus by 4-5% if or rather when the mixing uncertainty is 5-6% or above. This creates a great risk of deficiency of the pigs.

On the basis of this test, phase feeding for finishers is only recommended when it can be conducted without any or only few extra investments as a consequence. This means at eg. multisite and certain liquid feeding systems. Furthermore, thorough analyses of the ingredients and a good mixing certainty are perquisites for phase feeding.

It can be concluded that phase feeding does not reduce nitrogen discharge greatly from finisher production unless a reduction in productivity is accepted. However, it is possible to obtain a significant reduction in the discharge of nitrogen by lowering the crude protein level in the finisher diet with an extra supply of free amino acids. The optimum level of crude protein has not yet been established; it will depend on the price relations between soyabean meal, free amino acids, and in the long term on whether the requirement to the number of finishers per ha is adjusted according to the individual herd's documented allocation of nitrogen via the feed.

Participants

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Appendix 1a

Description of the herds

Herd	**A**	**B**	**C**
Health status	MS	MS	Conventional
Feeding system	Computer controlled dry feeding	Computer controlled dry feeding	Computer controlled dry feeding
Feed	Home-mixed with purchase of mineral feed mix	Purchased feed mix	Home-mixed with purchase of mineral feed mix
Feeding strategy	Ad libitum	Ad libitum	Ad libitum
Type of dispenser	Simple dry feed dispenser	Simple dry feed dispenser	Tube dispenser with water
Water supply in dispenser	No	No	Yes
Type of floor	Fully slatted	Fully slatted	Fully slatted
Sectioned operation (all in/all out)	Partly: cleaning walls between some sections	Yes: fully sectioned	Yes: fully sectioned
Purchase of weaners	No	Yes	No
Separation of female pig/castrates	No	No	No
No. of pigs per pen/feed valve	20/20	15/15	20/40
No. of pigs penned per block	40	30	80

Appendix 1b

Herd A: Planned composition of diets, % of kg product

Diet	**Start (30-49 kg)**	**Middle (50-70 kg) = control mix**	**End (71-100 kg)**
Planned energy content, FUp/100 kg	110	110	110
Wheat	56.31	59.21	64.26
Barley	10.00	10.00	10.00
Oats	4.00	4.00	4.00
Soyabean meal	23.94	21.58	17.02
Animal fat (92/4)	2.73	2.92	2.56
Mineral feed mix*	3.02	2.29	2.16

* One mineral feed mix for each of the three ready-mixed diets that contained L-lysine hydrochloride, DL-methionine, L-threonine, vitamins, micro- and macro minerals.

Appendix 1c

Herd B: Planned composition of diets, % of kg product

Diet	**Start (30-49 kg)**	**Middle (50-70 kg) = control mix**	**End (71-100 kg)**
Planned energy content, FUp/100 kg	109	107	105
Wheat	39.20	40.30	45.30
Barley	20.00	20.00	20.00
Soyabean meal	19.73	14.90	6.87
Rapeseed cake, double low	6.00	7.00	9.00
Rye	4.00	5.00	5.00
Animal fat	3.50	2.90	2.40
Sunflower seed, extracted	2.50	4.00	6.00
Sugar beet molasses	2.00	3.00	3.00
Dicalcium phosphate	1.30	1.20	0.80
Calcium carbonate (chalk)	0.85	0.80	0.75
Salt (NaCl)	0.45	0.45	0.40
Pre-mix*	0.20	0.20	0.20
L-lysine hydro chloride	0.18	0.20	0.25
DL-methionine	0.06	0.03	-
L-threonine	0.03	0.02	0.03

* Contained vitamins and micro minerals

Appendix 1d

Herd C: Planned composition of diets, % of kg product

Diet	**Start (30-49 kg)**	**Middle (50-70 kg) = control mix**	**End (71-100 kg)**
Planned energy content, FUp/100 kg	108	108	108
Wheat	59.95	61.96	66.59
Spring and winter barley	15.00	15.00	15.00
Soyabean meal	20.05	18.33	13.91
Animal fat (92/10)	1.50	1.50	1.50
Mineral feed mix*	3.50	3.21	3.00

* One mineral feed mix for each of the three ready-mixed diets that contained L-lysine hydrochloride, DL-methionine, L-threonine, vitamins, micro- and macro minerals.

Appendix 2

Foreign models for phase feeding

It is relevant to compare the Danish strategy with a unity or average mix for finishers in the growth interval 30-100 kg to foreign feeding strategies in eg. Holland, France and parts of the USA where they conduct various models of phase feeding. Particularly the Dutch have expressed surprise that phase feeding is not widespread in Denmark. An explanation of their surprise may be that the traditional Dutch average diet for finishers had a far higher nutrients concentration than the Danish one thereby providing an obvious environmental gain by introducing phase feeding in Holland. Via the calculated lysine content from current recipe, the figures below show the phase feeding models used in Holland, France, and North Carolina in the USA.

It can be seen that the Dutch phase feeding principally consists of giving the pigs a weaner diet with 9.6 g digestible lysine until they reach a weight of 45 kg, and subsequently one diet containing 7.1 g digestible lysine per FUp is given until slaughter. Assuming that the Dutch pigs eat approx. 20% of the total amount of feed in the growth interval 30-100 kg in the form of the diet containing 9.6 g digestible lysine per FUp, this corresponds to an average supply of 7.6 g per FUp in the entire period. Furthermore, assuming that the relation between crude protein and lysine is the same in the typical Dutch diets as in Denmark, the Dutch feed their finishers 4% more protein in the growth interval 30-100 kg than we do in Denmark.

In France, 2-phase feeding is employed with a switch at approx. 60 kg (Relandeau, 1999) with an average lysine supply that apparently is 6-7% below the Danish.

The type of phase feeding employed many places in North Carolina is basically a 2-phase feeding for the female pigs in the growth interval 35-92 kg with an average lysine supply close to the Danish. For the castrates, the amino acid supply is reduced further when they weigh approx. 78 kg.

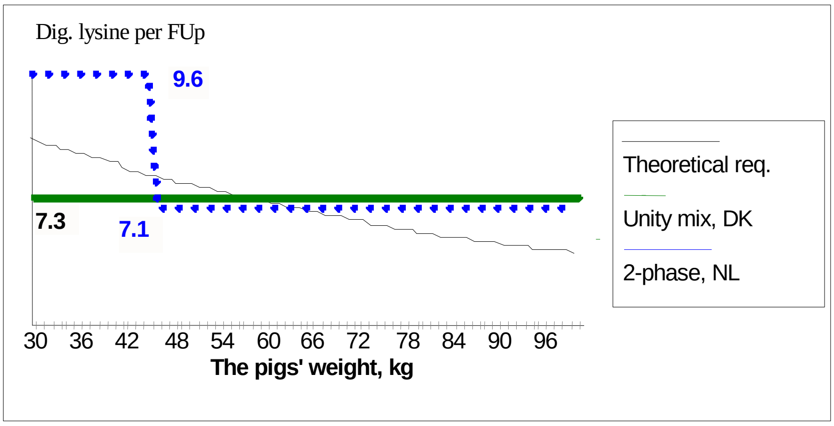

Figure 3. 2-phase feeding, the Netherlands

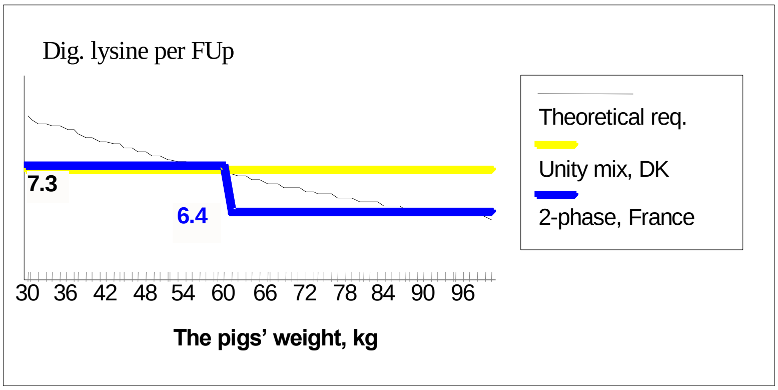

Figure 4. 2-phase feeding, France

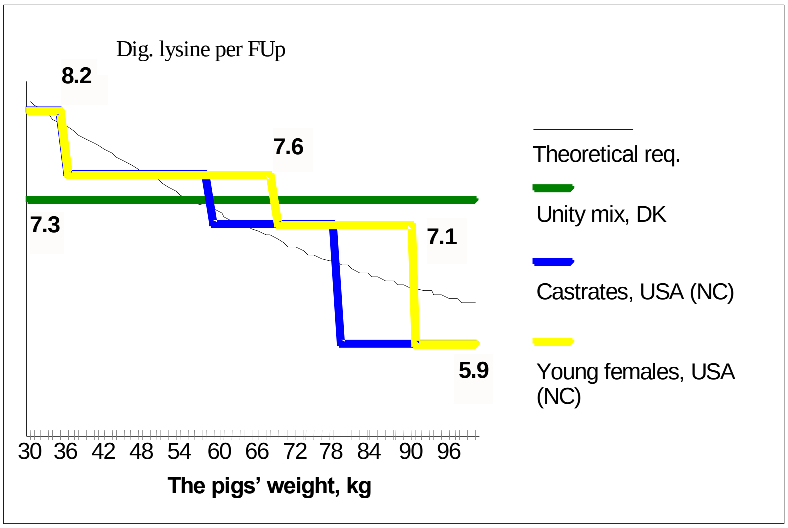

Figure 5. 2-phase feeding, North Carolina, the USA

Test no. 513.