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Hanne Damgaard Poulsen and Verner Friis Kristensen (eds.)

Standard Values for Farm Manure

A Revaluation of the Danish Standard Values concerning the Nitrogen, Phosphorus and Potassium Content of Manure

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Ministry of Food, Agriculture and Fisheries
Danish Institute of Agricultural Sciences

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"Normtal for Husdyrgødning. En revuedering af danske normtal for husdyrgødningens indhold af kvælstof, fosfor og kalium".

Hanne Damgaard Poulsen and
Verner Friis Kristensen
Department of
Animal Nutrition and Physiology
Research Centre Foulum
P.O. Box 50
DK-8830 Tjele

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Department of Agricultural Engineering
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Units at other locations

Department of Variety Testing
Teglværksvej 10, Tystofte, DK-4239 Skælskør
Tel. +45 58 16 06 00. Fax +45 58 16 06 06

Askov Experimental Station
Vejenvej 55, DK-6600 Vejen
Tel. +45 75 36 02 77. Fax +45 75 36 62 77

Biotechnology Group (Dept. of. Plant biology)
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DK-1871 Frederiksberg C
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Borris Experimental Station
Vestergade 46, DK-6900 Skjern
Tel. +45 97 36 62 33. Fax +45 97 36 65 43

The Ecological Experimental Station Rugballegaard
P.O. Box 536, DK-8700 Horsens
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Foulumgaard, P.O. Box 50, DK-8830 Tjele
Tel. +45 89 99 19 00. Fax +45 89 99 19 19

Jyndevad Experimental Station
Flensborgvej 22, 6360 Tinglev
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Hestehave 20, DK-6400 Sønderborg
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Højmarken 12, DK-7700 Thisted
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Tylstrup Experimental Station
Forsøgsvej 30, DK-9382 Tylstrup
Tel. +45 98 26 13 99. Fax +45 98 26 02 11

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Preface

The latest revaluation of Danish farm manure standard values was published in 1994 (Danish Institute of Agricultural and Fisheries Economics, Report No. 82). Since then, new advances have been made, and also considerable changes in the composition and nutrient content of feed have taken place. As a result of that, it has been pointed out on the part of the users that the nitrogen values set out in Report No. 82 sometimes are too high. Furthermore, it has been stated that the nutrient excretion in manure varies a lot from farm to farm as a result of different feed efficiency, nutrient content of the feed, housing system, yield level etc.

Therefore, in June, 1996, the Danish Ministry of Food, Agriculture and Fisheries requested the Danish Institute of Animal Science to set up a committee for the revaluation of the general standard values for manure. The work of the committee should also comprise an analysis of the variation in the standard values for each category of animals on the basis of feed efficiency, content of feed, and for dairy cattle also on the basis of milk yield level.

In July 1996, the Danish Institute of Animal Science set up a committee with representatives from research and advisory departments and public authorities. The committee consisted of the following members:

Ole Olsen, *Danish Institute of Animal Science (chairman)*
José Fernández, *Danish Institute of Animal Science*
Boie Frederiksen, *Danish Institute of Agricultural and Fisheries Economics*
Ejvind Hansen, *Danish Environmental Protection Agency*
Ole Klejs Hansen, *National Department of Cattle Husbandry*
Berit Hasler, *National Environmental Research Institute*
Henrik B. Jensen, *Danish Poultry Council*
Anita Kjeldsen, *Danish Plant Directorate*
Niels J. Kjeldsen, *The National Committee for Pig Breeding, Health and Production*
Leif Knudsen, *National Department of Plant Production*
Verner Friis Kristensen, *Danish Institute of Animal Science*
Helge Kromann, *National Department of Farm Buildings and Machinery*
Arne Kyllingsbæk, *Danish Institute for Soil and Plant Sciences*
Børge Nielsen, *Statistics Denmark*
Hanne Damgaard Poulsen, *Danish Institute of Animal Science*
Niels Therkildsen, *Danish Fur Breeders Research Centre*
Per Tybirk, *The National Committee of Pig Breeding, Health and Production*

The working method of the committee
At its first meeting, the committee decided to set up 5 working groups that should each examine its particular sub-area. The following subjects were assigned to the working groups:
1. Pigs and horses (ex animal)
2. Cattle and sheep (ex animal)

3. Poultry (ex animal)
4. Fur bearing animals (ex animal)
5. Technology (ex building and ex storage)

The working groups were staffed with members of the committee, and some of the working groups were supplemented by representatives with special knowledge in the field of the subject in question.

Each working group prepared a paper consisting of a description of the main results (standard values and variation) and basic data. In that connection, a range of institutions, branches of the trade and organisations have assisted in compiling the data. In addition, the ex animal results formed the basis of the final calculations of the technology group.

The contributions prepared by the work groups are included in this report that has been prepared in the form of a main section with the main results (chapters 1 to 9) and a documentary section consisting of the basic data and references used (appendices, p. 78 to 162.

The main section contains ex animal calculations for the individual species of animals (Sections 1-6) followed by the calculations of ex building and ex storage (Section 7). The standard values stated for the individual species and categories of animals have been based on the average values of the produc-
tion in question. Where it is possible, the methods of calculating the ex animal values in situations where the production deviates from the standard are also stated. The individual sections also set out in detail deviations from Report No. 82, 1994 (Danish Institute of Agricultural and Fisheries Economics).

In Section 8, the standard values for the nutrient losses ex storage are stated in the form of a tables setting out the most important preconditions for the calculations. Corrections to be used in case of deviating preconditions are put in footnotes.

In Section 9, the total annual nutrient loss ex animal, ex building and ex storage has been calculated for the aggregate Danish livestock production based on the relevant categories of animals. In addition, the total amount of manure N, P and K discharged, is stated as a total and distributed on "types of manure".

Contents

Summary

The report describes the result of the work in the "Committee of the Revaluation of the General Standard Values for Manure". 5 working groups were set up, and this report contains the sub-reports of the individual working groups.

The sub-reports on ex animal (pigs, cattle, poultry, fur bearing animals, horses and sheep) and ex building and ex storage (technology) are based on information obtained from practice concerning the composition of feed, production data (average and variation) and type of production. Furthermore, the results of Danish and foreign research form the basis of the calculations carried out. Where it has not been possible to use documented values, estimates have been used. The documentation used is listed in the documentary section of this report.

Since production efficiency and method and the composition of feed usually vary dramatically in practice, two calculation models have been prepared for the above-mentioned species of livestock where possible. **Model 1** can be applied to herds when the actual consumption and the composition of the feed are unknown. This model gives "fixed" standard values for the N, P and K amounts ex animal. **Model 2** can be applied to herds where the actual consumption of feed and the composition of feed are known and based on documentation. This model is structured so as to offer "individual" calculations of N, P and K amounts ex animal on herd level.

Pigs Compared to Report No. 82, an adaptation of weight limits for piglets (from 25-30 kg) has occurred, and also the number of piglets per sow per year is now 22 against 21 in Report No. 82. This results in a shifting of nutrients from the slaughter pigs to the sow unit. In addition, an adaptation of the consumption of feed concerning the sow unit has occurred. In Report No. 82, the consumption of feed by the sow unit was based on theoretical calculations which appeared to be too low as compared to practice. Due to the changes mentioned, a small rise in the N and P levels ex animal in the sow unit has occurred, while a considerable fall in the N amount and a small fall in the P amount ex animal of the slaughter pigs have occurred.

Cattle Where standard values for cattle so far have been based solely on model calculations, an analysis of the consumption of feed and the utilisation of energy and nutrients in practical cattle farming has now formed the major part of the basis of determining the new values and their variation. The new values show an increased N excretion by dairy cows when house-fed, but a lower N excretion by dairy cows that are grazing. A considerable increase in the values concerning the P excretion by dairy cows and young bulls has occurred. New valuations have resulted in considerable reductions of the standard values for the amounts of urine concerning young cattle.

Poultry Concerning layer type hens, an increase in the number of categories of floor management systems from one to three has occurred. The lower efficiency of the floor management systems is reflected in higher ex animal values, but the ex building values of

nitrogen are usually slightly lower than those of the previous report. Concerning layer hens, battery cage management with manure systems is an exception, since a considerable increase in the ex storage values for nitrogen has occurred. Concerning pullets, the most important change is that the time of the transfer from the rearing house has been reduced to 119 days. Concerning broilers, a general improvement of the production efficiency has occurred and is reflected in a lower manure production. Therefore, the nitrogen excretion by an average chicken has been reduced by approx. 15%. A considerable change is also the grouping of broilers according to various slaughter ages.

Fur bearing animals A change in the method of calculating the N excretion has occurred, since the calculation in this report has been based on the N intake (feed) and deposition in body, pelt and hair. This causes a rise in the N amount ex animal of over 30% as compared to Report No. 82. Concerning P, there has been a fall of almost 20%.

Horses The ex animal amounts are stated for 3 weight classes, where Report No. 82 only employs one weight category (600 kg). Concerning this category, the excretion is unchanged.

Sheep The values concerning sheep are based on data provided by herd experiments and are more or less unchanged as compared to Report No. 82.

Technology In the various production systems, varying amounts of bedding materials and water in the form of drinking water waste and cleaning water are introduced into the manure. The information about that has been gathered by means of questionnaires and measurements made in practice. The values concerning loss during housing have been estimated by means of a range of Danish measurements and by studying international literature. The basis on which to establish loss in the housing systems is often fragile, and that applies particularly to poultry manure and deep litter housing systems. The losses in storage systems concerning slurry are based on recent Danish investigations, while the losses by manure and liquid manure primarily are based on older investigations.

Compared to Report No. 82, the losses in the housing systems are almost unchanged. Concerning battery hens, the loss from the buildings has been reduced, though, while the loss by fur bearing animals has increased considerably.

The loss in storage systems concerning liquid manure and slurry as compared to Report No. 82 are almost unchanged. The determined N loss by storing of solid manure from pigs has increased, though, from 15 to 30% of the total nitrogen content. This change is based on Swedish investigations and a new Danish investigation.

The manure levels have also been calculated. The greatest change has occurred concerning slaughter pigs, where a considerable reduction has taken place in the slurry amount per unit. The change has been partly based on a lower urine level due to a lower protein level and a reduction in the introduction of cleaning water and drinking water waste.

National values Total N excretion ex animal makes out 270 million kg. Of this approx. 30 million kg is excreted during grazing and 240 million kg when housed. Compared to Report No. 82, a reduction has occurred in the excretion ex animal of about 30 million kg N. The amount excreted during grazing has been reduced by approx. 15 million kg N which is due to a change in the method of calculation. Ex storage has been calculated to an N amount of about 200 million kg N or approx. 15 million kg N below the values of Report No. 82.

The amounts of phosphorus and potassium have been increased from 44 to 49 and from 151 to 156 million kg, respectively, ex animal as compared to Report No. 82. The amount of potassium excreted during grazing has been reduced from 41 to 30 million kg potassium.

1 Pigs, ex Animal

The members of the working group

Hanne Damgaard Poulsen, *Senior Scientist, Danish Institute of Animal Science*

José A. Fernández, *Senior Scientist, Danish Institute of Animal Science*

Niels J. Kjeldsen, *Head of Department, The National Committee for Pig Breeding, Health and Production*

Per Tybirk, *Senior Advisor, The National Committee for Pig Breeding, Health and Production (Chairman)*

Summary of the working group's work

The work has been divided in the following way:

Data basis

A. Average values have been established for the feed consumption of sows, piglets and slaughter pigs on the basis of the national averages of the herds that are under the Efficiency Control (E-kontrol). The values are attached to the weight intervals of the "nation average herd". In addition, by combining the results of the Efficiency Control and experiments at the Danish Institute of Animal Science, the "gain per sow per year" exclusive of weaners has been calculated. Detailed report in *Pigs, Appendix 1.*

B. The average N and P content of the feed that is used in the feeding season 1996/97 has been established. Information has been obtained from the animal feed industry about the sale of feed by contract. The data of the animal feed industry have furthermore been compared with actual control analyses carried out by the Plant Directorate and show a very close correspondence between the information provided by the animal feed industry concerning warranties and the warranties for N and P that the Plant Directorate finds by means of its random samples. Detailed report in Pigs, Appendix 2.

C. Values have been established for N, P and K contained in pigs per kg live weight at different weight/age. Concerning sows and sucking pigs, the material consists primarily of foreign research reports, while the data concerning slaughter pigs are based on several Danish experiments carried out at the Danish Institute of Animal Science. Detailed report concerning sows and piglets in Pigs, Appendix 3, and detailed report concerning slaughter pigs in Pigs, Appendix 4.

D. Draft concerning the division of the N and P production into faeces and urine and the volume of faeces and urine in experiments with slaughter pigs. In practice, it is doubtful, though, whether the production of faeces and urine can be used so as to predict the manure volume, since there has not been free access to water during the experiments, and also the water waste has been minimal. The data of the experiments carried out at the Danish Institute of Animal Science have been included in *Pigs, Appendix 4.*

Calculation principles
The working group's proposal has been divided into two models.

Model 1
Standard values for herds with *no* documentation of the consumption of feed and the N and P content of the feed. Fixed standard values are used for the contribution by sows until weaning regardless of the number of weaners per sow per year, while the contributions by piglets and the slaughter pigs are calculated on the basis of the actual gain.

The new aspect is the division of the sow production into two parts, i.e., a fixed contribution per sow per year until weaning and a variable contribution by the piglets, thereby having regard to the number of pigs produced per sow per year and the weight at the time of leaving.

The reason for this division is both that a new type of production has been developed, i.e., the pigs are sold at the time of weaning, and also that there is great variation in the contribution by the piglets depending on the number of pigs produced and the weight interval (weight at the time of leaving).

Concerning the slaughter pigs, it will still be possible to correct on the basis of weight interval, while a correction on the basis of the actual feed consumption and the content of the feed requires complete documentation, cf. Model 2.

Model 2
Concerning Model 2, an individual calculation of N and P ex animal must be prepared with a simple equation for herds that can provide documentation of the amount of feed used and the content of the feed. There are used fixed values for the N and P contained in pigs per kg live weight and for gain of sows per sow per year. The calculation may be made on the basis of the documentation of the feed consumption and the content of the feed on the basis of the documentation provided by the animal feed company.

Important changes as compared to Report No. 82
The new, recommended standard values were introduced of the following reasons:

1. When calculating the national standard average, it is now preconditioned that the piglets leave the sow unit at a weight of 30 kg against 25 kg previously. Thereby feed and thus N and P are transferred from the slaughter pigs to the sow unit.

2. The values concerning feed consumption are based on the Efficiency Control average on a national scale meaning that the new standard values are based on a considerably higher consumption of feed by sows and piglets than that of the previous standards that were based on a theoretical calculation.

3. The actual values concerning the N and P content of the feed show that the slaughter pig feed contains considerably less N and slightly less P than estimated by the old standard

values. The reason being new experiments that, e.g., have documented the positive effect of reducing the protein level and adding amino acids.

Key figures to be used in equations and for the calculation of standard values

Data concerning the Efficiency Control average on a national scale
Based on the national average of the herds under the Efficiency Control, the below can be recommended for normal production:

Weaned and produced: 22 pigs per sow per year

Weight at weaning: 7.5 kg

Weight at transfer from piglet to slaughter pigs: 30 kg

Weight at slaughter: 75 kg (= 98.3 kg live weight)

FU_p feed per sow per year incl. replacement gilts + boars: 1,300 FU_p

FU_p/kg gain for piglets (7.5-30 kg):
2.0 FU_p/kg gain

FU_p/kg gain for slaughter pigs (30-98.3 kg):
2.94 FU_p/kg gain

Gain by sows, replacement gilts, and boars per sow per year: 60 kg

Data concerning the content of the feed provided by the animal feed industry and the Plant Directorate
Based on the data concerning the feed that has been sold by contract during 1996/97, the feed for the various categories contains as follows (Table 1.1):

Table 1.1 N and P in feed for pigs

Feed for	sows	piglets	slaughter pigs
g N/FU_p	24	28	26
g P/FU_p *	6.3	7.0	5.3

The recommended feeding standards concerning P for sows and piglets are lowered in May 1997.

Data concerning N and P in pigs
Based on investigations conducted at the Danish Institute of Animal Science and foreign literature (sows and piglets), the following estimates apply for the N and P content of the body and for the composition of the gain for the various categories. It should be noted that the N

and P content of the intestinal content of the pigs has been included in the calculation, since this follows the pig when it leaves the farm.

Table 1.2 The N and P content of the pig body per kg gain

Category	Sow	Piglet (7.5 kg)		Piglet (30 kg)		Slaughter pig (100 kg)
N per kg live weight	25 g	24 g		26 g		27 g
N per kg gain	25 g		26 g		28 g	
P per kg live weight	5.0 g	5.0 g		5.4 g		5.5 g
P per kg gain	5.0 g		5.5 g		5.5 g	

Model 1. Standard values for N and P ex animal without knowing the actual feed content and actual consumption of feed

N ex animal per sow per year on the basis of 22 pigs of 7.5 kg:

1,300 FU_p x 24 g N/FU_p - 60 kg gain x 25 g N/kg - 22 heads x 7.5 kg x 24 g N/kg = 25.7 kg N

P ex animal per sow per year at 22 pigs of 7.5 kg:

1,300 FU_p x 6.3 g P/FU_p - 60 kg gain x 5.0 g P/kg - 22 heads x 7.5 kg x 5.0 g P/kg = 7.1 kg P

By dividing into housing conditions, it is estimated that approx. 1/3 will come from the farrowing house, while the remaining 2/3 will come from the mating house + gestation house + replacement gilts.

N ex animal per kg gain, piglets 7.5-30 kg:

2.0 FU_p/kg gain x 28 g N/FU_p - 26 g N/kg gain = 30 g N/kg gain

P ex animal per kg gain, piglets 7.5-30 kg:

2.0 FU_p/kg gain x 7.0 g P/FU_p - 5.5 g P/kg gain = 8.5 g P/kg gain

N ex animal per kg gain, slaughter pigs 30-98 kg:

2.94 FU_p/kg gain x 26 g N/FU_p - 28 g N/kg gain = 48 g N/kg gain

P ex animal per kg gain, slaughter pigs 30-98 kg:

2.94 FU_p/kg gain x 5.3 g P/FU_p - 5.5 g P/kg gain = 10.1 g P/kg gain

Other weight intervals

For the calculation of other weight intervals, simple equations can be used. The equations are constructed as linear corrections so that the calculation "meets" the above-mentioned key figures for N and P per kg gain if the weight interval is like that of the national average value. The application of the equations will mean that the result of a calculation divided into several weight intervals will agree with a calculation by which a value for the aggregate weight interval (7.5-98 kg live weight) is calculated.

The following equations are recommended:

g N ex animal per kg gain =

22.4 + 0.4 x average weight

g P ex animal per kg gain =
7.8 + 0.036 x average weight,

where average weight = (leaving live weight + starting weight)/2 and leaving live weight = slaughter weight x 1.31

For a given weight interval, the loss can be calculated as:
g N ex animal (weight interval) =
(leaving live weight, kg - starting weight, kg) (22.4 + 0.4 x average weight)
g P ex animal (weight interval) =
(leaving live weight, kg - starting weight, kg) (7.8 + 0.036 x average weight)

The equations apply up to 120 kg *only.*

Absolute values
Based on these calculations, the N and P loss ex animal has been calculated for a wide range of possible weight intervals for piglets and slaughter pigs. The values are shown in Table 1.3. In practice, the N and P loss ex animal per pig produced can in the given weight interval be read directly. - It will be possible to convert the values into ex storage values by allowing for the loss percentage in the housing system and the loss percentage in storage systems (on the basis of the actual housing and manure systems). In practice, the calculation is then: Manure value ex storage = table value ex animal x number of pigs produced x (100 - loss percentage in housing system) x (100 - loss percentage in storage system).

Relative values
Values for N and P ex animal can also be calculated on the basis of relative values. The principle is then that the loss of N and P ex animal is related to the weight interval that has been the initial basis, 7.5 - 30 kg and 30 - 98 kg for piglets and slaughter pigs, respectively. The relative values are shown in the Tables 1.4 and 1.5.

The principle is then that standard values are established for ex storage for the weight intervals of 7.5-30 kg and 30-98 kg, respectively, for the actual housing and manure systems. These values are adapted to the actual weight intervals for pigs by means of the following equations:

Piglets (actual weight interval) = relative table value x standard values ex storage for piglets (at actual housing and manure systems)

Slaughter pigs (actual weight interval) = relative table value x standard values ex storage for slaughter pigs (at actual storage and manure systems).

Where relative values are used, it should be taken into consideration to apply the relative values equally for N and P. This is actualised by the expectation that the phosphorus content of the feed for sows and piglets will be lowered in the summer of 1997. The curve movements for N and P in respect of weight are expected to thereby be almost equal. Therefore, the relative values for N may most probably also be used for P.

1.5. Model 2. Standard values for N and P ex animal when knowing the actual content of the feed and the actual consumption of feed

It is recommended that it will be possible to make a direct calculation of N and P ex animal thereby applying the actual consumption of feed and the N and P content of the feed used.

Contribution by sows per sow per year including weaners:
N ex animal per sow per year, kg = N in sow feed - N in the gain of the sow (constant) - N in weaners = (kg sow feed per sow per year x kg N per kg feed) - 1.44 - (number of weaners per sow per year x weaning weight x 0.024 kg N per kg pig) = (FU_p sow feed per sow per year x g crude protein per FU_p/6250) - 1.44 -(number of weaners per sow per year x weaning weight x 0.024 kg N per kg pig).

Contribution by piglets:
N ex animal per piglet produced, kg = N in piglet feed - (gain per pig x N deposited per kg gain) = (kg piglet feed per pig produced x kg N per kg feed) –((leaving weight – weaning weight) x 0.026 kg N per kg gain) = FU_p piglet feed per pig produced x g crude protein per FU_p/6250) - ((leaving weight - weaning weight) x 0.026 kg N per kg gain).

Contribution by slaughter pigs:
N ex animal per slaughter pig produced, kg = N in feed - gain per pig x deposited N per kg gain = (kg feed per pig produced x kg N per kg feed) - ((slaughter weight x 1.31 - starting weight) x 0.028 kg N per kg gain) = (FU_p per pig produced x g crude protein per FU_p/6250 - ((slaughter weight x 1.31 - starting weight) x 0.028 kg N per kg gain).

Equations concerning P contribution
Contribution by sows including weaners:
P ex animal per sow per year = P in sow feed - P in the weight gain of the sow (constant) - P in weaners = (kg sow feed per sow per year x kg P per kg feed) - 0.3 kg P - (number of weaners per sow per year x weaning weight x 0.005 kg P per kg pig), where kg sow feed per sow per year x kg P per kg feed = FU_p sow feed per sow per year x g P per FU_p/1000.

Contribution by piglets:
P ex animal per piglet produced: P in piglet feed - (gain per pig x deposited P per kg gain) = (kg piglet feed per pig produced x kg P per kg feed) - ((leaving weight - weaning weight) x 0.0055 kg P per kg gain), where kg piglet feed per pig produced x kg P per kg feed = FU_p piglet feed per pig produced x g P per FU_p/1000.

Table 1.3. Absolute values for N and P ex animal, kg, for slaughter pigs (with varying starting and leaving weights)

Leaving weight, live, kg		15	20	25	30	35	40	45	50	60	91.7	98.3	104.8	111.4	117.9
Leaving slaughter weight, kg											70	75	80	85	90
Starting weight, kg															
7.5	N	0.20	0.35	0.51	0.67	0.85	1.04	1.23	1.44	1.88	3.56	3.96	4.36	4.79	5.24
	P	0.06	0.10	0.15	0.19	0.24	0.28	0.33	0.38	0.47	0.81	0.88	0.96	1.03	1.11
15	N		0.15	0.30	0.47	0.65	0.84	1.03	1.24	1.68	3.35	3.75	4.16	4.59	5.04
	P		0.04	0.09	0.13	0.17	0.22	0.27	0.31	0.41	0.75	0.82	0.89	0.97	1.05
20	N			0.16	0.32	0.50	0.69	0.89	1.09	1.54	3.21	3.61	4.02	4.45	4.89
	P			0.04	0.09	0.13	0.18	0.22	0.27	0.37	0.70	0.78	0.85	0.93	1.01
25	N				0.17	0.34	0.53	0.73	0.94	1.38	3.05	3.45	3.86	4.29	4.74
	P				0.04	0.09	0.13	0.18	0.23	0.33	0.66	0.73	0.81	0.89	0.96
30	N					0.18	0.36	0.56	0.77	1.21	2.88	3.28	3.69	4.12	4.57
	P					0.04	0.09	0.14	0.18	0.28	0.62	0.69	0.76	0.84	0.92
35	N						0.19	0.38	0.59	1.04	2.71	3.11	3.52	3.95	4.39
	P						0.05	0.09	0.14	0.24	0.57	0.65	0.72	0.80	0.87
40	N							0.20	0.40	0.85	2.52	2.92	3.33	3.76	4.21
	P							0.05	0.09	0.19	0.53	0.60	0.67	0.75	0.83
45	N								0.21	0.65	2.32	2.72	3.13	3.56	4.01
	P								0.05	0.15	0.48	0.55	0.63	0.70	0.78
50	N									0.44	2.12	2.51	2.92	3.35	3.80
	P									0.10	0.43	0.51	0.58	0.66	0.73
55	N									0.23	1.90	2.30	2.71	3.14	3.58
	P									0.05	0.38	0.46	0.53	0.61	0.69
60	N										1.67	2.07	2.48	2.91	3.36
	P										0.33	0.41	0.48	0.56	0.64

Deviating weight intervals have been calculated as follows:

g N ex animal = (leaving live weight - starting weight) x (22.4 + 0.4 x average weight)/1000

g P ex animal = (leaving live weight - starting weight) x (7.8 + 0.036 x average weight)/1000

Average weight = (leaving live weight + starting weight)/2

Table 1.4 Relative values for N and P ex animal for piglets

Leaving weight, kg		15	20	25	30	35	40	45	50
Starting weight, kg									
7.5	N	0.30	0.52	0.75	**1.00**	1.26	1.54	1.83	2.14
	P	0.32	0.54	0.77	**1.00**	1.23	1.47	1.72	1.97
15	N			0.45	0.70	0.96	1.24	1.53	1.84
	P			0.45	0.68	0.91	1.15	1.39	1.64
20	N				0.48	0.74	1.02	1.32	1.62
	P				0.46	0.69	0.93	1.17	1.42
25	N					0.51	0.79	1.08	1.39
	P					0.46	0.70	0.95	1.20
30	N						0.54	0.83	1.14
	P						0.47	0.72	0.97

Deviating weight intervals can be calculated by means of the following equations:

$N_{relative}$ = (leaving live weight - starting weight) x (22.4 + 0.4 x average weight)/673

$P_{relative}$ = (leaving live weight - starting weight) x (7.8 + 0.036 x average weight)/191, where average weight = (leaving live weight - starting weight)/2

Table 1.5 Relative values for N and P ex animal for slaughter pigs

Live weight, kg		40	45	50	60	91.7	98.3	104.8	11.4	117.9
Slaughter weight, kg						70	75	80	85	90
Starting weight, kg										
7.5	N	0.32	0.38	0.44	0.57	1.08	1.21	1.33	1.46	1.60
	P	0.41	0.48	0.54	0.69	1.17	1.28	1.38	1.50	1.61
20	N	0.21	0.27	0.33	0.47	0.98	1.10	1.22	1.36	1.49
	P	0.26	0.33	0.39	0.54	1.02	1.13	1.23	1.35	1.46
25	N	0.16	0.22	0.29	0.42	0.93	1.05	1.18	1.31	1.44
	P	0.20	0.26	0.33	0.47	0.96	1.06	1.17	1.28	1.40
30	N	0.11	1.17	0.23	0.37	0.88	**1.00**	1.13	1.26	1.39
	P	0.13	0.20	0.27	0.41	0.89	**1.00**	1.11	1.22	1.33
35	N	0.06	0.12	0.18	0.32	0.83	0.95	1.07	1.20	1.34
	P	0.07	0.13	0.20	0.34	0.83	0.95	1.04	1.16	1.27
40	N	0.00	0.06	0.12	0.26	0.77	0.89	1.01	1.15	1.28
	P	0.00	0.07	0.14	0.28	0.76	0.87	0.98	1.09	1.20
45	N				0.20	0.71	0.83	0.95	1.09	1.22
	P				0.21	0.69	0.80	0.91	1.02	1.13
50	N				0.14	0.65	0.77	0.89	1.01	1.16
	P				0.14	0.63	0.73	0.84	0.95	1.06
55	N					0.58	0.70	0.83	0.96	1.09
	P					0.56	0.66	0.77	0.88	0.99
60	N					0.51	0.63	0.76	0.89	1.02
	P					0.48	0.59	0.70	0.81	0.92

Deviating weight intervals can be calculated by means of the following equations:

$N_{relative}$ = (leaving live weight - starting weight) x (22.4 + 0.4 x average weight)/3280

$P_{relative}$ = (leaving live weight - starting weight) x (7.8 + 0.036 x average weight)/690, where average weight = (leaving live weight - starting weight)/2

Contribution by slaughter pigs:

P ex animal per slaughter pig produced = P in feed - gain per pig x deposited P per kg gain = (kg feed per pig produced x P, kg per kg feed) - ((slaughter weight x 1.31 - starting weight) x 0.0055 kg P per kg gain), where kg feed per pig produced x P kg per kg feed = FU_p per pig produced x g P per FU_p/1000.

Comparison between new and old standard values

In Report No. 82, the main tables and correction tables are related to ex storage values - and these corrections have hence been converted into ex animal on the basis of the difference between ex animal and ex storage for slurry in Table 9b of Report No. 82. In order to make a correction from 21 pigs of 25 kg to 22 pigs of 30 kg, the Appendices 26 and 27 of Report No. 82 have been applied, and also Appendix 27 has formed the basis for the correction for the slaughter pig weight interval.

Table 1.6 Comparison between the new manure standard values ex animal and those of Report No. 82

	N, kg		P, kg	
	1997	Report No. 82	1997	Report No. 82
Per sow per year (until weaning)	25.7		7.1	
Per produced piglet of 30 kg	0.675		0.191	
1 sow per year + 21 pigs of 25 kg	36.7	33.1	10.2	9.5
1 sow per year + 22 pigs of 30 kg	40.5	39.2	11.3	10.9
1 slaughter pig 25-95 kg	3.25	4.60	0.70	0.77
1 slaughter pig 30-98 kg	3.28	4.55	0.69	0.75

2 Cattle, ex animal

The members of the working group

Ole Klejs Hansen, *Senior Advisor, The National Department of Cattle Husbandry*
Ole Aaes, *Consultant, The National Department of Cattle Husbandry*
Troels Kristensen, *Scientist, Danish Institute of Animal Science*
Verner Friis Kristensen, *Senior Scientist, Danish Institute of Animal Science (chairman)*

Summary of the working group's work

All documentation and description that form the background of the standard values are included in *Cattle, Appendix 1*.

The listed standard tables are based on the results of a combination of the model calculations and the analyses of the data provided by practice. Extensive model calculations have been made, primarily, for the estimation of the faeces and urine excretion and the nutrient content of these waste products and for the determination of the variations thereof. At the same time, a statistical analysis of a considerable data material provided by practical cattle farms has been carried out. The model calculations and analyses have been used for supplementing each other and for a mutual testing and verification in respect of establishing values and their variations.

The model calculations are balance calculations that are based on knowledge about the digestion and conversion of feed and nutrients, the deposition of nutrients and the nutrient excretion in milk. As input for these calculations, data concerning the feeding in practice are used. The data are provided by statistical results published by The National Department of Cattle Husbandry concerning the feeding and the composition of feed rations according to updated feeding plans in the electronic feed planning systems. Where no information about the feeding are available, standard feeding plans from instructions material have sometimes been used. This applies primarily to heifers and suckler cows. The cow testing associations' recording of the dairy cattle yield forms the basis of the determination of the yield and the N excretion in milk. The results of investigations carried out by The National Department of Cattle Husbandry on pilot farms and experimental farms have been used for the description of certain connections concerning the feed and nutrient intake by cattle.

The analysis of the practice data are based on data provided by the Periodic Feed Control, which in practice is used so as to analyse and check the feeding management and feed utilisation. By the Periodic Feed Control, the feed consumption is recorded on the basis of One-day Feed Controls and stock-taking of feed in stock. In addition, the feed composition, the production and stock-taking changes in the herd are recorded. The data of the Periodic Feed Control are currently stored in data bases for the immediately preceding period of two years.

In some cases, the effects of the variations in certain parameters are described by means of an existing model, SAMSPIL, which is based on the connections described in Report No. 551 by the Danish Institute of Animal Science and developed for the purpose of describing the

nutrient flow and utilisation on cattle farms. These calculations are also used for the verification of variations recorded in practice.
In the vast majority of cases, the work shows a close correspondence between the results of the model calculations and the analyses of the data on practice. Deviations were detected on the following points: Concerning diary cows, the analysis of the Periodic Feed Control data showed a somewhat lower feed efficiency than estimated by the model calculations. This applied especially to heavy breeds, while the difference was smaller concerning Jersey. A lower feed efficiency results in a higher calculated nutrient excretion in manure. On the other hand, the Periodic Feed Control analysis showed that the amount of fresh grass and the protein content of the supplementary feed added to the grass for dairy cows during the summer season is somewhat lower than estimated in connection with previous model calculations. In addition, the Periodic Feed Control analysis revealed that in practice, the dairy cows are assigned considerably more phosphorus than estimated by previous model calculations.

Concerning young cattle, the Periodic Feed Control analysis showed that the protein level of the feed for replacement heifers and the protein and phosphorus amounts of the feed for young bulls were higher than estimated in previous model calculations.

The previous standard values for manure were based on model calculations only, since no analyses of the nutrient balance based on data from practice have been made before. When establishing the new standard values, regard has been taken to the values that have been found by means of the analysis of the Periodic Feed Control data. The differences between the previous and the new standard values for dairy cows are shown in Table 2.1.

Table 2.1 Comparison between the old (Laursen, 1994) and the new average values for dairy cows, total excretion per cow per year, heavy breed

	Manure, t	Dry matter, %	Kg N	Kg P	Kg K
Old values, animals permanently housed	17.22	11.8	121.4	16.3	93.7
Old values, animals grazing during summer	18.13	11.2	135.6	16.4	111.4
New values	17.7	11.9	128	23	100

The new values show the same average nutrient excretion whether or not the cows are grazing during the summer season, while the previous values show great difference between animals grazing and animals permanently housed. Concerning the nitrogen, the new value is higher for house-fed animals, but lower for cows that are grazing during the summer.

In general, the N excretion has increased by approx. 4 kg per cow per year due to an increased milk production since establishing the standard values previously in force. This change has been offset by a reduction of the protein content of the feed resulting in a reduction of the N excretion by 5-6 kg N per cow per year. The increase in the N excretion by house-fed animals that is reflected in the new average values as compared to the old values is primarily caused by the lower feed efficiency that was detected by the analysis of the Periodic Feed Control data. Concerning the phosphorus, the excretion is also assessed considerably higher as a consequence of the high phosphorus assignment in practice that was detected. It is expected that the phosphorus levels will be reduced considerably in the near future as a consequence of the corrections to the feed planning system and the advise.

A revaluation of the urine amounts by young animals that is based on information from the literature has resulted in a considerable reduction in the estimated production of urine. Concerning the breeding stock, it has resulted in a reduction in the urine amount by approx. 50%, and concerning young bulls a reduction by approx. 25% as compared to the previous standard values. In addition, a certain increase in N excretion by young cattle has taken place and in the phosphorus excretion by young bulls in accordance with the higher level for these nutrients that was detected by the analysis of the Periodic Feed Control data. In the new values, the N excretion by young bulls is slightly lower than previously, since the feed standards of the previous material had been estimated on a too high level.

It has not been considered necessary to make any revaluation of the standard values for suckler cows.

Analyses have been made of the variation in N excretion in manure by dairy cattle and of the most important reasons for this variation. Also in this analysis, both model calculations and analyses of data provided by the Periodic Feed Control on practical cattle farms have been used. There were a close correspondence between the model calculations and the variations recorded in practice. The variations and the most import reasons for the variations are described in the section on the new standard values.

Concerning breeding stock and suckler cows, data were not available for analyses of the variation.

Key figures
The following key figures have been used when calculating the nutrients deposited in products and animals.

Size of yield, gain and embryo production
Cows, heavy breed: 40 kg gain, 0.6 embryo of 40 kg per cow per year.

Cows, Jersey: 25 kg gain, 0.6 embryo of 25 kg per cow per year.

Yield, heavy breeds: 7,450 kg milk, 251 kg milk protein per cow her year.

Yield, Jersey: 5,230 kg milk, 213 kg milk protein per cow per year.

Breeding stock, heavy breeds: 600 g gain per day, 0.4 embryo of 40 kg per head of breeding stock per year.

Young bulls, heavy breeds, 0-6 months: 1000 g gain per day.

Young bulls, heavy breeds, 1-2 years: 1100 g gain per day.

Table 2.2 Nutrient content of milk and gain

	N	P	K
Milk	Milk protein/6.38	Heavy breeds: 0.96 g/kg milk Jersey: 1.08 g/kg milk	1.6 g/kg energy corrected milk
Gain, cows	25.6 g/kg	8 g/kg	1.8 g/kg
Gain, young cattle	21.2-285 g/kg	6.4-7.3 g/kg	1.8-2.3 g/kg
Embryo	29.6 g/kg	8 g/kg	2.1 g/kg

The nutrient absorption and - excretion by young cattle of Jersey breed has been assessed at 75% of that of the heavy breeds.
Bullocks, heavy breeds: 600 g gain per day.

The amounts of faeces excreted have been calculated as follows:

Amount of faeces, kg = kg feed dry matter x (1 - digestibility coefficient/100)/(% dry matter in manure/100)
where the digestibility coefficient = the digestibility coefficient of feed dry matter.

Where during the various periods of the year, different digestibility coefficient of feed dry matter may be used and different dry matter content of the manure, the manure level for each period is calculated individually and summed up over the year.

Urine level
Dairy cows: Level of faeces/2.2

Young cattle and suckle cattle: 0 - 6 months: Amount of faeces/1.5

Young cattle and suckle cattle: >6 months housed: Amount of faeces/2

Young cattle and suckle cattle: >6 months grazing: Amount of faeces/1.5

Factors for the calculation of the manure amounts and rounded-off values for the urine excretion and dry matter content of urine can be seen in Table 2.3.

Table 2.3 Factors for the calculation of the manure amounts ex animal and the determination of the amounts of the dry matter (DM) content of urine

Category of animals	kg feed, DM per animal per year	Digest. coef. feed, d. m.	DM, % in faeces	kg urine per day	DM, % in urine
Bull calves under 6 months, heavy breed	1240	79	17	3	4
ditto, Jersey	930	79	17	2	4
Young bulls, 6 months-1 year, heavy breed	2300	75	17	5	5
ditto, Jersey	1725	75	17	3	5
Young bulls, 1-2 years, heavy breed	2700	75	17	5	5
ditto, Jersey	2025	75	17	4	5
Cowcalves and steers under 6 months, heavy breed	950	78	17	3	4
ditto, Jersey	675	78	17	2	4
Heifers and bullocks, 6 mths-1 year, hvy breed, winter season*	1000	70	20	4	5
ditto, Jersey	750	70	20	3	5
Heifers and bullocks, 6 mths-1 year, hvy breed, grazing season*	650	78	16	4	5
ditto, Jersey	475	78	16	3	5
Heifers and bullocks, 1-2 years, heavy breed, winter season*	1400	71	20	5	5
ditto, Jersey	1050	71	20	4	5
Heifers and bullocks, 1-2 years, heavy breed, grazing season*	900	78	16	5	5
ditto, Jersey	675	78	16	4	5
Heifers, pregnant, above 2 years, heavy breed, winter season*	1600	73	20	6	5
ditto, Jersey	1200	73	20	4	5
Heifers, pregnant, above 2 years, heavy breed, grazing season*	1200	78	16	7	5
ditto, Jersey	900	78	16	5	5
Non-preg. heifers+bullocks above 2 yrs, hvy br., winter season*	1800	73	20	6	5
ditto, Jersey	1350	73	20	5	5
Non-preg. heifers+bullocks ab. 2 yrs, hvy br., grazing season*	1100	78	16	6	5
ditto, Jersey	825	78	16	5	5
Dairy cows, heavy breed	6500	71	15	16	5
ditto, Jersey	5350	71	15	13	5
Suckler cows, winter season*	1700	67	20	8	5
Suckler cows, grazing season*	1530	77	16	8	5

* For animals that are grazing during the summer, the amount of feed per animal per year and the related data have been divided into that which belongs to the winter season (200 days) and that which belongs to the grazing season (165 days).

Standard values

Dairy cows

Cows that are grazing excrete a proportion of the manure in the field. No exact figure can be stated for how much of the manure that is excreted in the field, since the grazing season may vary a lot. It is estimated that the manure excretion in the field is proportional to the period of time the cow stays in the field.

Variation in the nutrient excretion by dairy cows

Variations in N excretion by heavy breeds have been measured in the range of 105-110 kg and 150-155 kg per cow per year. The most important reasons for the variations are the protein content of the feed, the feed efficiency and the yield level. A difference in the yield level of ±1000 kg energy-corrected milk results in a difference of ±9 kg N excreted. This difference does not result in major changes in the division between faeces and urine. Despite the fact that an increased yield level results in a higher N excretion per cow per year, it means a lower N excretion per kg milk produced.

A variation in the protein content of the ration that occurs independently of production and requirements means that the total difference in the N intake is also reflected in the excretion of manure. A deviation in the digestible crude protein content of the feed per FU of 1 g expressed as the average per cow per year results in a change in total N excretion of 1.1 kg per cow per year. Over the recent years, the average digestible crude protein content of the feed has been 131 g per FU. Feeding with large amounts of fresh grass may be one of the cases where the protein content of the feed is high and the N excretion great. The analyses carried out showed that if grass makes out up to 10 FU per cow per day for 150 days, the N excretion is increased by up to 10 kg N per cow per year. On a level of 4 FU of grass, the N excretion was on the same level as that of house-fed animals.

Variations in the feed efficiency, other things being equal, vary in reverse ratio with the changes in the N excretion of manure. These differences may most probably include variations in feed wastage which means that varying quantities of feed protein are directly transferred to the manure. An improvement of the feed efficiency of one pct. point causes a fall in the N excretion of about 1.5 kg N per cow per year.

No analyses have been made of the variation in the P and K excretions. The amount of P varies like that of N in proportion to the level of feed intake, yield and feed efficiency. A major reduction of the P excretion is expected to occur in the near future, since the P intake so far has been considerably in excess of the standard, and a correction to the P levels through feed planning has been implemented. The K excretion varies first and foremost in proportion to the amount of roughage, since roughages have a high K content. No separate supplement of K is assigned.

Table 2.4 Manure and nutrient excretion ex animal by dairy cows. Unit: 1 cow per year

	Heavy breed					Jersey				
	Manure, t	% DM	N	P	K	Manure, t	% DM	N	P	K
Faeces	12.2	15.0	58	22.3	20	10.3	15.0	46	18.6	16
Urine	5.5	5.0	70	0.7	80	4.7	5.0	61	0.4	59
Totally	17.7	11.9	128	23.0	100	15.0	11.9	107	19.0	75

The N content of the feed and thereby the N excretion varies to a wide extent regardless of the production level and feed efficiency, i.e. there may, e.g., be great variation in the N excretion among herds with the same yield level. Any establishing of the N excretion on herd level should therefore be based directly on some kind of N accounts concerning the herd or the farm. Individual herd accounts are prepared for the individual categories of animals (e.g. dairy cows, young cattle, young bulls) of the herd based on the equation below. The basis of such accounts may be feed analyses and feeding plans perhaps supplemented by the One-day Feed Controls or the Periodic Feed Controls. It would however be much simpler to operate with N balances on farm level. The same considerations apply to phosphorus.

kg N excreted per cow per year = Nfeed - (Nmilk + Ngain + Nembryo)

where

Nfeed= FU per cow per year x kg crude protein per FU/6.25
Nmilk = kg milk protein per cow per year/6.38
Ngain= kg gain per cow per year x 0.0256
Nembryo= kg calf x 0.0296.

Young cattle

In practice, little calves are often confined in deep litter housing systems during the first months of their life, and then they are transferred to another housing system. In order to make subsequent calculations of the manure and nutrient amount by one head of breeding stock easier, the average excretion by 1 head of breeding stock per year in the following three tables has been divided into the amount by little calves (0-6 months) and the amount by the remaining age group from 6 months until calving, respectively, when the animals are housed during the entire breeding period, and when animals above 6 months are grazing during the summer.

Table 2.5 Manure and nutrient excretion ex animal by young cattle permanently housed. Unit: 1 head of breeding stock per year

	Heavy breed					Jersey				
			Kg					Kg		
	Manure, t	Dry matter, %	N	P	K	Manure, t	Dry matter, %	N	P	K
Faeces	3.02	19.7	13.3	4.8	7	2.22	19.7	9.5	3.5	5
Urine	1.57	4.9	23.3	0.1	29	1.15	4.9	17.4	0.1	22
Totalling	4.59	14.6	36.6	4.9	36	3.37	14.6	26.9	3.6	27

Table 2.6 Manure and nutrient excretion ex animal by breeding stock when animals over 6 months are grazing 165 days during the summer. Unit: 1 head of breeding stock per year

	Heavy breed					Jersey				
			Kg					Kg		
	Manure, t	Dry matter, %	N	P	K	Manure, t	Dry matter, %	N	P	K
Housed										
Faeces	1.76	19.6	7.7	2.7	4	1.31	19.6	5.8	2.0	3
Urine	0.92	4.8	11.7	0.1	17	0.69	4.8	8.8	0.1	13
Totalling	2.68	14.3	19.4	2.8	21	2.00	14.3	14.6	2.1	16
Grazing										
Faeces	0.96	16.0	4.8	2.1	3	0.70	16.0	3.6	1.5	2
Urine	0.64	5.0	15.4	-	12	0.46	5.0	11.6	-	9
Totalling	1.60	11.6	20.2	2.1	15	1.16	11.6	15.2	1.5	11

If the animals are outside the housing system during part of the winter (above 165 days), the amounts excreted during the winter season are still calculated like as for housed animals (Table 2.8). Part of the amount of manure excreted proportional to the period of time the animal is in the outdoor pen during the winter season is added to the amounts excreted in the field. As with the breeding stock, the amounts per young bull produced in the following two tables are divided into the amounts belonging to the first six months of the life of the calves and the amounts belonging to the remaining period from 6 months until 382 days.

Table 2.7 Manure and nutrient excretion ex animal by breeding stock 0-6 months housed. Unit: Share of 1 head of breeding stock per year

	Heavy breed, 0.2148 head of breeding stock					Jersey, 0.2405 head of breeding stock				
	Tons		Kg			Tons		Kg		
	Manure, t	Dry matter, %	N	P	K	Manure, t	Dry matter, %	N	P	K
Faeces	0.26	17.0	1.4	0.2	1	0.22	17.0	1.2	0.2	1
Urine	0.17	4.0	4.4	-	2	0.15	4.0	3.7	-	2
Total	0.43	10.8	5.8	0.2	3	0.37	10.8	4.9	0.2	3

Table 2.8 Manure and nutrient excretion ex animal by breeding stock 6 months until calving, permanently housed. Unit: Share of 1 head of breeding stock per year

	Heavy breed, 0.7852 head of breeding stock per year					Jersey, 0.7595 head of breeding stock per year				
			Kg					Kg		
	Manure, t	Dry matter, %	N	P	K	Manure, t	Dry matter, %	N	P	K
Housed										
Faeces	2.76	20.0	11.9	4.6	6	2.00	20.0	8.3	3.3	4
Urine	1.40	5.0	18.9	0.1	27	1.00	5.0	13.7	0.1	20
Total	4.16	15.0	30.8	4.7	33	3.00	15.0	22.0	3.4	24

Table 2.9 Manure and nutrient excretion ex animal by breeding stock 6 months until calving, grazing during the summer. Unit: Share of 1 head of breeding stock per year

	Heavy breed, 0.7852 head of breeding stock year					Jersey, 0.7595 head of breeding stock per year				
	Manure,	Dry	Kg			Manure,	Dry	Kg		
	t	matter, %	N	P	K	t	matter, %	N	P	K
Housed										
Faeces	1.50	20.0	6.3	2.5	3	1.09	20.0	4.6	1.8	2
Urine	0.75	5.0	7.3	0.1	15	0.54	5.0	5.1	0.1	11
Total	2.25	15.0	13.6	2.6	18	1.63	15.0	9.7	1.9	13
Grazing										
Faeces	0.96	16.0	4.8	2.1	3	0.70	16.0	3.6	1.5	2
Urine	0.64	5.0	15.4	-	12	0.46	5.0	11.6	-	9
Total	1.60	11.6	20.2	2.1	15	1.16	11.6	15.2	1.5	11

Table 2.10 Manure and nutrient excretion ex animal by young, bulls when housed. Unit: 1 head of young bull produced with a final age of 382 days

	Heavy breed, final weight 440 kg					Jersey, final weight 328 kg				
	Manure,	Dry	Kg			Manure,	Dry	Kg		
	t	matter, %	N	P	K	t	matter, %	N	P	K
Faeces	2.64	17.0	12.5	7.1	5	1.98	17.0	9.4	5.3	4
Urine	1.32	4.7	23.4	0.2	15	0.99	4.7	17.6	0.2	11
Total	3.96	12.9	35.9	7.3	20	2.97	12.9	27.0	5.5	15

Table 2.11 Manure and nutrient excretion ex animal by young, housed bulls 0-6 months. Unit: 1 bull calf of 6 months produced

	Heavy breed, final weight 220 kg					Jersey, final weight 145 kg				
	Manure,	Dry		Kg		Manure,	Dry		Kg	
	t	matter, %	N	P	K	t	matter, %	N	P	K
Faeces	0.76	17.0	4.2	2.0	2	0.57	17.0	3.2	1.5	1
Urine	0.38	4.0	7.4	0.1	6	0.29	4.0	5.6	0.1	5
Total	1.14	12.7	11.6	2.1	8	0.86	12.7	8.8	1.6	6

Table 2.12 Manure and nutrient excretion ex animal by young, housed bulls 6 months - 382 days. Unit: 1 young bull produced

	Heavy breed, final weight 440 kg					Jersey, final weight 328 kg				
	Manure,	Dry	Kg			Manure,	Dry	Kg		
	t	matter, %	N	P	K	t	matter, %	N	P	K
Faeces	1.88	17.0	8.3	5.1	3	1.41	17.0	6.2	3.8	3
Urine	0.94	5.0	16.0	0.1	9	0.70	5.0	12.0	0.1	6
Total	2.82	13.0	24.3	5.2	12	2.11	13.0	18.2	3.9	9

The accumulated feed consumption by young bulls of heavy breed from birth up to a live weight of 450 kg can be described by means of the following equation that is based on "Danske Fodernormer for Kvæg" (Strudsholm et al., 1992) (Danish Feeding Standards for Cattle)

$$FU = 1.825x + 0.00605x^2 - 75$$

where x is live weight in kg, and a feed efficiency of 88% is estimated.

This equation can be used for an adaptation of the N excretion to other slaughter weights than that of 440 kg, since it is estimated that the difference in the N excretion is proportional to the feed consumption. For example, the feed consumption during the period from a weight of 220 kg to 350 kg is 54% of the consumption during the period from 220 to 440 kg. The N excretion is therefore estimated at 54% of the 24.3 kg shown in Table 2.12. or 13.1 kg.

A similar equation for young Jersey bulls is as follows:

$$FU = 2.308x + 0.00676x^2 - 35$$

Individual herd accounts can be prepared according to the same principles as described in the section on dairy cows, thereby using key figures for the nutrient deposition.

Suckler cows

If the suckler cows are outside during the winter, the amounts of manure and nutrient excretion are calculated in the same way as if the animals were housed. The proportion excreted in the outdoor pen in winter is calculated as proportional to the period the animals stay in the pen.

No separate calculations have been made for breeding stock and young feeders in suckle herds. However, the calculations can be initially based on the above-mentioned standard values for breeding stock and young bulls in dairy herds. However, especially the N excretion during the first six months is slightly higher in suckler herds than by young cattle in dairy herds, since the calves in the suckle herds are grazing during the major part of the first six months of their life. The house feeding is estimated not to differ particularly in the two types of herds. Calving age is normally lower in suckle herds than in dairy herds.

A calculation has been made concerning the manure and nutrient excretion by a beef unit that is defined as 1 suckler cow of heavy breed per year + 1.02 heads of breeding stock per year + 0.47 head of young bull produced of 470 kg (Håndbog for Driftsplanlægning 1996-97) (guide to management planning). In that connection, the values concerning the young cattle have been based on the standard values for the breeding stock and young bulls in dairy herds with the difference that the excretion by both breeding stock and young bulls during the first six months has been calculated as excreted in the field. In addition, the amounts concerning the young bulls in the period from 220 kg until slaughter have been multiplied by 1.17, since a slaughter weight of 470 kg instead of 440 kg has been estimated for young bulls in suckle hers. This correction is based on the equation of accumulated feed consumption.

Table 2.13 Manure and nutrient excretion ex animal by suckler cows grazing 184 days

			Kg		
	Manure, t	Dry matter, %	N	P	K
Housed					
Faeces	2.82	20.0	10.2	3.5	5
Urine	1.41	5.0	18.1	0.2	27
Totalling	4.23	15.0	28.3	3.7	33
Grazing					
Faeces	2.09	16.0	11.0	3.5	5
Urine	1.40	5.0	34.0	0.2	37
Totalling	3.49	11.6	45.0	3.7	42

Table 2.14 Manure and nutrient excretion ex animal for suckler cattle incl. young cattle. Unit: 1 suckler cow per year, 1.02 heads of breeding stock per year, 0.47 head of young bull produced of 470 kg

		Kg		
	Manure, t	N	P	K
Housed				
Faeces	5.39	21	8.9	10
Urine	2.70	34	0.4	47
Totalling	8.09	55	9.3	57
Grazing				
Faeces	3.69	19	6.8	10
Urine	2.40	58	0.2	54
Totalling	6.09	77	7.0	64

Poultry, ex animal

The members of the working group
Henrik Bang Jensen, *Consultant, The Danish Poultry Council (Chairman)*
Martin Gaardbo Thomsen, *Scientist, Danish Institute of Animal Science*

Summary of the working group's work
The working group has been working with 12 categories of poultry (*Poultry, Appendix 1)*. The purpose has been after establishing the standard values for the production, feed composition and deposition in gain and eggs (Section 3.3) to state for each category of poultry:

1) A standard value (for broilers differentiated according to slaughter age) for the ex animal amounts of N, P and K
2) A set of equations by which - with knowledge of the composition of the feed, feed intake and gain or egg production - it will be possible to calculate the ex animal amounts of N, P and K.

The standard values and equations are set out under Section 3.4.

Establishing of standard values for production, nutrient content of the feed, and composition of the deposition

Production: Gain, egg production and feed consumption
Concerning the four categories of *layer type hens*, The Danish Poultry Council's standard values for egg production and feed consumption have formed the basis of the calculations. In *Poultry, Appendix 2,* the standard values have been compared to production data provided by the Efficiency Control (E-kontrol). The gain during the production period consists of estimated "normal values".

For *parent stock for broiler production* and for the two categories of *pullets*, the same standard values have been applied to the production as in Report No. 82 except for an adjustment of the age by the transfer of pullets (see section 3.2.2) and minor adjustments to the nutrient content of the feed.

Concerning *broilers* of the slaughter ages from 34 to 45 days, standard values have been calculated on the basis of the data provided by the Efficiency Control on the feed consumption and gain. In *Poultry, Appendix 3,* these data are set out together with the equations concerning the weight and feed consumption of the chickens formed on the basis of these data.

Concerning *turkeys* (2 categories), *ducks* and *geese*, the standard values are unchanged as compared to Report No. 82.

Feed: Protein, phosphorus and potassium content
The protein, phosphorus and potassium content of commercial premixed feed for the 12 categories of poultry has been determined on the basis of questionnaires sent to the feed

industry and consultants. For all categories of poultry *except for* broilers, it is estimated that commercial premixed feed makes out 100% of the feed.

Concerning *broilers*, it is normal feeding practice to feed a mix consisting of whole-wheat and commercial premixed feed. For the purpose of establishing the N, P and K content of broiler feed, an admixture percentage of whole-wheat of 20.5% is used regardless of the age of the broilers. The reason for choosing this wheat percentage and feeding practice has been explained in *Poultry, Appendix 3.*

For the purpose of establishing the protein, phosphorus and potassium content of *wheat*, an average of the standard cereal analyses for 1990-94 compiled by the National Committee for Pig Breeding, Health and Production has been applied together with table values provided by The Danish Poultry Council's report 1996.

Deposition: Establishing the protein, phosphorus and potassium content in gain and eggs
The establishing of the composition of the deposition has been based on investigations conducted at the Danish Institute of Animal Science (broilers) and on foreign literature (Scott et al., 1988, Summers et al., 1985; Sørensen, 1985; Uijttenboogaart & van Cruijningen, 1988).

Important changes as compared to Report No. 82

Increase in number of poultry categories
In Report No. 82, there was only one category of layer type hens. In this report, the layer type hens have been grouped in four categories: Battery hens, deep-litter hens, free-range hens and organic hens. Since the publishing of Report No. 82 in 1994, a considerable increase in the production of non-battery systems (the three last-mentioned categories) has occurred. The four categories are *clearly defined* in the EU trade practices/business code for eggs and in the national legislation, and consequently, poultry farming is subject to the authorities' control concerning compliance with the trade practices/ business code. Since at the same time, there are *differences* in respect of the *management* of the four categories, it has been only natural to make a division among them.

Broiler age-differentiated standard values
Practice has shown that it is difficult to only operate with one standard value for broilers, since production as to weight and age is very widespread. It is therefore recommended to differentiate the standard values for broilers according to slaughter age.

Efficiency level in the broiler production
The values for the feed consumption and gain in the broiler production forming the basis of the calculation of the standard value for broilers in Report No. 82 were in force at the beginning of the 1990s, when the Danish broiler production was based on Danish breeding stock only. Since then, the Danish breeding stock has been pushed aside by that of foreign countries, which is reflected in the efficiency values for the Danish broiler production. The average values for slaughter age, gain and feed consumption have been stated for 1996 and

compared to the values applying to Report No. 82. It appears that broilers today reach the same slaughter weight 3 days earlier by using 200 g less feed.

	1996	Report No. 82
Age at slaughter/days	39.1	42.0
At slaughter:		
Weight, g	1787	1800
Feed utilization, kg/kg gain	1.74	1.83
Feed intake, g	3109	3300

Change in pullets leaving age
The age at which pullets are transferred from the rearing house to the production building is changed from 20 weeks (140 days) to 17 weeks (119 days). There has been corrected with 80 g feed per day which is then added to the hens.

Adjustments to the protein, phosphorus and potassium content of feed
For all poultry categories except for ducks,
geese and turkeys, adjustments to the protein, phosphorus and potassium content of the feed have been made. Most dramatical ly, the phosphorus content of feed for layer type hens been *increased* from 0.57% in Report No. 82 to 0.65% in this report. The average phosphorus content of broiler feed cmmercial premixed feed + whole-wheat) is *reduced* from 0.7% in Report No. 82 to 0.65% in this report.

Key figures to be used in equations and for the calculations of standard values

Key figures concerning gain, feed consumption and egg production

Layer type hens

Type	Category	Production time, days	Gain, kg	Egg production, kg per hen introduced	Feed, kg per hen introduced
Hens in battery cage systems	1	413	0.65	20.18	46.02
Deep litter hens	2	385	0.65	17.14	46.43
Free-range hens	3	357	0.65	15.85	41.62
Organic hens	4	357	0.65	15.14	45.05

Parent stock for broiler production per 100 females and 9 males

Type	Category	Prod. time, days	Gain, kg	Egg production, kg per hen introduced	Feed, kg per hen introduced
Parent stock for broiler prod.	5	315	2	10.27	54.90

Pullets, eggs for consumption and parent stock for broiler production

Type	Category	Prod. time, days	Gain, kg	Feed, kg per pullet intr.
Commercial eggs	6	119	1.35	5.30
Parent stock for broiler production	7	119	1.70	7.50

Broilers (category 8)

Age, days	Calculated on the basis of equations in *Poultry, Appendix 3*	
	Weight, kg	Feed intake
34	1.462	2.416
35	1.529	2.562
36	1.596	2.707
37	1.664	2.852
38	1.731	2.998
39	1.798	3.143
40	1.865	3.288
41	1.933	3.434
42	2.000	3.579
43	2.067	3.724
44	2.134	3.870
45	2.201	4.015

Turkeys, ducks and geese

Type	Category	Production time, days	Gain, kg	Feed, kg per animal produced
Turkeys, young	9	70	4.5	7.9
Turkeys, heavy	10	133	14.0	37.0
Ducks	11	52	3.5	10.5
Geese	12	91	6.5	28.0

Key figures concerning the protein, phosphorus and potassium content of the feed

Whole-wheat

10.8% protein
0.28% phosphorus
0.39% potassium

Protein, phosphorus and potassium content of the feed

Type	Category	Protein %	Phosphorus %	Potassium %
Layer type hens, all types	1,2,3,4	17.0	0.65	0.70
Parent stock for broiler production	5	16.0	0.60	0.70
Pullets, commercial egg	6	15.5	0.75	0.65
Pullets, parent stock for broiler prod.	7	15.0	0.65	0.60
Broilers*	8	20.5	0.65	0.80
Turkeys, young	9	24.0	0.80	0.90
Turkeys, heavy	10	18.5	0.80	0.80
Ducks	11	17.0	0.70	0.70
Geese	12	16.0	0.70	0.60

*: Mix of 20.5% whole-wheat and 79.5% commercial premixed feed. Commercial premixed feed contains 23% protein, 0.75% phosphorus and 0.9% potassium

Key figures concerning the composition of the deposition: gain and eggs

Layer type hens and parent stock for broiler production (category 1,2,3,4,5)

	N	P	K
Deposited in gain, kg/kg gain	0.0288	0.0067	0.0028
Deposited in eggs, kg/kg eggs	0.0181	0.0020	0.0013

Pullets, broilers, turkeys (category 6,7,8,9,10)

	N	P	K
Deposited in gain, kg/kg gain	0.0288	0.0067	0.0028

Ducks and geese (category 11,12)

	N	P	K
Deposited in gain, kg/kg gain	0.0240	0.0055	0.0023

Standard values and equations for the calculation of ex animal quantities of N, P and K
In order to deviate from the standard values, documentation of the parameters that form part of the equations is required, i.e.:

1) Documentation of the size of the gain.
2) Documentation of the size of the egg production and for the length of the production period in layer type hens and parent stock broiler production.
3) Documentation of the amount of feed used (purchased and home-grown).
4) Documentation of the N (protein), P and K content of the feed purchased.

Documentation of the N (protein), P and K content of home-mixed cereals that are mixed with the purchased feed (table values are applied) is not expected to be required. It is preconditioned that the values used in this report concerning the N, P and K in gain and eggs are applied.

Layer type hens (category 1,2,3,4)

	Category	Prod. time,	Ex animal, kg/100 hens introduced			Ex animal, kg/100 hens intro. for 365 d*		
Type		days	N	P	K	N	P	K
Hens in battery cage systems	1	413	86.8	25.4	29.4	74.2	21.7	25.1
Deep litter hens	2	385	93.4	26.3	30.1	85.4	24.1	27.5
Free-range hens	3	357	82.6	23.4	26.9	81.3	23.0	26.5
Organic hens	4	357	93.2	25.8	29.4	91.7	25.4	28.9

* : Production for 365 days is calculated as: ex animal production * 365/(production time + 14).
Two weeks are added for dry period.

Equation for calculation of kg N ex animal
kg feed per hen introduced x (% protein in feed) x 0.16 - kg eggs per hen introduced x 1.81 - gain per hen introduced x 2.88
= kg N ex animal per 100 hens introduced

(kg N ex animal per 100 hens introduced) x 365/(production period for days + 14)
= kg N ex animal per 100 hens for 365 days

Equation for calculation of P ex animal
kg feed per hen introduced x (% phosphorus in feed) - kg eggs per hen introduced x 0.2 - kg gain per hen introduced x 0.67
= kg P ex animal per 100 hens introduced

(kg P ex animal per 100 hens introduced) x 365/(production period for days + 14)
= kg P ex animal per 100 hens for 365 days

Equation for calculation of K ex animal
kg feed per hen introduced x (% potassium in feed) - kg eggs per hen introduced x 0.13 - kg gain per hen introduced x 0.275
= kg K ex animal per 100 hens introduced

(kg K ex animal per 100 hens introduced) x 365/(production period for days + 14)
= kg K ex animal per 100 hens for 365 days.

Parent stock for broiler production

Type	Category	Production time, days	Ex animal, kg/100 hens introduced incl. 9 cocks			Ex animal, kg/100 hens introduced for 365 days incl. 9 cocks*		
			N	P	K	N	P	K
Parent stock for broiler production	5	315	116.2	29.5	36.5	128.9	32.8	40.5

* : Production for 365 days is calculated as: ex animal production * 365/(production time + 14).

Two weeks are added as dry period

For the equation for the calculation of kg N, P and K ex animal, see under 3.4.1, layer type hens.

Pullets

Type	Category	Production time, days	Ex animal, kg per 100 animals produced		
			N	P	K
Commercial eggs	6	119	9.3	3.1	3.1
Parent stock for broiler production	7	119	13.1	3.7	4.0

Equation for calculation of kg N ex animal
kg feed per pullet produced x (% protein in feed) x 0.16 - kg gain per pullet produced x 2.88
= kg N ex animal per 100 pullets produced

Equation for calculation of kg P ex animal
kg feed per pullet produced x (% phosphorus in feed) - kg gain per pullet produced x 0.67

= kg P ex animal per 100 pullets produced

Equation for calculation of kg K ex animal

kg feed per pullet produced x (% potassium in feed) - kg gain per pullet produced x 0.275
= kg K ex animal per 100 pullets produced

Broilers

Average *) excretion of N, P and K:

N: 50.6 kg ex animal per 1000 broilers produced

P: 8.4 kg ex animal per 1000 broilers produced

K: 19.8 kg ex animal per 1000 broilers produced

*): The average excretion is a weighted average of the ex animal values shown in the table below. The weights used are the total number of chickens slaughtered at the various slaughter ages (see *Poultry, Appendix 3,* Table "Broilers. Division into groups and number of chickens slaughtered at all slaughter ages: all groups").

N, P and K excretion according to age (broilers)

	Ex animal, kg per 1000 animals produced		
Slaughter age, days	N= -59.11 +2.83 x slaughter age	P= -10.99 +0.5 x slaughter age	K= -17.82 +0.97 x slaughter age
34	37.1	6.0	15.2
35	40.0	6.5	16.2
36	42.8	7.0	17.1
37	45.6	7.5	18.1
38	48.5	8.0	19.1
39	51.3	8.5	20.1
40	54.1	9.0	21.0
41	57.0	9.5	22.0
42	59.8	10.0	23.0
43	62.6	10.5	23.9
44	65.5	11.0	24.9
45	68.3	11.5	25.9

Equation for calculation of kg P ex animal

kg feed per broiler produced x (% phosphorus in feed) x 10 - kg gain per chicken produced x 6.7
= kg P ex animal per 1000 broilers produced

Equation for calculation of kg K ex animal

kg feed per broiler produced x (% potassium in feed) x 10 - kg gain per broiler produced x 2.75
= kg K ex animal per 1000 broilers produced

Equation for calculation of kg N ex animal

kg feed per broiler produced x (% protein in feed) x 1.6 - kg gain per chicken produced x 28.8
= kg N ex animal per 1000 broilers produced

Turkeys

Type	Category	Production time, days	Ex animal, kg per 100 animals produced		
			N	P	K
Turkeys, young	9	70	17.4	3.3	5.9
Turkeys, heavy	10	133	69.2	20.2	25.75

Equation for calculation of kg N ex animal
kg feed per turkey produced x (% protein in feed) x 0.16 - kg gain per turkey produced x 2.88
= kg N ex animal per 100 turkeys produced

Equation for calculation of kg P ex animal
kg feed per turkey produced x (% phosphorus in feed) - kg gain per turkey produced x 0.67
= kg P ex animal per 100 turkeys produced

Equation for calculation of kg K ex animal
kg feed per turkey produced x (% potassium in feed) - kg gain per turkey produced x 0.275
= kg K ex animal per 100 turkeys produced

Conversion of the ex animal amounts of N, P and K for turkeys into ex animal per kg gain is made by dividing the values in Section 3.4.5 by the weights for the relevant type of poultry in the table in Section 3.3.1.

Ex animal amounts of N, P and K for turkeys, g per kg gain

	N	P	K
Turkeys, young	38.7	7.3	13.1
Turkeys, heavy	49.4	14.4	18.4

Ducks and geese

Equation for the calculation of kg N ex animal
kg feed per duck/goose produced x (% protein in feed) x 0.16 - kg gain per duck/goose produced x 2.4

= kg N ex animal per 100 ducks/geese produced

Type	Category	Production time, days	Ex animal, kg per 100 animals produced		
			N	P	K
Ducks	11	52	20.2	5.4	6.5
Geese	12	91	56.1	16.0	15.3

Equation for calculation of kg P ex animal
kg feed per duck/goose produced x (% phosphorus in feed) - kg gain per duck/ goose produced x 0.55

= kg P ex animal per 100 ducks/geese produced

Equation for calculation of kg K ex animal

kg feed per duck/goose produced x (% potassium in feed) - kg gain per duck/goose produced x 0.23

= kg K ex animal per 100 ducks/geese produced.

The conversion of the ex animal amounts of N, P and K for ducks and geese into ex animal per kg gain is made by dividing the values under Section 3.4.6 by the weights for the relevant type of poultry in the table under Section 3.3.1.

Ex animal levels of N, P and K for ducks and geese, g per kg gain

	N	P	K
Ducks	57.7	15.4	18.6
Geese	86.3	24.6	25.3

3.5 References

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4 Fur bearing animals, ex animal

The members of the working group
Chr. Børsting, *Senior Scientist, Danish Institute of Animal Science*
Niels Enggaard Hansen, *Associate Professor, Royal Veterinary and Agricultural University*
Henning Jensen, *Secretariat Director, Danish Fur Breeders Association*
Steen Møller, *Scientist, Danish Institute of Animal Science*
Hans Pedersen, *Fur Farming Consultant, North Jutland Fur Breeders Association*
Niels Therkildsen, *Director of the Danish Fur Breeders Research Centre (Chairman)*

Summary of the working group's work

Concerning mink and ferret
The working group has primarily been working with nitrogen and phosphorus excretion by mink. In accordance with Report No. 82 published by Institute of Agricultural Economics, the nutrient excretion ex animal is estimated to be the same for mink and ferret.

Nitrogen
The present standard values for nitrogen set out in Report No. 82 are based in the first place on digestibility and balance experiments where 85% of the nitrogen intake is digested, i.e., 15% of total N intake is found in the faeces. The balance showed an N excretion in urine of "only" 65% of the N intake. Despite laboratory facilities for the collection of N in the urine, it was not possible to collect the expected N amount. The missing N amount in the urine has evaporated, and the present standard values for the N excretion ex animal (Report No. 82) should be considered as values between the theoretically correct values for ex animal and ex building.

The working group has therefore decided to calculate the theoretical N excretion on the basis of the N intake by the feed and the N deposition in body, pelt and hair. As will appear from *Fur bearing animals, Appendix 1* ("Standard values for N input and output on a mink farm"), the calculations are based on a range of scientifically documented estimations which perhaps after a later revaluation may be easily updated. Based on the given estimations, the N excretion ex animal (plus N in feed wastage) by mink is 4.59 kg N in faeces, urine and feed wastage per year per female per year or 879 g N in faeces, urine and feed wastage per mink pelt produced. In Report No. 82, these values were 3.50 kg and 658 g, and thus the new values show an increase of more than 30%.

The standard values of Report No. 82 are still high as compared to the manure value at the time of spreading on arable land. The reason for that is a considerable evaporation loss of N in housing systems due to structural matters. Faeces and urine lie in a very thin layer, and the surface is very large as compared to the volume.

Regard should therefore be taken to the very high rate of the N evaporation when estimating the N loss in housing and storage systems. It is therefore of great importance to work out correct values for the N content of solid manure and slurry from fur farms.

Summary: Based on the relevant conditions, the annual N excretion in manure, urine and feed wastage is as follows:

	In manure	In urine	In feed wastage	Total
Per female with puppies per year	676 g	3520 g	392 g	4588 g
Per mink pelt produced	130 g	674 g	75 g	879 g

As a comparison, Report No. 82 states an N level ex animal per female (incl. kits produced) per year of 3500 g and per mink pelt produced 658 g.

Phosphorus
Based on the feed intake and the phosphorus content of the feed, the total amount of phosphorus in faeces and urine was calculated, thereby having regard to the phosphorus content of the body. The phosphorus content has been calculated on the basis of the feedstuff composition in 1985/86 and 1995/96, respectively, at five large feed factories, set out in detail in *Fur bearing animals, Appendix 2* ("Concerning phosphorus in mink faeces and urine"). The same standard for daily energy supply during the two years of production have been used. The standard value for daily energy supply is the same as that applying to the calculations of the nitrogen excretion. The actual breeding results for 1985 and 1995 were used in the calculations.

Based on the relevant preconditions, the P excretion in faeces, urine and feed wastage per female (incl. kits produced) per year and per pelt in 1985/86 and 1995/96, respectively, has been calculated as follows:

Feed factories	A	B	C	D	E	Average
1985/86:						
Per female with kits per year, g	1041	966	1154	1182	1060	1081
Per mink pelt produced, g	222	206	246	252	226	230
1995/96:						
Per female with kits per year, g	877	919	908	960	825	895
Per mink pelt produced, g	168	176	174	184	158	171

Summary: Based on the relevant estimations, P excretion in faeces, urine and feed wastage has been calculated to 895 g per female (including kits) per year and 171 g per mink pelt produced, respectively. As a comparison, Report No. 82 states a P level ex animal per female (including kits) per year of 1100 g and per mink pelt produced 207 g.

Potassium
Based on the ratio for phosphorus, it is estimated that the K content of faeces, feed wastage and urine by mink has been reduced correspondingly by about 17% as compared to the information given in Report No. 82. The K excretion in faeces, urine and feed wastage is stated as 415 g per female (including kits) per year and 80 g per mink pelt produced, respectively.

Variation in N, P and K excretion

Factors like feeding practice, housing and sheltering systems, size of farm, colour types and breeding result affect the feed consumption per pelt produced. Thus it is possible for a number of mink farms to reduce the consumption of feed per pelt produced as compared to the conditions stated and thereby reduce the N, P and K excretion ex animal.

At present, the only practicable method of describing the variation in the nutrient excretion by a given mink production is the feed consumption per pelt produced. Based on the previous model calculations and estimations for standard values for the N, P and K excretion ex animal, it is possible to reduce the feed consumption by up to 10%, perhaps more, per pelt produced. The model calculations set out in *Fur bearing animals, Appendix 1* (Table 2), yields a feed consumption of 35.5 kg per pelt produced under the given conditions. If the feed consumption is reduced by e.g. 10% to 32.0 kg feed per pelt produced, the N, P and K excretion ex animal (inclusive of feed wastage) will be reduced by about 10% to 791 g N, 154 g P and 72 g K per pelt produced (879 g N, 171 g P and 80 g K respectively, in the model calculation).

Production data on feed consumption per pelt produced in 1995 on 34 mink farms show a feed consumption of 35.6 ± 2.1 kg with a range from 30.7 to 38.6 kg per pelt.

Under present-day conditions of production in Denmark, the most important factor for the variation in the N, P and K excretion per mink pelt produced is the feed consumption per mink pelt produced. This variation is to a high degree due to varying management conditions on the farms. In addition, the N, P and K content of the feed supplied by feed factories may be slightly different and thereby via the nutrient content of the feed affect the nutrient excretion by the animals.

At present, there is no practical method describing the influence of feed composition on variation in nutrient excretion ex animal. This will demand calculations of the nutrient content of the feed supplied by the individual feed factories to the mink farmers.

Concerning fox and finnracoon

As a consequence of a qualitative and quantitative lack of documentation of nutrient excretion by fox and finnracoon, the standard values of Report No. 82 are recommended to in principle apply for the future. As a consequence of the relatively lower phosphorus content (see mink and ferret) as compared to the values introduced 10 years ago, it is justified to reduce the P level for fox and finnracoon by 17% as compared to the values stated in Report No. 82. Based on the estimations and calculations of the N excretion by mink, the consequence must be that the N excretion ex animal by fox is increased on a similar level by 30%.

Report No. 82 states the following nutrient levels ex animal from 1st year female with kits and male animals:

	Report No. 82	Changed to
N	9,300 g	12,090 g
P	2,900 g	2,407 g
K	1,300 g	1,079 g

The N emission from urine and manure from fox and finnracoon is considered to be high and on the level of that of mink.

5 Horses, ex animal

The members of the working group
Eric Clausen, *Senior Advisor, The National Department of Horse Breeding*

Preconditions
As the initial basis, a mature, housed horse of 600 kg is used. The energy requirement is estimated at 5 FU/day for maintenance + 2 FU/day for work, in total 7 FU per day.

Protein requirement is estimated at 80 g digestible crude protein/FU. The protein digestibility is estimated at 65%. A total of 560 g digestible crude protein per day.

The content of other nutrients is calculated proportionately based on the average composition of N, P and K: 14.0, 2.2 and 12.8 lbs. per tonne in horse manure (including urine) (Morrison, 1959).

For a horse of 600 kg, the same preconditions are applied and consequently the same nutrient excretion as that of Report No. 82 published by the Institute of Agricultural and Fisheries Economics.

Table 5.1 Nutrient content of horse manure
The nutrient excretion ex animal per year depending on horse weight

	Horse weight, kg		
	400	600	800
Kg N	38	50	63
Kg P	6	8	10
Kg K	35	46	58

For the horse of 400 kg, the energy requirement is estimated at 3.6 FU for maintenance + 1.6 for work/production. The protein requirement is then 5.2 FU of 80 g digestible crude protein = 416 g digestible crude protein. With a digestibility of 65%, the crude protein supplied is then 640 g that is equal to 103 g N per day for 365 days ~ 38 kg N per year.

For the horse of 800 kg, the energy requirement is estimated at 6.4 FU for maintenance and 2.4 FU for work/ production feed. A total of 8.8 FU of 80 g digestible crude protein/FU that makes out 63 kg N per year.

Table 5.2 Manure amount

According to Pferdefütterung (Meyer, 1986), the manure amount is between 1 - 3% of the body weight. Then, an estimation of 2% is used.

	Weight of horse, kg		
	400	600	800
Manure per year, tons	2.920	4.380	5.840
+ bedding, tons*	0.900	0.900	0.900
Total, tons	3.820	5.280	6.740

*A bedding consumption of approx. 5.0 kg straw per day during the housing period (180 days) is estimated. The manure dry matter content when house feeding is about 25 and 22% during grazing (Meyer, 1986).

References

Meyer, H., 1996. Pferdefütterung

Morrison, F.B., 1959. Feeds and feeding. Handbook for student and stockman.

6 Sheep, ex animal

The members of the working group
The members of the working group are identical with those of cattle.

Basis
The values are based primarily on information compiled by herd experiments on sheep (Report No. 609 by the National Institute of Animal Science). There are only minor changes as compared to the values stated in Report No. 82 by the Institute of Agronomy and Fisheries, however, the amount of feed and thereby the amounts of manure and urine are larger.

Key figures
Key figures for the calculation of the amount of manure and the estimated amount of urine appear from Table 6.1.

The calculations are based on the total amount of feed for 1 breeding ewe per year including 1.5 lambs to be slaughtered in the autumn and the ram stock and gimmer breeding. For that, a total consumption of 800 FU has been estimated out of which about 200 FU are fed during the winter and the 600 FU during grazing. An indoor feeding period of 100 days is estimated.

Table 6.1 Factors for the calculation of the amount of manure and urine and the estimated dry matter content of urine. 1 breeding ewe including 1 lamb, ram stock and gimmer breeding

	Kg dry matter in feed	Digest. coeff., feed	Dry matter % in faeces	Kg urine per kg dry matter in feed	Dry matter % in urine
Winter	300	67	40	1.75	5
Summer	700	75	35	1.75	5

A feed consisting of 1.5 kg of dry matter per 1 FU for indoor feeding, and 1.2 kg dry matter per FU in grass is preconditioned:

300 kg dry matter in indoor feeds
700 kg dry matter in grass

The total feed contains 170 g total crude protein per FU, 119 g digestible crude protein per FU.

The following amounts of N deposition are estimated:
Embryos: 185 g protein per kg (8 kg)
Gain of the ewe: 160 g prot. per kg (10 kg)
Lamb: 1.5 finished lambs, 170 g protein per kg (75 kg)

No scientific documentation has been examined in relation to the P and K conversion, and the previous standard values are maintained.

Standard values

Table 6.2 Manure and nutrient excretion ex animal per year. Unit: 1 breeding ewe including 1.5 lambs and ram stock and gimmer breeding

	Manure, t	Dry matter in manure, %	Kg		
			N	P	K
Housed	0.77	16	6	1.0	7
Grazing	1.73	14	14	2.5	16

7 Technology, ex building and ex storage

The members of the working group

Arne Kyllingbæk, *Scientist, National Institute of Plant and Soil Science - loss in storage system*
Hans Benny Rom, *Scientist, National Institute of Animal Science - loss in storage system*
Sven G. Sommer, *Scientist, National Institute of Plant and Soil Science - loss in storage system*
Poul Petersen, *Consultant, The National Committee for Pig Breeding, Health and Production - housing systems, pigs*
Helge Kromann, *The National Department of Farm Building and Machinery - housing systems, cattle*
Leif Knudsen, *The National Department of Plant Production - generally (Chairman)*

Loss and conversion in housing and storage systems in general

In order to calculate the manure production and composition *ex storage*, i.e., the amount of manure and nutrients that are actually applied to the field, the production ex animal must be corrected for the application and the loss of nutrients that occur during the period of time the manure is lying in the housing and storage systems.

Table 7.1 shows a survey of the effects on the amounts of manure in housing and storage systems:

Table 7.1 Application, loss and the transfer of manure and nutrients in housing and storage systems

	Housing	Storage
Application	Bedding Drinking water waste Cleaning water Feed wastage	Rainwater directly into storage Surface water from consolidated areas Silage effluent etc.
Loss	Ammonia evaporation Denitrification of nitrogen Dry matter loss by composting Water evaporation	Ammonia evaporation Denitrification of nitrogen Dry matter loss by composting
Transfer between manure types	Faeces in urine Absorption of urine in faeces Absorption of urine in straw	Effluent from farmyard manure to liquid manure

In the following sections, the preconditions for stating the individual factors of the calculation of the conversion in housing and storage systems are described. On pages 45 and 46, the specific parameters for each type of housing used in the calculations are stated.

When calculating the ex storage manure and nutrient levels, the following definitions of manure types are used:

Manure

Is the solid fraction of the animal manure that results when urine is separated from faeces. The manure therefore consists of primarily faeces mixed with varying amounts of bedding straw.

Liquid manure
Consists of the urine that is separated from the faeces in the housing system. In addition to the urine, the liquid manure may contain water that has been introduced during the production.

Deep litter
Deep litter builds up in housing systems when the excreted amount of manure is not removed daily from the house and the layer is thick enough for a liquid fraction of the manure not to accumulate or to accumulate only to very limited extent.

Slurry
Is the designation of the type of manure that results from a mixture of faeces and urine in the housing system.

Conversion and loss in housing systems
When using bedding straw, the volume and nutrients are applied to the amount of manure excreted. The calculations estimate that 50% of the amount of bedding materials may be barley straw and 50% wheat straw. The average nutrient content of the straw is estimated at:

Nutrient content of straw (as a percentage of the commodity in question):

Nitrogen: 0.0050 kg N per kg dry matter
Phosphorus: 0.00068 kg P per kg dry matter
Potassium: 0.01475 kg K per kg dry matter

The dry matter percentage is estimated at 85%.

No possible feed wastage has been added to the amount of manure ex animal. When calculating the nutrient level ex animal, the feed wastage has been included.

Loss in housing system
The losses stated are estimated on the basis of results provided by researches conducted in Denmark and the Northern part of Europe and testing results by The National Committee for Pig Breeding, Health and Production. The nitrogen loss stated is calculated as loss in percentage nitrogen ex animal. The bracket states the variation in the loss factor.

Research results within the area reflect great variations from experiment to experiment and from country to country. A great proportion of the variations can be explained as a result of various matters concerning e.g. climate, feed level, production level, housing design, ventilation system, manure handling and the usage of bedding.

Pig housing systems are normally mechanically ventilated which makes it possible to relatively accurate measure the ventilation air flow rate and hence the ammonia emission. Most deep litter housing systems has natural ventilation based on the calculated amounts of

Species and Housing System	Nitrogen loss in % of total N ex animal	Standards in Report no. 82
<u>**Pig housing systems**</u>		
Slaughter pigs 30-100 kg		
Slatted floors and slurry	15 (12-16)	15
Solid floor – straw flow	18 (14-22)	15-17
Solid floor with dung passage	18 (14-22)	-
Deep litter (throughout pen)	25 (15-30)	27
Weaners 7-30 kg		
Two climate housing, partially slatted floor	10 (8-12)	20
Slatted floor with slurry	15 (12-16)	20
Solid floor	25 (20-28)	24
Deep litter	25 (15-30)	24
Farrowing housing systems		
Farrowing pen, partially slatted floor	10 (8-12)	16
Farrowing pen, fully slatted floor	15 (13-17)	16
Loose housing system, solid floor	15 (10-20)	16
Gestation housing systems		
Tied-up animals w. dung passage w. slurry	5 (3-6)	21
Slatted floor	15 (12-16)	-
Solid floor – straw flow	20 (16-24)	21
Solid floor with dung passage	20 (16-24)	23
Deep litter	25 (15-30)	19
<u>**Cattle housing systems**</u>		
Tie-up and self-locking standings		
Dung channel w. liquid manure drain or slurry w. floor grating	5 (3-7)	3.7-6.2
Cubicles and feed cubicles		
Walk-way areas with solid floor	10 (8-15)	10
Walk-way areas with slatted floor	8 (5-10)	8
Deep litter housing systems		
Deep litter throughout house, single pens + large common pens	8 (5-12)	8
Deep litter with solid floor or slatted floor at feeding area	8 (5-12)	8
Straw-bedded sloped floor		
Straw-bedded sloped floor throughout pens	8 (5 – 12)	-
Fully slotted floor pens		
Slatted floor throughout pen with deep cellar	8 (6-10)	8
<u>**Poultry**</u>		
Layers		
Floor hens		
Deep litter area	25 (20-35)	22
Droppings pits	40 (30-50)	27
Battery hens		
Droppings belt	10 (8-12)	27
Manure cellar	12 (9-15)	27
Broilers		
Deep litter	20 (15-24)	22
<u>**Fur bearing animals**</u>		
Dung channel	65 (50-80)	25
Grit	25	25

ventilation air. According to Ouwerkerk & Pedersen, 1994, the ventilation level has been calculated by means of the CO_2 balance that is subject to an uncertainty of ±15% as compared to the ventilation measured. Ooster, 1994 detected an uncertainty in the area of ±25% by experiments on a naturally ventilated housing system with cubicles for cows. To that should be added an uncertainty for the measuring of the ammonia concentration and the differences in the manure handling and weather conditions and general management.

The calculations are initially based on a variation of the loss factors on the basis of relevant literature and an uncertainty due to local differences which all together make out an uncertainty of about ±15% for mechanically ventilated housing systems and ±25% for housing systems with natural ventilation.

Pig housing systems
Pig housing systems with slatted floor and slurry cover both totally slatted floor and partially slatted floor housing systems. Results from own and international experiments show that the ammonia emission level by housing systems with totally slatted floor is 10-15% higher than that of housing systems with partially slatted floor. The stated variation can therefore be used to place partially slatted floor housing systems in the lower half and housing systems with totally slatted floor in the upper half. But there may be great variations among the housing systems in practice.

No data are available about nutrient loss for housing systems with solid floor, straw-flow and two-climate housing with partially slatted floor. But the loss in housing system is based on results of individual measurements made by the Danish Applied Pig Research Scheme by the National Committee for Pig Breeding, Health and Production. It is supposed that the ammonia loss is on the same level as that of the housing systems with dung passage and deep litter.

Concerning farrowing houses, the loss is based on Dutch investigations.

Cattle housing systems
As mentioned under general remarks, most of the loose housing systems for cattle are with natural ventilation and, therefore, the calculation of the ammonia emission is subject to great uncertainty. Losses in tie-up housing systems with dung channel and solid floor are usually placed in the upper part of the interval, and housing systems with dung channel and slatted floor or floor grating are placed in the lower part of the interval. Concerning housing systems with cubicles and solid floor and scraper, the decisive factor is how often the floor is scraped. New Dutch results show that V-formed floors (3% sloped towards a liquid manure channel) with the liquid manure channel in the middle, and provided that the floor is scraped every hour, will reduce the emission by about 40% as compared to slatted floor.

Poultry housing systems
It is difficult to find relevant data about loss in poultry housing systems. This is primarily because only few Danish investigations have been carried out in that field, and most foreign investigations cover housing systems that are not quite comparable with Danish conditions. The losses listed in the table are based on Dutch and Belgium research results that have been corrected on a rough estimate to the housing systems used in Denmark.

Fur animal housing systems
Loss in fur animal housing systems have been established in connection with carrying out balance tests (Møller, 1997, cf. *Fur Bearing Animals, Appendix 1*). Foreign investigations have been carried out in housing systems that are so different from Danish conditions that they cannot be used here.

Dry matter percentage in deep litter manure

Loss in housing systems of dry matter and water
In deep litter manure, a decomposition of dry matter occurs both in housing and storage systems. This conversion occurs during the generation of heat, and this generation of heat results in a considerable evaporation of water. The dry matter loss by the deep litter in the housing system is estimated at 10% for deep litter from pigs and sheep and at 20% for deep litter from cattle and horses. The water evaporation is hence adjusted thereby achieving a deep litter dry matter content on a level with the dry matter percentages recorded in practice. In poultry deep litter, a drying up of the manure occurs, and the conversion of dry matter is minimal. Thus, in poultry housing systems, a water loss of 55% is estimated.

Losses in storage systems of dry matter and water
Losses in storage systems of deep litter manure are estimated at 10% for cattle, 20% for pigs, poultry, sheep and horses. As with the loss in housing system, the evaporation of water has hence been adjusted thereby achieving a deep litter dry matter content on a level with the dry matter percentages recorded in practice.

Comparison between present losses in housing system and the previous standard values
Compared to Report No. 82 (Laursen, 1994), only minor adjustments have been made to the loss values concerning pig housing systems. Concerning weaners 7-30 kg, farrowing houses, and gestation houses, a division into housing systems has been made which gives a more differentiated stating of the loss percentages. Concerning weaners in housing systems with double deck, the loss is thus reduced considerably as compared to previously. The same applies to farrowing houses with farrowing pens and partially slatted floor and gestation houses with slatted floor.

Concerning cattle housing systems, the losses are unchanged as compared to Report No. 82.

Concerning poultry, a considerable upgrading of the values for layers in floor management systems has occurred, but on the other hand a reduction for N loss in battery keeping has occurred. Concerning poultry (for slaughtering), a minor reduction in the losses has occurred.

Concerning fur bearing animals, the loss in housing system has increased considerably. The losses by fur bearing animals have not been estimated on the basis of concrete measurements, but have alone been based on the knowledge of the housing systems, including, in particular, the time the manure is lying in the slurry channels etc.

Transfer of manure amounts and nutrients among the individual manure types in the housing system

In addition to the nitrogen loss in the form of ammonia and the denitrification in the housing system, a transfer of the nutrients occurs in the housing system. The parameters used in this report are unchanged as compared to Report No. 82. The following parameters have been used:

Faeces in urine ex animal (in liquid manure):

5% of faeces ex animal

Urine absorbed in pig faeces:

0.5 kg per kg faeces ex animal

Urine absorbed in bedding straw:

2.5 kg per kg bedding straw

Conversion and loss in manure storage

The loss of nitrogen, phosphorus and potassium in storage systems listed below have been established on the basis of the investigations into the loss by various types of manure during storage. The most important changes as compared to the loss in storage systems of Report No. 82 are that the loss by solid cattle and pig manure is stated separately and that losses from storage of deep litter manure are included.

The reason why the loss by solid cattle and pig manure has been stated separately is that new investigations have shown that the loss by solid pig manure is considerably heavier than previously believed.

The loss by deep litter in storage systems has been included because deep litter sometimes is stored before spreading on the field. This applies to deep litter from slaughter pigs and broilers, in particular. No investigations have been made concerning deep litter loss in storage system. The values stated have therefore been estimated on the basis of the loss by the solid manure.

Loss of nitrogen $NH_3 + N_\Delta$ by:	Estimated at	Report No. 82
Liquid manure tanks	2% of total N content ex building	1
Slurry tank	2% of total N content ex building	1.5
Solid cattle manure	15 ±5% of total N content ex building	15
Solid pig manure	30 ±10% of total N content ex building	15
Poultry manure	15 ±5% of total N content ex building	15
Deep litter from cattle, sows and hens	10 ±5% of total N content ex building	0
Deep litter from slaughter pigs and broilers	25 ±10% of total N content ex building	0
From animals with grazing	10% of total N content ex building	10

Loss of solid manure dry matter in storage system, % of the amount of dry matter ex building	
Cattle	5%
Pigs	30%
Deep litter	20%

Loss of slurry dry matter in storage system

No loss of slurry dry matter in storage system has been established in Report No. 82. However, a constant anaerobic conversion occurs in dry matter into e.g. methane and CO_2. The calculated dry matter percentages in Report No. 82 are therefore relatively high and are seldom found by means of analyses in practice.

Preliminary experiments made by the Danish Institute of Plant and Soil Science have shown that about 20% of the slurry dry matter is lost during storage. The experiments also indicated that the major part of this dry matter loss occurs within the first weeks of the storage period. The dry matter loss by stored slurry is therefore estimated at 20% of the dry matter ex building.

Loss of the nutrients nitrogen, phosphorus and potassium during the storage of manure

The loss of nitrogen during the storage of manure results both by ammonia evaporation and the release of nitric oxides and free nitrogen to the atmosphere and also by percolation with manure effluent and manure heap liquid from solid manure and deep litter storage systems. Phosphorus and potassium are lost only by means of percolation. According to the legislation in force, manure effluent and manure heap liquid must be introduced into the liquid manure tank or slurry tank or other kind of tank. The nutrients in manure effluent and manure heap liquid are not lost then, but transferred from the solid manure to the liquid fraction.

Most Danish investigations concerning the loss of nutrients during the storage of manure and liquid manure have been made during the period from 1925 to 1950. The handling and storage of manure as slurry did not attract much attention until the 1970s and 1980s. The establishing of nutrient loss from slurry has been based on investigations made in the 1980s and 1990s.

Losses in liquid manure (urine) tanks

The first investigations into storage of liquid manure (urine) in Denmark was carried out at Dalum Landbrugsskole (Dalum Agricultural School) in the period from 1889-98. The liquid manure was stored in relatively small tanks with wood cover. The average loss made out 1.3% per month varying from 0.8% during the winter months to 1.8% during the summer months. Similar investigations into small tanks but with a more or less tight cover were carried out at the request of the Jyske Landboforeninger (Federation of Jutland farmers' union) in 1909 - reported by Iversen, 1925. From tanks with a more or less leaky cover, a loss of 23-49% was detected after storage for a period of 8 months (August - April), and from tanks with a tight cover, a loss of 4-7% was detected. The loss by tanks with a tight cover is equal to 0.5 – 0.9% per months.

The importance of the tightness of the liquid manure tank on the N loss also appears from the results of measurements of the N content of liquid manure tanks on a great number of farms. By investigations into the N content of the liquid manure tank at various depths, Kristensen detected in 1907 - what could be expected - that the N content was lowest at surface level. Total N loss made out about 22% which was said to be due to an uncovered pump hole of the size of 8 by 16 cm. The importance of the tightness of the liquid manure tank was certified by subsequent investigations. By sampling of the liquid manure on 72 farms and a grouping of the liquid manure tanks into four groups according to tightness of the covering of the pump hole, Iversen detected in 1925, an N content of approx. 0.6% for the group with the best cover and about 0.3% for the group with the poorest cover. Similarly, Iversen detected in 1925 by an investment into liquid manure sampling from 160 farms that were grouped into four groups according to difference in the N content of 0.2 pct. point. The average N content for the lowest group was approx. 0.15% and for the group with the highest N content 0.86%. Also in this case, the difference may primarily be due to differences in the tightness of the manure tank.

There are no results available from more recent investigations into N losses by liquid manure (urine) tanks that reflect present-day conditions, but the results from the above-mentioned investigations show that the N loss can be limited to a very small loss by storing in tight tanks. In the light of the fact that liquid manure, according to the current legislation, must be stored in closed tanks, the annual N loss by ammonia evaporation from the liquid manure tanks estimated by Sommer, 1994b to make out a maximum of 3% of the N content. Due to the building up of methane and the consequent explosive gas hazard, a certain ventilation of the liquid manure tank is recommended.

Loss in slurry tanks

Since slurry is normally stored in open tanks, the N loss by ammonia evaporation is to a great extent depending on whether or not a floating layer is formed. Converted into annual loss, a loss of 1.5 kg N per m^2 in cattle slurry agitated once a week was detected by the investigations conducted by Sommer et al., 1993 and Sommer, 1994a and similarly for pig slurry an annual loss of 1.6 kg N per m^2. For a 4 m deep slurry tank, this was equal to an annual loss of 6 and 9%, respectively, of the total N content of the slurry if the tank is filled continuously from May to late April. A wood cover reduced the loss to 2% of the loss by agitated slurry. Plastic film, a layer of light-expanded clay aggregates (leca) or rapeseed oil reduced the loss to 10-12%, and sphagnum, wheat straw or a natural floating layer reduced the loss to 15-20% of the loss by agitated slurry. Calculated on the basis of total N content of slurry, it is equal to a loss of 0.6-1.1% by cover with plastic film, a layer of light-expanded clay aggregates (leca) or rapeseed oil, and a loss of 0.9-2% by a cover of sphagnum, wheat straw or a natural floating layer. The same size of loss and effect of the various forms of cover are found by Dutch investigations (Bode, 1991).

In a full-scale experiment on degassed slurry in slurry tanks (diameter 20-28 m and 3.5 m depth) carried out at Ribe Biogas Plant (Sommer, 1996) a loss of 3.3 kg N/m^2 per year was found in a slurry tank without cover, and a loss of 0.1 and 0.3 kg N/m^2 per year in a similar tank with a layer of light-expanded clay aggregates (leca) or straw. The heavier loss by degassed slurry without other floating layer than that detected by the above-mentioned experiments is considered due to a greater ammonia content and higher pH in degassed slurry than in ordinary slurry. Total N content of manure with a layer of light-expanded clay aggregates (lecasten) and straw was about 4 kg N per m^3. When anticipating that this content is equal to the N content of the slurry "without loss", the losses in the tanks that were covered with lightweight-expanded bricks (leca) and straw respectively, were 0.7% and 2% per year of the total N content.

Solid manure loss

As mentioned by way of introduction, most Danish investigations into the loss of nutrients during storage of solid manure have been carried out in the period from 1925 to 1950. The results of previous investigations into the loss by manure heaps cannot be expected to directly reflect the loss by present manure heaps. Thus, the investigations have been carried out on the basis of well-managed manure heaps or manure being stored in concrete manure pits where the manure during piling was compressed which means that the air change that is of importance to the conversion probably is less than the air change in present manure heaps. Today's manure heaps are often shaped like manure stacks, where the manure is hauled daily to the top of the stack by means of manure disposal systems.

Previous investigations into nutrient loss by solid manure have been carried out both on the basis of manure heap shelters and open manure heaps. Since present manure heaps are, probably without exception, stored in open manure heaps, the following investigation is alone based on investigations into open manure heaps.

In previous investigations (Hansen, 1928; Iversen and Dorph-Petersen, 1949, and Iversen, 1957), the experiments were carried out on concrete pits with a storage time varying from above 2 and 8 months. In most cases, the investigations have been carried out on cattle manure and in few cases with a mixture of cattle, pig and horse manure. The amount of bedding varied from about 1 kg (normal amount) to 5 kg straw per cow per day. The investigations showed a weight loss of 5-18% and an N loss of 10-30%, the heaviest loss was by storing during the summer months. By increasing the amount of bedding from 1 to 5 kg per cow per day (Hansen, 1928) or adding 100 kg of straw per tonne of manure before storing (Iversen and Dorph-Petersen, 1949), the temperature in the manure increased by 30-40ºC as compared to the temperature of the manure with a smaller amount of straw. Despite the increased conversion in the manure caused by the higher content of straw, it did not give rise to any appreciable change in total N loss, but in the last-mentioned investigation, the admixture of the straw caused that the loss by the NH_3 evaporation made out a greater proportion of the total loss than when straw was not added.

In an extensive review concerning loss of N during the storage of solid manure (Kirchmann, 1985), the loss of N from solid manure has been listed showing the losses of N found by a wide range of investigations into various storage conditions. The loss during storage conditions comparable to storing in open manure heap, is in the range of 20-25% of the total N content of the manure.

In recent investigations into the N loss from manure (Petersen et al., 1996), a considerably heavier loss was found by pig manure than by cattle manure. The loss by pig manure made out 50-55% of the total N content against approx. 20% by cattle manure. The major part of the loss occurred during the first 10-15 days, and in the case of the pig manure, it coincided with a temperature rise to 60-70ºC which indicates that it is a question of composting. The temperature in the cattle manure was very close to the temperature of the air.

The great difference in temperature between the pig and cattle manure is in harmony with investigations made in Sweden where temperatures at 48ºC or above that were found in only 4 out of 83 manure heaps on cattle farms with solid manure, while it was the case in 27 out of 34 manure heaps on pig farms (Forshell, 1993). The greater conversion in the pig manure has obviously resulted in the N loss being proportionally heavier by the pig manure than by the cattle manure. It is therefore reasonable to believe that similar conditions may apply to Denmark, which is also indicated by the above-mentioned investigations. In one of the older reported investigations using manure heap shelter, an N loss of 21 and 14%, respectively, of the N content of the manure was also found in two experiments (Iversen and Dorph-Petersen, 1949). This difference is ascribed to the fact that in experiment 1 where the loss was heaviest, the manure contained proportionately much pig manure, rich in straw, while the manure in experiment 2 primarily consisted of cattle manure where the loss was least.

No Danish experiments are available concerning the loss in storage systems by poultry manure and deep litter.

Based on, e.g., the results of the above-mentioned investigations, Sommer, 1994b and Sommer and Hutchings, 1995, estimate that the annual N loss by solid manure makes out 25% of total N content of the manure.

In the older investigations concerning loss by solid manure, the loss of P and K is in the range of 2-6% for P and 20-45% for K of the total content of the manure.

Comparison between loss in storage systems with previous standard values

Compared to Report No. 82 (Laursen, 1994), almost the same values for ammonia evaporation by slurry and liquid manure have been used. Concerning solid poultry and cattle manure, the losses are unchanged. Based on more recent investigations (Petersen et al., 1996), an adjustment of the losses by solid pig manure from 15 to 30% has occurred, though.

No deep litter loss in storage systems have been stated in Report No. 82, since it is preconditioned that all deep litter is spread directly from the housing system on the field. However, it is not so, since the deep litter is stored in field stack for a shorter or longer period of time before spreading. This applies primarily to deep litter from slaughter pigs and broilers, since the cleanout from the housing systems takes place at the time of delivering the individual animal units and therefore it does not always take place at a time that is convenient for spreading on the field. The N loss has therefore been estimated on average at 25% for deep litter from pigs and broilers, and 10% on average for deep litter from cattle and hens.

Introduction of manure effluent and rainwater to the storage

From solid manure, part of the semi-solid/liquid fraction is lost in the form of manure effluent that is normally introduced into a liquid manure tank or a slurry tank or in rare cases into a separate tank.

In slurry storage tanks without cover, the slurry amount is increased by the net precipitation that falls into the tank. Normally, manure effluent and the amount of precipitation that falls on the manure site are introduced into the liquid manure tanks. The net precipitation is the precipitation minus the evaporation. Concerning both slurry tanks and liquid manure tanks, an amount of net precipitation of 400 mm per year or 0.4 m^3 per m^2 slurry tank surface or manure site are estimated.

Runoff from consolidated areas like silage sites, waste water from washing sites etc., particularly on cattle farms, are often introduced into both slurry tanks and liquid manure tanks. The various runoff has *not* been included in the standard values. Therefore such runoff should be added to the standard values. Normally, a runoff of 0.7 m^3 per m^2 consolidated area is supposed. In addition to that, silage runoff from silaging of beet tops, grass without preliminary drying etc. may be introduced.

Concerning liquid manure (urine), this report includes an introduction of liquid manure of 0.22 m^3 water per tonne of solid manure ex building. The value has been calculated on the basis of a heard size of 75 cows and a manure site for 9 months' storage. The manure site is surrounded by a 2 m marginal zone (without manure) to two sides, and manure stacks of 1.6 m height on average.

Similarly, this report has included an introduction of precipitation water of 0.11 m^3 water per tonne of slurry ex storage. The calculation has been based on a storage time for slurry of 12 months and a height of the slurry tank of 4 m.

Survey of the transfer and loss of nutrients and the introduction of precipitation into manure storage

Manure effluent

11.5% of the amount of manure ex building 8% of the total nitrogen in manure ex building
3% of phosphorus in manure ex building
22% of potassium in manure ex building
Dry matter in manure effluents is 2.7%

Precipitation in storage

Into liquid manure tanks: 0.22 m^3 of water per tonne of solid manure ex building
Into slurry tanks without cover: 0.11 m^3 of water per tonne of slurry ex building

Housing systems cattle, pigs, poultry and other livestock
In *Technology, Appendix 1*, a survey of the parameters used for the calculation of ex building and ex storage for cattle is set out. Also *Technology, Appendix 2,* shows the parameters for the calculation of ex building and ex storage for pigs. In *Technology, Appendix 3*, a survey of other livestock is shown. In the above-mentioned appendices, the housing systems, the amounts of litter (bedding straw) used, the amounts of drinking water waste, milking centre waste water etc. are set out in more detail. The information is obtained from actual investigations and also from experience gained in practice. In practice, there may be great deviations from these average values, and corrections for individual conditions may therefore be necessary.

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8 Tables of the nutrient content ex storage

In this section, the N, P and K content of manure ex storage is set out in the form of tables for the production relevant livestock categories. The individual tables are introduced by specified preconditions for the calculations that have been carried out. In addition, there are footnotes that show how corrections for deviations as compared to the preconditions can be made.

Slaughter pigs, 1 head prod., 68.3 kg gain
(30 kg to 98.3 kg live weight = 30 kg to 75 kg slaughter weight)

Preconditions :

Gain:	68.3 kg
FU_p per kg gain:	2.94
Crude protein per FU_p:	163 g
Phosphorus per FU_p:	5.3 g

Ex animal, total excretion:

Amount	0.34 tons
N	3.28 kg
P	0.69 kg
K	1.43 kg

Amount ex storage: Housing system	Manure type	Manure, t	Dry matter, percentage	Total content: Kg N	Total content: Kg NH_4-N	Total content: Kg P	Total content: Kg K	Content per t manure: Kg N	Content per t manure: Kg NH_4-N	Content per t manure: Kg P	Content per t manure: Kg K
Totally slatted floor	**Slurry**	0.48	6.5	2.73	1.93	0.69	1.43	5.63	3.99	1.42	2.95
Partially slatted floor	**Slurry**	0.48	7.0	2.74	1.94	0.69	1.46	5.69	4.03	1.44	3.04
Solid floor	**Manure +**	0.14	23.0	0.91	0.32	0.59	0.74	6.70	2.34	4.34	5.50
	liquid manure	0.32	1.9	1.42	1.31	0.11	0.84	4.37	4.02	0.35	2.57
Sub-divided lying	**Deep litter**	0.11	33.0	1.02	0.31	0.37	1.12	9.46	2.84	3.42	10.34
area	**+ slurry**	0.27	5.9	1.37	0.97	0.35	0.71	5.11	3.61	1.29	2.67
Deep litter	**Deep litter**	0.22	33.0	2.04	0.61	0.74	2.23	9.46	2.84	3.42	10.34

Quantity correction for deviating weight interval:

Correction factor:

(weight, leaving. - weight, starting) x (22.4 + (0.2 x (weight, leaving + weight, starting)))/3280

Correction of nitrogen amount by deviating feed amount and composition:

Correction factor:

((kg feed per pig produced x kg N per kg feed) - ((slaughter weight x 1.31 – starting live weight) kg x 0.028 kg N per kg gain))/3.28
or ((FU_p per pig produced x g crude protein per FU_p /6250) - ((slaughter weight x 1.31 - starting live weight) kg x 0.028 kg N per kg gain))/3.28

Correction of phosphorus amount by deviating feed amount and composition:

Correction factor:

((kg feed per pig produced x kg P per kg feed) - ((slaughter weight x 1.31 - starting live weight) kg x 0.0055 kg P per kg gain))/0.69
or ((FU_p per pig produced x g phosphorus per FU_p /1000) - ((slaughter weight x 1.31 – starting live weight) kg x 0.0055 kg P per kg gain))/0.69

1 sow per year with 22 pigs at 7.5 kg (weaning)

Preconditions :

FU_p per sow per year:		1300
Crude protein per FU_p:	150 g	
Phosphorus per FU_p:		6.3 g
Weaning, days:	28	

Ex animal, total excretion:

Amount	3.35 tons
N	25.70 kg
P	7.10 kg
K	10.76 kg

Amount ex storage: Housing system	**Manure type**	**Manure, t**	**Dry matter, percentage**	**Total content:** Kg N	Kg NH_4-N	Kg P	Kg K	**Content per t manure** Kg N	Kg NH_4-N	Kg P	Kg K
Individ. housing, part. slatted	**Slurry**	3.67	5.6	21.66	15.35	7.10	10.76	5.90	4.18	1.93	2.93
Individ. housing, solid floor	**Manure +**	0.79	23.0	5.49	1.92	5.33	4.64	6.96	2.44	6.76	5.88
	liquid manure	2.84	2.2	12.76	11.74	1.82	6.98	4.50	4.14	0.64	2.46
Group penning, deep litter	**Deep litter**	2.04	33.0	21.38	6.42	7.64	19.94	10.46	3.14	3.74	9.75
Sub-divided lying area	**Deep litter**	0.79	33.0	5.89	1.77	2.01	6.71	7.46	2.24	2.55	8.50
	+ slurry	2.75	5.6	16.24	11.51	5.33	8.07	5.90	4.18	1.93	2.93

Normally the manure production per sow per year is divided into 2/3 in the mating and gestation houses and 1/3 in the farrowing house.

Correction of nitrogen amount by deviating feed amount and composition:
Correction factor:
((kg feed per sow per year x kg N per kg feed) -1.44 - (number of weaners per sow per year x weaning weight x 0.024 kg N per kg gain))/25.7
or ((FU_p per sow per year x g crude protein per FU_p /6250) - 1.44 - (number of weaners per sow per year x weaning weight x 0.024 kg N per kg gain))/25.7

Correction of phosphorus amount by deviating feed amount and composition:
Correction factor:
((kg feed per sow per year x kg P per kg feed) - 0.3 - (number of weaners per sow per year x weaning weight x 0.005 kg P per kg gain))/7.1
or ((FU_p per sow per year x g P per FU_p /1000) - 0.3 - (number of weaners per sow per year x weaning weight x 0.005 kg P per kg gain))/7.1

1 piglet, 7.5 to 30 kg

Preconditions :

Gain, kg:	22.5
FU_p per kg gain:	2.0
Crude protein per FU_p:	175 g
Phosphorus per FU_p:	7.0 g

Ex animal, total excretion:

Amount:	0.088 tons
N:	0.67 kg
P:	0.19 kg
K:	0.31 kg

Amount ex storage:				**Total content:**				**Content per t manure**			
Housing system	**Manure type**	**Manure, t**	**Dry matter, percentage**	**Kg N**	**Kg NH_4-N**	**Kg P**	**Kg K**	**Kg N**	**Kg NH_4-N**	**Kg P**	**Kg K**
Totally slatted floor	**Slurry**	0.114	4.5	0.57	0.40	0.19	0.31	5.0	3.5	1.68	2.70
Two-climate housing system with partially slatted floor	**Slurry**	0.120	4.9	0.60	0.42	0.19	0.32	5.0	3.5	1.60	2.65
Solid floor	**Manure +**	0.021	23.0	0.15	0.05	0.15	0.14	6.9	2.4	6.91	6.74
	liquid manure	0.076	2.1	0.30	0.28	0.05	0.19	3.9	3.6	0.61	2.53
Two-climate housing system with deep litter	**Deep litter**	0.038	33.0	0.41	0.12	0.20	0.46	10.9	3.3	5.23	11.94

Quantity correction for deviating weight interval:
Correction factor:
(weight, leaving - weight, starting) x (22.4 + (0.2 x (weight, leaving + weight, starting)))/673

Correction of nitrogen amount by deviating feed amount and composition:
Correction factor:
((kg feed per pig produced x kg N per kg feed) - ((leaving weight - weaning weight) x 0.026 kg N per kg gain))/0.67
or (FU_p per pig produced x g crude protein per FU_p /6250 - ((leaving weight - weaning weight) x 0.026 kg N per kg gain))/0.67

Correction of phosphorus amount by deviating feed amount and composition:
Correction factor:
((kg feed per pig produced x kg P per kg feed) - ((leaving weight - weaning weight) x 0.0055 kg P per kg gain))/0.19
or ((FU_p per pig produced x g P per FU_p /1000) – ((leaving weight - weaning weight) x 0.0055 kg P per kg gain))/0.19

1 cow per year, heavy breed

Preconditions :

Milk yield, kg milk/cow per year: 7450
Milk protein, kg/cow per year: 251
FU per cow per year: 6030
Crude protein per FU: 176
Digestible crude protein, g per FU: 131
Phosphorus, g per FU: 5.1
Feed efficiency, %: 82

Ex animal, total excretion:

Amount: 177 tons
N: 128 kg
P: 23.0 kg
K: 100.0 kg

Amount ex storage: Housing system	Manure type	Manure, t	Dry matter, percentage	**Total content:** Kg N	Kg NH_4-N	Kg P	Kg K	**Content per t manure** Kg N	Kg NH_4-N	Kg P	Kg K
Tie-up housing system with	**Manure +**	10.80	20.0	54.8	13.7	21.3	33.6	5.08	1.27	1.97	3.12
dung channel	**liquid manure**	10.41	3.4	58.5	53.8	2.1	72.6	5.62	5.17	0.20	6.98
Tie-up housing system with floor grating	**Manure + liquid manure**	19.84	10.6	121.7	84.5	23.4	106.3	6.14	4.26	1.18	5.36
Cubicles with solid floor	**Slurry**	23.17	9.1	115.3	68.0	23.4	106.3	4.98	2.93	1.01	4.59
Cubicles with slatted floor	**Slurry**	23.17	9.1	121.7	73.9	23.4	106.3	5.25	3.19	1.01	4.59
Deep litter (throughout area)	**Deep litter**	15.62	30.0	128.5	32.1	26.5	158.6	8.23	2.06	1.69	10.15
Deep litter, feeding area with	**Deep litter**	8.27	31.0	65.8	16.4	13.5	83.5	7.96	1.99	1.63	10.10
slatted floor	**+ slurry**	13.05	6.6	59.6	33.8	11.5	50.0	4.57	2.59	0.88	3.83
Straw-bedded sloped floor	**Deep litter**	14.71	24.0	108.4	27.1	24.2	120.9	7.37	1.84	1.65	8.22

Correction of N amount by deviating yield, feed amount and composition.
Correction factor:
((FU per cow per year x g crude protein per FU/6250) - (kg milk per cow per year x % protein in milk/638) - 1.7)/128

Correction of P amount by deviating yield, feed amount and composition.
Correction factor:
((FU per cow per year x g P per FU/1000) - (kg milk per cow per year x 0.00096) - 0.5)/23

1 cow per year, Jersey

Preconditions :

Milk yield, kg milk/cow per year:	5230
Milk protein, kg/cow per year:	213
FU per cow per year:	5000
Crude protein per FU:	176
Digestible crude protein, g per FU:	130
Phosphorus, g per FU:	5.0
Feed efficiency, %	84

Ex animal, total excretion:

Amount:	15.0 tons
N:	107.0 kg
P:	19.0 kg
K:	75.0 kg

Amount ex storage: Housing system	Manure type	Manure, t	Dry matter, percentage	**Total content:** Kg N	Kg NH_4-N	Kg P	Kg K	**Content per t manure** Kg N	Kg NH_4-N	Kg P	Kg K
Tie-up housing system with dung channel	**Manure +**	9.26	20.0	46.5	11.6	17.8	28.8	5.02	1.26	1.92	3.11
	liquid manure	8.86	3.3	48.5	44.6	1.5	52.5	5.47	5.04	0.17	5.93
Tie-up housing system with floor grating	**Manure + liquid manure**	16.92	10.6	102.2	69.6	19.4	81.3	6.04	4.11	1.14	4.80
Cubicles with solid floor	**Slurry**	20.25	8.9	96.8	56.0	19.4	81.3	4.78	2.76	0.96	4.01
Cubicles with slatted floor	**Slurry**	20.25	8.9	102.2	60.7	19.4	81.3	5.05	3.00	0.96	4.01
Deep litter (throughout area)	**Deep litter**	14.70	30.0	110.9	27.7	22.5	133.6	7.55	1.89	1.53	9.09
Deep litter, feeding area with slatted floor	**Deep litter**	7.83	31.0	57.0	14.2	11.5	71.0	7.28	1.82	1.47	9.07
	+ slurry	11.59	6.1	49.8	27.6	9.5	37.5	4.30	2.38	0.82	3.24
Straw-bedded sloped floor	**Deep litter**	13.19	24.0	91.8	22.9	20.2	95.9	6.96	1.74	1.54	7.28

Correction of N amount by deviating yield, feed amount and composition.
Correction factor:
((FU per cow per year x g crude protein per FU/6250) - (kg milk per cow per year x % protein in milk/638) - 1.0)/107

Correction of P amount by deviating feed amount and composition.
Correction factor:
((FU per cow per year x g P for FU/1000) - (kg milk per cow per year x 0.00108) - 0.3)/19

Heifer calves, 0-6 months

Preconditions:

	Heavy breed	Jersey
Number of FU:	188	158
Crude protein, g per FU:	199	199
Digest. crude protein, g per FU:	152	152
Phosphorus, g pr. FU:	3.3	3.3

Ex animal, total excretion:

	Heavy breed	Jersey
Amount	0.43	0.37 tons
N	5.80	4.90 kg
P	0.20	0.20 kg
K	3.0	3.0 kg

Amount ex storage: **Animal group**	**Manure type**	**Manure, t**	**Dry matter, percentage**	**Total content:**				**Content per t manure**			
				Kg N	Kg NH_4-N	Kg P	Kg K	Kg N	Kg NH_4-N	Kg P	Kg K
Heavy breed, 0.215 heads	**Deep litter**	0.36	23.0	5.34	1.33	0.28	4.32	14.73	3.68	0.77	11.93
Jersey, 0.240 heads	**Deep litter**	0.31	23.0	4.52	1.13	0.27	4.15	14.46	3.61	0.86	13.27

Heifers, heavy breed, 6 months until calving (28 months),
share of breeding stock per year, 0.785 heads (permanently housed)

Preconditions :

Number of FU:	1406
Crude protein per FU.:	160
Digestible crude protein, g per FU:	108
Phosphorus, g per FU:	4.5

Ex animal, total excretion:

Amount:	4.16 tons
N:	30.8 kg
P:	4.7 kg
K:	33.0 kg

Amount ex storage: **Housing system**	**Manure type**	**Manure, t**	**Dry matter, percentage**	**Total content:**				**Content per t manure**			
				Kg N	**Kg NH_4-N**	**Kg P**	**Kg K**	**Kg N**	**Kg NH_4-N**	**Kg P**	**Kg K**
Tie-up housing system with dung channel	**Manure +**	2.91	23.3	13.3	3.3	4.5	12.4	4.58	1.15	1.54	4.27
	liqu. manure	2.35	3.4	14.3	13.1	0.4	22.9	6.08	5.59	0.16	9.76
Tie-up housing system with floor grating	**Slurry**	4.85	12.3	29.3	20.0	4.8	34.6	6.06	4.14	0.99	7.15
Cubicles with solid floor	**Slurry**	4.85	12.3	27.8	18.0	4.8	34.6	5.74	3.71	0.99	7.15
Cubicles with slatted floor	**Slurry**	4.85	12.3	29.3	20.0	4.8	34.6	6.06	4.14	0.99	7.15
Deep litter (throughout area)	**Deep litter**	4.61	28.0	31.5	7.9	5.6	48.8	6.85	1.71	1.22	10.59
Deep litter, short feeding area, with solid floor	**Deep litter**	4.73	28.0	31.8	7.9	5.7	49.4	6.72	1.68	1.20	10.45
Deep litter, feeding area with slatted floor	**Deep litter**	2.30	28.0	15.8	3.9	2.8	24.4	6.85	1.71	1.22	10.59
	+ slurry	2.46	10.1	14.3	9.4	2.4	16.5	5.82	3.81	0.95	6.70
Straw-bedded sloped floor	**Deep litter**	4.97	24.0	27.3	6.8	5.2	41.6	5.49	1.37	1.05	8.36
Slatted-floor pens	**Slurry**	4.71	10.6	27.8	18.4	4.7	33.0	5.89	3.91	1.00	7.00

Heifers, Jersey, 6 months until calving (24 months), share of breeding stock per year, 0.760 heads (permanently housed)

Preconditions :

Number of FU:	1018
Crude protein per FU.:	160
Digestible crude protein, g per FU:	108
Phosphorus, g per FU:	4.5

Ex animal, total excretion:

Amount:	3.0 tons
N:	22.0 kg
P:	3.4 kg
K:	24.0 kg

Amount ex storage: Housing system	Manure type	Manure, t	Dry matter, percentage	Total content: Kg N	Total content: Kg NH_4-N	Total content: Kg P	Total content: Kg K	Content per t manure: Kg N	Content per t manure: Kg NH_4-N	Content per t manure: Kg P	Content per t manure: Kg K
Tie-up housing system with dung channel	**Manure + liqu. manure**	2.25 1.67	23.7 3.1	10.5 9.3	2.6 8.5	3.3 0.3	10.6 15.6	4.66 5.55	1.17 5.11	1.45 0.16	4.71 9.35
Tie-up housing system with floor grating	**Slurry**	3.58	12.7	21.1	14.0	3.5	25.6	5.90	3.92	0.98	7.15
Cubicles with solid floor	**Slurry**	3.58	12.7	20.0	12.7	3.5	25.6	5.59	3.54	0.98	7.15
Cubicles with slatted floor	**Slurry**	3.58	12.7	21.1	14.0	3.5	25.6	5.90	3.92	0.98	7.15
Deep litter (throughout area)	**Deep litter**	4.07	28.0	24.0	6.0	4.3	39.3	5.90	1.47	1.06	9.66
Deep litter, short feeding area, with solid floor	**Deep litter**	4.19	28.0	24.2	6.1	4.3	39.9	5.78	1.45	1.04	9.53
Deep litter, feeding area with slatted floor	**Deep litter + slurry**	2.03 1.83	28.0 9.8	12.0 10.2	3.0 6.5	2.2 1.7	19.6 12.0	5.90 5.59	1.47 3.55	1.06 0.93	9.66 6.55
Straw-bedded sloped floor	**Deep litter**	4.21	24.0	20.2	5.1	3.9	32.2	4.81	1.20	0.92	7.67
Slatted-floor pens	**Slurry**	3.45	10.4	19.8	12.9	3.4	24.0	5.75	3.73	0.99	6.95

Bull calves, 1 beef calf produced, 0-6 months

Preconditions:

	Heavy breed	Jersey
Number of FU:	620	465
Crude protein per FU:	169	169
Digest. crude protein, g per FU:	127	127
Phosphorus, g per FU:	4.3	4.3

Ex animal, total excretion

	Heavy breed	Jersey
Amount:	1.14	0.86 t
N:	11.6	8.8 kg
P:	2.1	1.6 kg
K:	8.0	6.0 g

Amount ex storage: Animal group	Manure type	Manure, t	Dry matter, percentage	**Total content:** Kg N	Kg NH_4-N	Kg P	Kg K	**Content per t manure** Kg N	Kg NH_4-N	Kg P	Kg K
Heavy breed, final weight 220 kg	**Deep litter**	0.92	23.0	10.85	2.71	2.29	11.13	11.84	2.96	2.49	12.15
Jersey, final weight 145 kg	**Deep litter**	0.72	23.0	8.28	2.07	1.75	8.51	11.56	2.89	2.44	11.88

1 bull, heavy breed, 1 animal produced,
6 months to 440 kg

Preconditions :

Gain, kg:	220
Number of FU:	1280
Crude protein, g per FU:	145
Digestible crude protein, g per FU:	105
Phosphorus, g per FU:	5.2

Ex animal, total excretion:

Amount:	2.82
tons	
N:	24.3 kg
P:	5.2 kg
K:	12.0 kg

Amount ex storage: **Housing system**	**Manure type**	**Manure, t**	**Dry matter, percentage**	**Total content:**				**Content per t manure**			
				Kg N	**Kg NH_4-N**	**Kg P**	**Kg K**	**Kg N**	**Kg NH_4-N**	**Kg P**	**Kg K**
Tie-up housing system with dung channel	**Manure +**	1.99	20.6	9.68	2.42	4.89	5.41	4.86	1.22	2.45	2.72
	liqu. manure	1.70	3.1	12.11	11.14	0.41	8.19	7.14	8.57	0.24	4.83
Tie-up housing system with floor grating	**Slurry**	3.52	12.8	23.09	18.45	5.27	13.14	6.56	5.25	1.50	3.74
Deep litter (throughout area)	**Deep litter**	3.04	28.0	24.35	6.09	5.85	22.99	8.02	2.01	1.93	7.57
Deep litter, feeding area with slatted floor	**Deep litter**	1.52	28.0	12.17	3.04	2.93	11.49	8.02	2.01	1.93	7.57
	+ slurry	1.84	9.9	11.31	7.86	2.80	6.00	6.14	4.27	1.41	3.26
Straw-bedded sloped floor	**Deep litter**	3.20	24.0	21.26	5.31	5.55	17.95	6.65	1.66	1.74	5.62
Slatted-floor pens	**Slurry**	3.41	10.8	21.91	16.48	5.20	12.00	6.43	4.84	1.53	3.52

Correction for deviating leaving weight.
Correction factor:
((1.825 x weight, leaving + 0.00605 x (weight, leaving)^2 - 75) – 620)/1280
l
Correction of N amount by deviating gain, feed amount and composition.
Correction factor:
((FU per bull from 6 months until leaving x g crude protein per FU/6250) - (kg gain x 0.0245))/24.3

Correction of P amount by deviating gain, feed amount and composition.
Correction factor:
((FU per bull from of 6 months until leaving x g P/FU/1000) - (kg gain x 0.0064))/5.2

1 bull, Jersey, 1 animal produced,
6 months to 328 kg

Preconditions :

Gain, kg:	183
Number of FU:	960
Crude protein, g per FU:	145
Digestible crude protein, g per FU:	105
Phosphorus, g per FU:	5.2

Ex animal, total excretion:

Amount:	2.11 tons
N:	18.2 kg
P:	3.9 kg
K:	9.0 kg

Amount ex storage: Housing system	Manure type	Manure, t	Dry matter, percentage	Total content:				Content per t manure			
				Kg N	Kg NH_4-N	Kg P	Kg K	Kg N	Kg NH_4-N	Kg P	Kg K
Tie-up housing system with dung channel	**Manure +**	1.60	21.2	8.0	2.0	3.7	5.1	5.01	1.25	2.31	3.20
	liqu. manure	1.28	2.8	8.4	7.7	0.3	5.5	6.51	5.99	0.24	4.27
Tie-up housing system with floor grating	**Slurry**	2.66	10.8	17.4	13.8	4.0	10.1	6.55	5.19	1.49	3.82
Deep litter (throughout area)	**Deep litter**	2.67	29.4	19.2	4.8	4.6	20.0	7.22	1.80	1.71	7.50
Deep litter, feeding area with slatted floor	**Deep litter**	1.32	29.7	9.6	2.4	2.3	10.0	7.28	1.82	1.72	7.56
	+ slurry	1.42	7.7	8.5	5.7	2.0	4.5	5.96	4.00	1.37	3.17
Straw-bedded sloped floor	**Deep litter**	2.72	25.0	16.4	4.1	4.3	15.0	6.05	1.51	1.56	6.60
Slatted-floor pens	**Slurry**	2.56	8.6	16.4	12.2	3.9	9.0	6.40	4.76	1.52	3.51

Correction for deviating leaving weight.
Correction factor:
((2.308 x weight, leaving + 0.00676 x (weight, leaving)^2 - 35) – 465)/980

Correction of N amount by deviating gain, feed amount and composition.
Correction factor:
((FU per bull from of 6 months until leaving x g crude protein per FU/6250) - (kg gain x 0.0245))/18.2

Correction of P amount by deviating gain, feed amount and composition.
Correction factor:
((FU per bull from of 6 months until leaving x g P/FU/1000) - (kg gain x 0.0064))/3.9

Suckler cows, 1 animal per year excl. replacement heifers, (permanently housed)

Preconditions :

Number of FU:	2515
Crude protein, g per FU:	200
Digestible crude protein, g per FU:	148
Phosphorus, g per FU:	3.6

Ex animal, total excretion:

Amount:	8.53 tons
N:	57.1 kg
P:	7.5 kg
K:	64.5 kg

Amount ex storage: Housing system	Manure type	Manure, t	Dry matter, percentage	Total content: Kg N	Kg NH_4-N	Kg P	Kg K	Content per t manure: Kg N	Kg NH_4-N	Kg P	Kg K
Tie-up housing system with dung channel	**Manure +**	5.56	22.8	21.4	5.4	6.8	19.0	3.85	0.96	1.23	3.42
	liquid manure	4.67	3.8	29.7	27.3	0.8	48.7	6.36	5.85	0.17	10.41
Deep litter (throughout area)	**Deep litter**	8.34	29.8	58.5	14.6	9.2	93.8	7.01	1.75	1.10	11.25
Deep litter and slatted floor	**Deep litter**	4.40	30.8	30.0	7.5	4.7	49.0	6.82	1.70	1.07	11.14
	+ slurry	4.72	10.8	26.6	16.9	3.7	32.3	5.63	3.59	0.79	6.84
Straw-bedded sloped floor	**Deep litter**	7.03	23.9	49.4	12.4	8.2	77.1	7.03	1.76	1.17	10.96

Broilers

Preconditions	Feed per animal produced, kg	Gain, kg	Protein in feed, %	Phosphorus in feed, %	Potassium in feed, %	Ex animal, total excretion: Amount, tons	N, kg	P, kg	K, kg
1000 broilers, 36 days	2.7	1.6	20.5	0.65	0.80	2.8	42.8	7.0	17.1
1000 broilers, 39 days	3.1	1.8	20.5	0.65	0.80	3.2	51.3	8.5	20.1
1000 broilers, 42 days	3.6	2.0	20.5	0.65	0.80	3.7	59.8	10.0	23.0
100 turkeys, heavy	37.0	14.0	18.5	0.80	0.80	3.8	69.2	20.2	25.8
100 turkeys, young	7.9	4.5	24.0	0.80	0.90	0.81	17.4	3.3	5.9
100 ducks	10.5	3.5	17.0	0.70	0.70	1.2	20.2	5.4	6.5
100 geese	28.0	6.5	16.0	0.70	0.60	3.1	56.1	16.0	15.3

Type of poultry	Manure type	Content ex storage: Manure, t	Dry matter, %	Kg N total	Kg NH_4-N total	Kg P total	Kg K total	Kg N per t	Kg NH_4-N per t	Kg P per t	Kg K per t
Broilers, 36 days, 1000 produced	Deep litter	1.0	57.8	26.3	7.9	7.1	18.2	26.6	8.0	7.1	18.5
Broilers, 39 days, 1000 produced	Deep litter	1.2	57.8	31.5	9.4	8.6	21.2	27.2	8.2	7.4	18.4
Broilers, 42 days, 1000 produced	Deep litter	1.3	57.8	36.6	11.0	10.1	24.1	27.7	8.3	7.6	18.3
Turkeys, heavy, 133 days 100 prod.	Deep litter	1.5	52.1	42.2	10.6	20.2	26.4	27.6	6.9	13.3	17.3
Turkeys, young, 70 days, 100 prod.	Deep litter	0.33	54.9	10.7	2.7	3.3	6.2	32.2	8.1	10.0	18.9
Ducks, 52 days, 100 produced	Deep litter	0.54	71.1	13.0	3.6	5.6	9.4	24.1	6.7	10.3	17.3
Geese, 91 days, 100 produced	Deep litter	1.3	56.0	34.8	9.8	16.2	18.2	26.3	7.4	12.2	13.7

Quantity correction for deviating feed amount and composition:

The nitrogen amount is corrected by the following factor (per 1000 broilers; per 100 turkeys, ducks, geese):

Broilers, 36 days	((kg feed per chicken produced x protein percentage of feed x 1.6) - (kg gain per chicken produced x 28.8))/42.8
Broilers, 39 days	((kg feed per chicken produced x protein percentage of feed x 1.6) - (kg gain per chicken produced x 28.8))/51.3
Broilers, 42 days	((kg feed per chicken produced x protein percentage of feed x 1.6) - (kg gain per chicken produced x 28.8))/59.8
Turkeys, heavy	((kg feed per turkey produced x protein percentage of feed x 0.16) - (kg gain per turkey produced x 2.88))/69.2
Turkeys, young	((kg feed per turkey produced x protein percentage of feed x 0.16) - (kg gain per turkey produced x 2.88))/17.4
Ducks	((kg feed per duck produced x protein percentage of feed x 0.16) - (kg gain per duck produced x 2.4))/20.2
Geese	((kg feed per goose produced x protein percentage of feed x 0.16) - (kg gain per goose produced x 2.4))/56.1

The amount of phosphorus amount is corrected with the following factor (per 1000 broilers, per 100 turkeys, ducks, geese):

Broilers, 36 days	((kg feed per chicken produced x phosphorus percentage of feed x 10) - (kg gain per chicken produced x 6.7))/7.0
Broilers, 39 days	((kg feed per chicken produced x phosphorus percentage of feed x 10) - (kg gain per chicken produced x 6.7))/8.5
Broilers, 42 days	((kg feed per chicken produced x phosphorus percentage of feed x 10) - (kg gain per chicken produced x 6.7))/10.0
Turkeys, heavy	((kg feed per turkey produced x phosphorus percentage of feed) - (kg gain per turkey produced x 0.67))/20.2
Turkeys, young	((kg feed per turkey produced x phosphorus percentage of feed) - (kg gain per turkey produced x 0.67))/3.3
Ducks	((kg feed per duck produced x phosphorus percentage of feed) - (kg gain per duck produced x 0.55))/5.4
Geese	((kg feed per goose produced x phosphorus percentage of feed) - (kg gain per goose produced x 0.55))/16

Hens and pullets

Preconditions and content ex animal:	Per introduced hen				In feed, %			Ex animal, total excretion: per 100 hens per year/ 100 produced			
	Prod. time, days	Gain, kg	Eggs prod., kg	Feed, kg	Protein	P	K	Amount, tons	N kg	P kg	K kg
Free-range hens	357	0.65	15.85	41.62	17.0	0.65	0.70	4.5	81.3	23.0	26.5
Organic hens	357	0.65	15.14	45.05	17.0	0.65	0.70	4.9	91.7	25.4	28.9
Deep-litter hens	385	0.65	17.14	46.43	17.0	0.65	0.70	4.7	85.4	24.1	27.5
Battery hens	413	0.65	20.18	46.02	17.0	0.65	0.70	4.3	74.2	21.7	25.1
Par. stock f. broiler prod.	315	2.00	10.27	54.90	16.0	0.60	0.70	5.6	128.9	32.8	40.5
Pullets, layer type	119	1.35	-	5.30	15.5	0.75	0.65	0.54	9.3	3.1	3.1
Pullets, par. st. br. prod.	119	1.70	-	7.50	15.0	0.65	0.60	0.77	13.1	3.7	4.0

Type of poultry	Manure storage	Manure type	Content ex storage									
			Manure, t	Dry m., %	Kg N total	Kg NH_4-N, total	Kg P total	Kg K total	Kg N, per ton	Kg NH_4-N, per ton	Kg P, per ton	Kg K, per ton
Free-range, floor prod. with outside area, 100 hens per yr	Deep-litter area Manure basin	Deep litter + manure	0.61 1.89	63.3 40.0	13.20 24.88	3.56 8.71	6.91 13.80	8.09 15.90	21.5 13.2	5.8 4.6	11.3 7.3	13.2 8.4
Organic, floor prod. with outside area, 100 hens per yr	Deep-litter area Manure basin	Deep litter + manure	0.66 2.05	63.3 40.0	14.89 28.06	4.02 9.82	7.63 15.24	8.81 17.34	22.4 13.7	6.1 4.8	11.5 7.4	13.3 8.5
Deep-litter hens without outside area, 100 hens per year	Deep-litter area Manurebasin	Deep litter + manure	0.70 2.19	63.2 40.0	15.25 29.18	4.12 10.21	7.96 16.15	9.21 18.43	21.8 13.3	5.9 4.7	11.4 7.4	13.2 8.4
Battery hens, 100 hens per yr	Manure cellar	Manure	3.03	40.0	55.50	19.43	21.70	25.10	18.3	6.4	7.2	8.3
Battery hens, 100 hens per yr	Slurry tank	Slurry	8.72	11.1	63.99	40.95	21.70	25.10	7.3	4.7	2.5	2.9
Battery hens, 100 hens per yr	Manure shelter	Manure	3.03	40.0	55.50	19.43	21.70	25.10	18.3	6.4	7.2	8.3
Parent stock for broiler prod. floor man. 100 hens per year	Floor area	Deep litter	2.55	63.0	78.42	21.17	32.82	40.91	30.7	8.3	12.9	16.0
Pullets, layer type, mesh prod., 119 days, 100 prod.	Slurry tank	Slurry	0.97	11.1	8.02	5.13	3.10	3.10	8.2	5.3	3.2	3.2
Pullets, layer type, floor man., 119 days, 100 produced	Floor area	Deep litter	0.27	68.9	5.83	1.57	3.14	3.79	21.6	5.8	11.6	14.0
Pullets, parent stock for broiler prod., floor man., 119 days, 100 produced	Floor area	Deep litter	0.38	68.3	8.20	2.22	3.76	4.93	21.5	5.8	9.9	12.9

Correction for deviating feed amount and composition (per 100 hens per year/100 produced):

The nitrogen amount can be corrected by means of the following factor:

Free-range hens	((kg feed per hen introd. x protein percentage in feed x 0.16) -(kg egg per hen introd. x 1.81) - (kg gain per hen introd. x 2.88))/82.6
Organic hens	((kg feed per hen introd. x protein percentage in feed x 0.16) - (kg egg per hen introd. x 1.81) - (kg gain per hen introd. x 2.88))/93.2
Deep-litter hens	((kg feed per hen introd. x protein percentage in feed x 0.16) - (kg egg per hen introd. x 1.81) - (kg gain per hen introd. x 2.88))/93.4
Battery hens	((kg feed per hen introd. x protein percentage in feed x 0.16) - (kg egg per hen introd. x 1.81) - (kg gain per hen introd. x 2.88))/86.8
Par. st. broiler prod.	((kg feed per hen introd. x protein percentage in feed x 0.16) - (kg egg per hen introd. x 1.81) - (kg gain per hen introd. x 2.88))/116.2
Pullets, layer type	((kg feed per pullet produced x protein percentage in feed x 0.16) - (kg gain per pullet produced x 2.88))/9.3
Pullets, par. st. br. prod.	((kg feed per pullet produced x protein percentage in feed x 0.16) - (kg egg per pullet produced x 2.88))/13.1

The phosphorus amount can be corrected by means of the following factor:

Free-range hens	((kg feed per hen introd. x phosphorus percentage in feed) - (kg egg per hen introd. x 0.2) - (kg gain per hen introd. x 0.67))/23.4
Organic hens	((kg feed per hen introd. x phosphorus percentage in feed) - (kg egg per hen introd. x 0.2) - (kg gain per hen introd. x 0.67))/25.8
Deep-litter hens	((kg feed per hen introd. x phosphorus percentage in feed) - (kg egg per hen introd. x 0.2) - (kg gain per hen introd. x 0.67))/26.3
Battery hens	((kg feed per hen introd. x phosphorus percentage in feed) - (kg egg per hen introd. x 0.2) - (kg gain per hen introd. x 0.67))/25.4
Par. st. broiler prod.	((kg feed per hen introd. x phosphorus percentage in feed) - (kg egg per hen introd. x 0.2) - (kg gain per hen introd. x 0.67))/29.5
Pullets, layer type	((kg feed per pullet produced x phosphorus percentage in feed) - (kg gain per pullet produced x 0.67))/3.1
Pullets (par. st. br.. prod.)	((kg feed per pullet produced x phosphorus percentage in feed) - (kg gain per pullet produced x 0.67))/3.7

Fur-bearing animals   Ex animal, total excretion:

Preconditions for mink:
5.22 kits per female per year
35.5 kg feed per pelt produced

	Mink, female per year	Mink, 1000 pelts	Foxes + finnraccon, female per year
Amount, tons	0.16	29.8	0.41
N, kg	4.59	879	12.09
P, kg	0.90	171	2.41
K, kg	0.42	80	1.08

Housing system	Manure type	Content ex storage									
		Manure, t	Dry m., %	Kg N total	Kg NH_4-N, total	Kg P total	Kg K total	Kg N, per ton	Kg NH_4-N, per ton	Kg P, per ton	Kg K, per ton
Mink, 1 female per year	Slurry	0.31	5.5	1.58	1.16	0.90	0.47	5.1	3.8	2.9	1.5
Mink, 1 female per year	Solid manure	0.09	20.2	1.00	0.45	0.84	0.14	11.0	4.9	9.1	1.5
Mink, 1000 pelts	Slurry	58.9	5.5	303	221	172	90	5.1	3.8	2.9	1.5
Mink, 1000 pelts	Solid manure	17.5	20.2	192	87	160	27	11.0	4.9	9.1	1.5
Foxes and finnracoons, per female per year	Slurry	0.78	4.4	4.15	3.03	2.41	1.08	5.3	3.9	3.1	1.4
Foxes and finnracoons, per female per year	Solid manure	0.13	27.0	2.68	1.20	2.24	0.26	20.9	9.4	17.5	2.0

Mink:
Correction of nitrogen, phosphorus and potassium amounts by changed feed consumption per pelt produced:

The nitrogen, phosphorus and potassium amount is corrected by means of the following factor (see Section 5.3):
Kg feed per pelt produced/35.5

1 mature horse per year

Preconditions:	FU per day	Digest. crude protein per FU
Horses, 400 kg	5.2	80
Horses, 600 kg	7.0	80
Horses, 800 kg	8.8	80

Ex animal, total excretion:

	400 kg	600 kg	800 kg
Amount, t	2.9	4.4	5.8
N, kg	38.0	50.0	63.0
P, kg	6.0	8.0	10.0
K, kg	35.0	46.0	58.0

		Content ex storage									
Weights	Manure type	Manure, t	Dry matter, %	Kg N total	Kg NH_4N total	Kg P total	Kg K total	Kg N per t	Kg NH_4N per t	Kg P per t	Kg K per t
Horses, 400 kg	Deep litter	4.3	26.0	33.7	8.4	6.8	49.0	7.8	1.9	1.6	11.3
Horses, 600 kg	Deep litter	6.5	26.0	45.2	11.3	9.2	66.9	6.9	1.7	1.4	10.3
Horses, 800 kg	Deep litter	8.7	26.0	57.5	14.4	11.7	85.9	6.6	1.7	1.3	9.9

1 ewe with lamb per year, permanently housed

Preconditions:

Feed consumption, FU 800

Ex animal, total excretion:

Amount	2.81 t
N	21.9 kg
P	3.7 kg
K	25.6 kg

		Content ex storage									
	Manure type	Manure, t	Dry matter, %	Kg N total	Kg NH_4 – N total	Kg P total	Kg K total	Kg N per t	Kg NH_4-N per t	Kg P per t	Kg K per t
Ewe with lamb	Deep litter	2.38	34.6	18.8	4.7	4.0	31.8	7.9	2.0	1.7	13.4

9 Manure on a national scale

Leif Knudsen
The National Department of Plant Production
15 Udkærsvej, Skejby, DK-8200 Aarhus N

The calculations are based on statistical information obtained from Statistics Denmark's June counts 1995, other information obtained from Statistics Denmark 1995, information provided by various national departments of The Danish Agricultural Advisory Centre, and by The Danish Poultry Council. This section describes the practice followed.

Dairy cattle, heavy breed and Jersey
Statistics Denmark's June counts have been applied directly. The number is divided into heavy breed and Jersey according to Report No. 68 by The National Department of Cattle Husbandry on the basis of 3 counts made by the Ydelseskontrollen (Milk recording) 1988, 1995 and 1996. The division of the manure excreted during housing and during grazing is calculated on the basis of the feed consumption during grazing by means of the Periodic Feed Control average (10%).

Heifers, from birth until calving
The standards for breeding are divided into two periods: from birth until 6 months and from 6 months until calving. Statistics Denmark provides information on all heads of breeding stock. The standards are stated in the share of head of breeding stock per year. Thus, the counts obtained from Statistics Denmark have been used directly. The grazing season is calculated by the rule of three based on the division of nitrogen excreted in housing systems and grazing, cf. the information set out under Section 2 (Cattle, ex animal).

Slaughter calves - young bulls
The standards in Statistics Denmark are divided into age categories. For a calculation of the number of young bulls produced, the number of bulls is divided into heavy breed (91.5%) and Jersey (8.5%). Then the number of bulls has been converted into bulls produced per year according to a production time for Jersey of 358 days and heavy breed of 382 days. Bulls and bullocks above 2 years are estimated at one young bull produced. The division between slaughter calves/ young bulls is subject to some uncertainty, since the slaughter for special purposes may occur at different slaughter weights. In the final returns, it is of minor importance, though.

Suckler cows
The number of suckler cows is obtained directly from Statistics Denmark. The grazing season has been calculated by means of the rule of three based on the division of the nitrogen excreted in housing systems and during grazing, cf. the information set out under Section 2 (Cattle, ex animal)

Sows
The number of sows has been obtained directly from Statistics Denmark's counts.

Piglets 7-30 kg
The number of piglets has been calculated on the basis of the number of slaughters (slaughter pigs) plus the export of live pigs (slaughter pigs and piglets) plus replacement gilts (culled sows). The information is obtained directly from Statistics Denmark and the Danish Bacon and Meat Council.

Slaughter pigs
The number of slaughter pigs is the number of pigs slaughtered plus the export of live slaughter pigs plus the addition of culled sows. The culled sows are added in order to have included the replacement gilts up to slaughter weight, since they are not included in the standards for sows.

Pigs in general
Concerning pigs, the distribution of pigs into the housing systems are based on information obtained from the Danish Bacon and Meat Council based on an investigations performed by Danish Crown (group of slaughterhouses).

Broilers
The number of broilers has been obtained from the report by authorised Danish poultry slaughterhouses (112 million) plus the addition of 7 million of broilers being slaughtered at foreign slaughterhouses. The average slaughter age of 39 days has been established on the basis of the information provided by the report submitted to The Danish Poultry Council by the poultry slaughterhouses.

Turkeys
The number of turkeys has been obtained from the survey of slaughters by Statistics Denmark. The calculation estimates that all turkeys have been heavy turkeys.

Ducks and geese
The number of ducks has been obtained from the survey of slaughters by Statistics Denmark. The number of geese has been calculated as a factor 2 multiplied by Statistics Denmark's counts. There is considerable uncertainty concerning the number of both geese and ducks, since many are privately slaughtered. Brood geese and brood ducks have not been included in the statistics. In relation to their modest number as compared to the total animal stock, it causes a minor uncertainty, though, in respect of the total number.

Hens
The number of hens and the division into production systems have been made on the basis of information from the poultry sector. The record has been based on the number of hens on poultry farms that supply eggs to authorised egg packing stations. The record is based on the anticipation that there are 4.4 million layer type hens divided into the following production

systems. On the basis of that, the number of hens per year has been calculated on the basis of the production time.

	Number (1000)	Production time	Hens per year (1000)
Battery hens	3,362	413	2,873
Deep-litter hens	532	385	487
Free-range hens	330	357	325
Organic hens	176	357	173
Total	4,400		3,858

The record of hens is the number of hens on poultry farms that supply to authorised egg packing stations.

Concerning parent stock for broiler production (HPV hens), the size of production is estimated at 1 million.

Pullets
The number of pullets is obtained from Statistics Denmark. The division of pullets into mesh production and deep-litter systems is obtained from the division between battery hens and other hens.

Fur-bearing animals
The number of mink females, foxes and finnracoons is obtained directly from Statistics Denmark. It is estimated that all fur-bearing animals are confined in "slurry systems".

Horses
The number of horses and the division according to weight is obtained from The National Department of Horse Breeding.

Breeding ewes
The number of breeding ewes is obtained from Statistics Denmark.

Amounts on a national scale
The N excretion ex animal makes out a total of 270 million kg. Of this, an amount of about 30 million kg is excreted during grazing and 240 million kg when housed.

Compared to Report No. 82 (from the Institute of Agricultural Economics, 1994), the excretion ex animal has been reduced by about 30 million kg N. The amount excreted during grazing has been reduced by about 15 million kg N which is due to a change in the calculation method used. Concerning ex storage when spread on the field, a nitrogen amount that is approx. 200 million kg N or approx. 15 million kg N below the values of Report No. 82 has been calculated.

The amounts of phosphorus and potassium have been increased from 44 to 49 and from 151 to 156 million kg ex building as compared to Report No. 82. The amount of potassium excreted during grazing has been reduced from 41 to 30 million kg.

Survey of standards		Total ex animal, incl. grazing			Total content ex building			Total content ex storage				Excreted during grazing		
	Number	Total nitrogen	Phos-phorus	Potas-sium	Total nitrogen	Phos-phorus	Potassium	Total nitro-gen	Nitrogen, NH4	Phosphorus	Potassium	Total nitrogen	Phosphorus	Potassium
		----------1000 kg----------			----------1000 kg----------			-------------1000 kg-----------				---------1000 kg----------		
Cows per year, heavy breed	611152	78227	14056	61115	68648	12917	59496	65668	41147	12917	59496	7823	1406	6112
Cows per year, Jersey	91321	9771	1735	6849	8411	1562	6681	8039	4963	1562	6681	977	174	685
Breed. stock 0-6 mo.,hvy br., share of br. stock per yr	750145	4351	150	2250	4447	209	3240	4003	1001	209	3240			
Breed. stock 0-6 mo., Jersey, share of br. stock per yr	112091	549	22	336	563	30	465	507	127	30	465			
Breed. stock 6-28 mo., hvy br., share br. stock per yr	750145	23104	3526	24755	10857	1768	13748	10208	4939	1768	13748	12407	1893	13293
Breed. stock 6-24 mo., Jersey, share br. stock per yr	112091	2466	381	2690	1194	196	1576	1121	524	196	1576	1324	205	1445
Bulls produced, 0-6 mo., heavy breed	347500	4031	730	2780	4190	794	3869	3771	943	794	3869			
Bulls produced, 0-6 mo., Jersey	34175	301	55	205	314	60	291	283	71	60	291			
Bulls produced, 6 mo. - 440 kg, heavy breed	347500	8444	1807	4170	8484	1901	5763	7983	4276	1901	5763			
Bulls produced, 6 mo. - 328 kg, Jersey	34175	622	133	308	641	143	464	602	315	143	464			
Suckler cows, excl. of breeding stock, perm. housed	124466	7107	933	8028	3075	434	4383	2773	789	434	4383	4361	570	4932
Bulls and bullocks above 2 years	8870	161	35	142										
Sows per year with pigs up to 7 kg	1015077	26087	7207	10912	21976	7098	11300	21233	13968	7089	11300	522	144	218
Piglets, 7-30 kg, produced	20148000	13499	3828	6246	11729	3858	6375	11316	7994	3858	6375			
Slaughter pigs, 30-98.3 kg produced	19710000	64649	13600	28185	54748	13671	29378	51420	36156	13671	29378			
Broilers, 36 days, 1000 produced														
Broilers, 39 days, 1000 produced	119486	6130	1016	2402	5013	1024	2539	3760	1128	1024	2539			
Broilers, 42 days, 1000 produced														
Turkeys, heavy, 100 produced	9888	684	200	255	557	200	261	417	104	200	261			
Turkeys, young , 100 produced														
Ducks, 100 produced	23601	477	127	153	410	131	221	308	86	131	221			
Geese, 100 produced	494	28	8	8	0	0	0	0	0	0	0	28	8	8
Hens, 100 hens per year	48583	3605	1054	1219	3432	1176	1388	2822	977	1176	1388	42	12	14
Pullets, 100 pullets	17226	160	53	53	146	55	59	134	74	55	59			
Mink, females per year	1834169	8419	1651	770	2658	1615	600	2372	1474	1591	563			
Foxes, females per year	15394	186	37	17	59	36	11	53	33	36	10			
Horses, 400 kg, horses per year	45000	1710	270	1575	843	154	1102	759	190	154	1102	855	135	788
Horses, 600 kg, horses per year	45000	2250	360	2070	1131	208	1506	1018	254	208	1506	1125	180	1035
Horses, 800 kg, horses per year	10000	630	100	580	319	58	430	288	72	58	430	315	50	290
Sheep, ewe with lamb	67255	1473	249	1722	386	74	587	347	87	74	587	1069	178	1248
Total		269122	53324	169796	214232	49373	155732	201202	121691	49349	155695	30849	4954	30066

	Amount ex animal 1000 t	Total amount ex building					Total amount ex storage				
		Manure	Liquid manure	Deep litter	Slurry	Total	Manure	Liquid manure	Deep litter	Slurry	Total
		------------------- 1000 t -------------------					------------------- 1000 t -------------------				
Cattle	18568	2676	957	3069	9561	16264	2149	2050	2551	10371	17121
Pigs	11885	1872	1639	181	10750	14443	934	2408	145	11754	15242
Poultry	668	97	0	238	39	374	97	0	199	42	339
Fur-bearing animals	292	97	0	0	263	360	85	0	0	288	373
Horses	387	0	0	251	0	251	0	0	288	0	288
Sheep	189	0	0	44	0	44	0	0	44	0	44
Total	31989	4742	2597	3783	20613	31735	3266	4459	3227	22455	33406
Percentage		15	8	12	65	100	10	13	10	67	100

	Nitrogen ex animal 1000 kg	Total nitrogen ex building					Total nitrogen ex storage				
		Manure	Liquid manure	Deep litter	Slurry	Total	Manure	Liquid manure	Deep litter	Slurry	Total
		------------------- 1000 kg -------------------					------------------- 1000 kg -------------------				
Cattle	139135	13842	10720	24954	61309	110825	10824	11590	22459	60083	104956
Pigs	104235	9769	9913	1527	67244	88453	6291	10481	1298	65899	83969
Poultry	11083	1974	0	7257	327	9558	1677	0	5443	321	7441
Fur-bearing animals	8605	1204	0	0	1513	2717	941	0	0	1483	2424
Horses	4590	0	0	2293	0	2293	0	0	2064	0	2064
Sheep	1473	0	0	386	0	386	0	0	347	0	347
Total	269122	26788	20632	36418	130393	214232	19735	22071	31611	127785	201202
Percentage		13	10	17	61	100	10	11	16	64	100

	Phosphorus ex animal 1000 kg	Total amount ex building					Total amount ex storage				
		Manure	Liquid manure	Deep litter	Slurry	Total	Manure	Liquid manure	Deep litter	Slurry	Total
		------------------- 1000 kg -------------------					------------------- 1000 kg -------------------				
Cattle	23564	4330	272	3820	11593	20015	4200	402	3820	11593	20015
Pigs	24635	4526	837	468	18797	24627	4390	972	468	18797	24627
Poultry	2458	700	0	1773	114	2586	700	0	1773	114	2586
Fur-bearing animals	1688	809	0	0	842	1651	784	0	0	842	1627
Horses	730	0	0	420	0	420	0	0	420	0	420
Sheep	249	0	0	74	0	74	0	0	74	0	74
Total	53324	10364	1108	6556	31345	49373	10074	1374	6556	31345	49349
Percentage		21	2	13	63	100	20	3	13	64	100

	Potassium ex animal 1000 kg	Potassium ex building					Potassium ex storage				
		Manure	Liquid manure	Deep litter	Slurry	Total	Manure	Liquid manure	Deep litter	Slurry	Total
		------------------- 1000 kg -------------------					------------------- 1000 kg -------------------				
Cattle	113629	8676	12314	26555	52432	99976	6767	14222	26555	52432	99976
Pigs	45343	6715	4678	1371	34288	47053	5238	6156	1371	34288	47053
Poultry	4091	807	0	3536	125	4468	807	0	3536	125	4468
Fur-bearing animals	787	169	0	0	442	611	132	0	0	442	574
Horses	4225	0	0	3037	0	3037	0	0	3037	0	3037
Sheep	1722	0	0	587	0	587	0	0	587	0	587
Total	169796	16368	16992	35086	87286	155732	12945	20378	35086	87286	155695
Percentage		11	11	23	56	100	8	13	23	56	100

Pigs, Appendix 1

Efficiency control average on a national scale
A description of the basic data concerning weight intervals and feed consumption

by

Per Tybirk, Senior Advisor
National Committee for Pig Breeding, Health and Production
The Danish Agricultural Advisory Centre
Skejby, DK-8200 Aarhus N, Denmark

Conclusion
The production data on 7.2 million of piglets produced and 4.4 million of slaughter pigs produced form part of the Efficiency Control average on a national scale. Based on these data, a " national herd average" can be simulated, and also it can be used for analysing variations in practice. In the light of that, it is recommended, that 30 kg is chosen as the time at which to distinguish between piglets and slaughter pigs and let the average values concerning feed consumption and pigs produced form the basis of the standard values for N and P ex animal, for that matter.

Documentation concerning the average on a national scale
It is estimated that about 50% of the Danish sows and about 30% of the slaughter pigs produced are subject to the Efficiency Control - particularly via the Integrated Farm Management System (IFMS). Other Efficiency Controls make out a significant part particularly in respect of herds where the farmers themselves perform the efficiency control.

Every 6 months, the local agricultural advisory services submit disks with the Efficiency Control records from as many as possible herds to The National Department of Pig Production. At the National Department of Pig Production, cross analyses of data, and the national average is calculated for the most important key figures of the production. The latest processing was performed in December 1996 and represents the data on the period from October 1, 1995 until September 30, 1996.

At the processing, a sorting of the data is performed, e.g. a period of minimum 170 days is demanded - and very atypical data (errors in keying etc.) are sorted out.

The basis of the national average for sow herds is 1,847 approved herds with a total production of 7.2 million piglets. The national average for slaughter pigs includes the data on 1,673 herds with a total production of 4.4 million slaughter pigs.

In the following, the most recent national average is shown and a recommendation for a rounded-off value for standard tables:

Sow herds	Average	Recommended standard
Number of approved herds	1,847	
Pigs produced per herd per year	3,887	
Weight per pig at weaning	7.27	7.5
Weight per leaver	29.3	30
Weaners per sow per year	22.3	22.0
Pigs produced per sow per year	21.66	22.0
First parity litter, %	20.2	
Dead pigs until weaning, %	11.67	
FU_p per piglet produced	103.9	
FU_p per sow per year, incl. replacement gilts, boars and piglets feed	2250	
Calculated FU_p per kg gain, piglets 7.5-30 kg	2.00	2.00
Calculated FU_p per sow per year, excl. of piglets	1,297	1,300
Calculated piglet feed per sow per year (at 2.0 FU_p/kg gain)	953	990

Sow gain

In sow herds, the gain of the sows should be included in the calculation of the N and P deducted. The gain occurs by means of the annual growth of the sows - where the average growth depends on the distribution by age. Further, the gain consists of young females and boars. The net deduction occurs in that the slaughter weight is higher than the starting weight, but in practice, the starting weight and the leaving weight of sows and boars are difficult to control, and therefore individual calculation on a herd level is unrealistic. Nutrients are also deducted from sow herds in the form of dead sucking pigs.

The total gain per sow per year (exclusive of piglets and weaners) can be calculated as follows:

Litter No.	% of herd	Gain/litter
1^{st} parity	20	46 kg
2^{nd} parity	18	27 kg
3^{rd} parity	16	12 kg
4^{th} parity	12	5 kg
5^{th} parity	10	2 kg
6^{th} parity	24	1 kg
	100	(weighted average) 17 kg

Here the percentage distribution by litter numbers is calculated on the basis of the data on 39 sow herds provided by the HEPS-H (Health and Production Surveillance System) - corrected slightly, though, in order to fit into the actual 20% 1^{st} parity litter in the Efficiency Control average on a national scale.

Hence the calculation is:

The sow: 2.27 litters/sow per year x 17 kg =	39 kg
Boar: 0.04 boar per year x 50 kg/year (calculated) =	2 kg
Replacement gilts: 2.27 x 0.20 young pig x 30 kg (calculated)	14 kg
Dead sucking pigs: 2.5 dead sucking pigs < 2 kg =	5 kg
Gain per sow per year totalling	60 kg

Slaughter pig herds	Average	Recommended standard
Number of approved herds	1,673	
Weight when introduced	30.4	30
Average slaughter weight	75.0	75
Calculated live weight at slaughter	98.25	
Gain per slaughter pig produced	67.8	
FU_p per kg gain	2.94	2.94
Dead and culled pigs, %	3.17	

Variation

The recording of the Efficiency Control average on a national scale has been carried out twice a year since 1992. The changes from year to year in the average values on a national scale have only been minor changes during this period, however, there has been a rise in pigs produced per year and daily gain by slaughter pigs. In 1994, an analysis was made into the differences between the best and poorest herds for a range of characteristics where the relevant values in connection with the N and P standard values are as follows:

Quantile	10%	25%	50%	75%	90%
Pigs produced per sow per year	18.8	20.3	21.8	23.2	24.4
FU_p gain, slaughter pigs	3.18	3.05	2.96	2.78	2.67

In relation to the N and P production of an actual herd, the actual starting/leaving weights are of great importance. No analyses are available as to how much the leaving weight for piglets - slaughter herds, respectively, - vary. However there is no doubt that there are many herds that deviate considerable from the "national average herd".

Discussion

In order to evaluate the Efficiency Control average on a national scale in relation to the data known by farmers of herds without Efficiency Control, it is advantageous to know some definitions in order to be able to determine the scope of production for a herd:

1. One sow counts as a sow per year from the first mating as a replacement gilt until she leaves the herd, i.e., all animals having been mated must be included in the count.

2. Sow feed per sow per year includes feed for replacement gilts and boars. The amount of feed for replacement gilts may vary to some extent from one herd to the other, depending on whether the replacement gilts are "homebred" or whether they are purchased at a weight of 100 kg. Concerning home breeding, it may vary from herd to herd whether or not the feed up to 100 kg counts in the sow feed. It is expected that the national average of 1,300 FU_p sow feed per sow per year on a national scale is equal to the replacement gilts having been given sow feed from almost 100 kg. It is likely that the feed for the replacement gilts makes out 75-100 FU_p per sow per year which is included in the 1,300 FU_p.

Feed for boars may also vary to a certain extent, depending , in particular, on whether or not IA is used to a wide extent. Feed for boars may make out up to approx. 50 FU_p per sow per year.

3. Concerning piglets, dead pigs are not included in the number of piglets produced, i.e., the feed is included, but the dead pigs removed/deducted are not included in the count of the kg produced. This means that the N and P ex animal is overestimated slightly when including the feed for the dead animals although the removal/deduction of the kg of pigs produced are not included. In the slaughter pig reports, the dead pigs are included in the kg produced and in FU_p/kg gain. That means that the record based on the Efficiency Control data is correct. On the other hand, the application of the number of pigs slaughtered instead of pigs "produced" may give a minor estimation error concerning the actual loss to the slurry, but in practice, the error is unimportant, because the feed consumption by the dead pigs will be almost equal to that of the deducted/removed kg pig.

Protein and phosphorus content of pig feed 1997

by

Niels Kjeldsen, Head of Sector
National Committee for Pig Breeding, Health and Production
Federation of Danish Pig Producers and Slaughterhouses
Department for Nutrition and Reproduction
3 Axeltorv
DK-1609 Copenhagen V

Conclusion
The data material used, provided by the feed industry, is a realistic and adequate offer in respect of the protein and phosphorus content of Danish feeds for pigs in 1997. The material shows that the feed industry in general follows the recommendations by the National Committee and thus has clearly demonstrated its willingness to reduce the content of superfluous nutrients in the feed concurrently with advances of new knowledge.

The material covers 80-90% of the Danish pig production, since the remainder of the production consists of home-mixed feed based on individual raw-materials. There is no reason to believe, though, that pig producers who mix their own feeds do not follow the guidelines recommended, since these pig producers typically have large herds and often are highly educated thereby applying the most recent knowledge in the field of feeds.

On the basis of the material compiled, the standard values are set out in the table below:

Table 1. Standard values for nitrogen and phosphorus in pig feed, 1997

Feed for	Sows	Piglets	Slaughter pigs
FU_p/kg	1.06	1.15	1.07
Protein, %	16.1	20.2	17.5
g N per FU_p	**24**	**28**	**26**
g P per kg	6.7	8.0	5.7
g P per FU_p	**6.3**	**7.0**	**5.3**

Documentation

Collection of material
In order to appraise the protein and phosphorus in feed for pigs, the two Danish trade organisations The National Association of Farm Supply Co-operatives and The Danish Feed and Grain Trade Organisation (DAKOFO) were contacted. Both organisations collected material from their members, and the results of the material were as follows:

- Estimated sales of feed in the feeding season of 1996/97 (12 months) divided into categories of mix
- Minimum and maximum protein and phosphorus content of the product selection
- A calculation of the weighted average
- Recommended percentage for supplementary feed

In addition, The DAKOFO stated the content of FU_p /kg feed. The material provided by The National Association of Farm Supply Co-operatives does not include this information. Some of the companies have not submitted data to the trade organisations.

Contribution ratio of the material

In order to appraise whether or not the estimated sales of feed in 1996/97 are realistic, the values are compared with total sales of feed in 1995. Tables 2 and 3 show the reported amounts of commercial premixed and supplementary feed and actual sales in 1995.

The reported amounts of commercial premixed feed make out a very large proportion of the documented sale of commercial premixed feed in 1995 (Statistics Denmark), so subject to the same total amounts of feed being sold in 1996/97, the reported amounts make out 96-98% of the market for commercial premixed feed for sows and slaughter pigs, respectively, (Table 2), which shows that the feed industry's companies to a wide extent have responded to the application.

Statistics Denmark does not calculate separate numerical values for supplementary feed for piglets, but includes supplementary feed in commercial premixed feed for piglets. Therefore, Tables 2 and 3 do not show any contribution ratio in percentage, but the aggregate amount of reported commercial premixed and supplementary feed for piglets makes out 94% of the total quantity of feed for piglets sold in 1995 according to Statistics Denmark.

Table 2. Reported amounts of commercial premixed feed compared with the actual sale in 1995

Category of mix	Sows	Piglets	Slaughter pigs
1,000 t per year:			
DAKOFO	335	342	1,171
Nat. Ass. of Farm Supply Co-operatives	136	142	469
Totalling	471	482	1,640
Sale of commercial premixed feed in 1995 (Statistics Denmark)	489	568	1,676
Contribution ratio in percentage	96		98

Concerning supplementary feed, the reported amounts make out 82 and 85 % for slaughter pigs and sows, respectively, (Table 3).

Concerning supplementary feed, the reported amounts make out a great proportion of the commercial feed that is used annually for pigs.

Denmark has a large production of home-mixed feed, primarily based on supplementary feed and locally grown cereals. A number of pig producers though, design their own feed based on purchased crude proteins, purchased mineral mixes and purchased or farm-produced cereals.

However, it is not quite clear how many pigs that are produced on the various categories of feed, but based on information provided by Statistics Denmark on the sale of commercial premixed feed and supplementary feed in 1995, a qualified guess can be calculated.

Table 3. Reported amounts of commercial premixed feed compared with the actual sale in 1995

Category of mix	Sows	Piglets	Slaughter pigs
1,000 t per year:			
DAKOFO	75	44	276
Nat. Ass. of Farm Supply Co-operatives	30	8	96
Totalling	105	52	372
Supplementary feed produced in 1995 (Statistics Denmark)	123	not calculated	452
Contribution ratio, percentage	85		82

A calculation of the number of pigs produced per year divided into the individual categories of feed based on the information on the amounts of commercial premixed feed and supplementary feed sold and admixture percentages is shown in Table 4.

Table 4. Division of sows and slaughter pigs produced on commercial premixed feed and supplementary feed, respectively. The remainder of the production is expected produced on home-mixed feed based on purchased raw materials.

	Premixed feed	Supplementary feed	Calculated remainder (based on purchased raw materials)
Slaughter pigs:		(29% admix.)	
Feed sold, 1,000 t	1,676	452	-
Pigs prod., divided up onto category of feed, head	8,8	8.2	3.2
Percentage of total no. produced (20.2 mill.*)	44	40	16
Sows:		(24% admix.)	
Feed sold, 1,000 t	489	123	-
Pigs prod., divided up onto category of feed, head	411	430	174
Percentage of total no. produced (1.015 mill.*)	40	16	17

* The calculations are based on the amount of feed sold and on the following preconditions: Denmark's total production in 1995 = 20.2 million slaughter pigs produced (Federation of Danish Pig Producers and Slaughterhouses) and 1,015 million sows per year (Statistics Denmark - Agricultural statistics) (Preconditions: 1.05 FU_p /kg feed. Consumption of feed = 200 FU_p /slaughter pig produced. Consumption of feed = 1,250 FU_p /sow per year).

As will appear from Table 4, it is estimated that 16% of the slaughter pigs and 17% of the sows are fed on feed mixes of which no information has been included in the data material provided by the feed industry.

Protein content of feed

The data material provided by the feed industry contains information about the protein content of the commercial premixes. The companies have stated the protein content of the mix that contains the lowest protein level (minimum) and the one that contains the highest protein level (maximum). This has been done in order to give an impression of the variation in the protein content of commercial premixes. In addition, the average protein content has been calculated on the basis of the weighted average and protein content of these types of mixes.

In Table 5, the protein content of feed for slaughter pigs is shown, and as will appear, the protein content is 17.4% in commercial premixed feed and 17.5% in feed based on supplementary feed when 29% supplementary feed is mixed with 71% cereals (half barley, half wheat with a protein content of 10.3%).

If the stated protein content is converted into gram of digestible protein per FU_p, it is seen that the percentage of digestible protein in commercial premixed feed is about 131 g against 137 g in feed based on supplementary feed. Thus it appears that the feed industry has chosen to keep close to the recommended minimum standard for slaughter pigs, i.e., 130 g digestible protein per FU_p as recommended by the National Committee.

In the data material provided by The National Association of Farm Supply Co-operatives, the FU_p/kg content has not been stated, but it appears from the association's enclosed nutrient labelling that the energy content does not deviate from the values stated by The Danish Feed and Grain Trade Organisation. Thus the calculated content of digestible protein per FU_p applies to the entire food industry.

Table 5. Protein content in feed for slaughter pigs

	Premixed feed	Supplementary feed	Suppl. feed conv. into premixed feed with half barley and half wheat*
DAKOFO:			(29% not admixed)
Minimum, %	15.7	32.0	
Maximum, %	18.5	39.0	
Weighted average, %	17.4	35.3	17.5
Weighted average, FU_p/kg	1.09	1.06	1.05
Nat. Ass. of Farm Supply Co-operatives		(29% not admix.)	
Minimum, %	16.5	26.4	
Maximum, %	19.7	39.9	
Weighted average, %	17.5	35.4	17.5
Weighted average, FU_p/kg	not recorded	not recorded	
Total weighted average, %	17.4	35.3	17.5
g digestible protein/FU_p (digest. coeff. = 82%)	131		137

*A cereal mix of half barley and half wheat contains 10.3% protein and 1.05 FU_p/kg ("Foderstoffer til svin", National Committee, Federation of Danish Pig Producers and Slaughterhouses).

Table 6 shows the protein content of feed for sows, and it appears from the table that the protein content of commercial premixed feed as a weighted average is 15.8%, while it in feed based on supplementary feed is 16.4% when 24% supplementary feed is mixed with 76% cereals.

If that is converted into g digestible protein per FU_p, the result is 122 and 128 g digestible protein/FU_p, in commercial premixed feed and feed based on supplementary feed, respectively. The minimum standard recommended for pigs by the National Committee is 110 g digestible protein/ FU_p.

Table 6. Protein content in feed for sows

	Premixed feed	Supplementary feed	Suppl. feed conv. into premixed feed with ½ barley and ½ wheat*
DACOFO:			(24% not admix.)
Minimum, %	12.0	30.0	
Maximum, %	17.8	40.0	
Weighted average, %	15.8	36.0	16.5
Weighted average, FU_p/kg	1.06	1.05	1.05
Nat. Ass. of Farm Supply Co-operatives			(23% not admix.)
Minimum, %	12.2	26.0	
Maximum, %	17.5	40.0	
Weighted average, %	15.8	35.1	16.0
Weighted average, FU_p/kg	not reported	not reported	
Total weighted average, %	15.8	35.7	16.4
g digestible protein/ FU_p (digest. coeff. = 82%)	122		128

*A cereal mix of half barley and half wheat contains 10.3% protein and 1.05 FU_p/kg ("Foderstoffer til svin", National Committee, Federation of Danish Pig Producers and Slaughterhouses).

Table 7 shows the protein content of feed for piglets. The Danish Feed and Grain Trade Organisation has stated the amounts of both post-weaning feed that is usually used from 0-14 days after weaning and feed for piglets that is typically used up to 25-30 kg. The average protein content of feed supplied by the Danish Feed and Grain Trade Organisation is therefore calculated as a weighted average in relation to the amounts of feed stated.

It appears that the protein content of commercial premixed feed is 20.2 % and 19.8% in supplementary feed.

By a conversion into g digestible protein/ FU_p, the results are 150 and 152 for commercial premixed feed and feed based on supplementary feed, respectively. Also here, the feed industry has chosen to keep close to the minimum standard of 150 g digestible protein per FU_p recommended by the National Committee, Federation of Danish Pig Producers and Slaughterhouses.

Phosphorus content of the feed

Table 8 shows the phosphorus content of the feed for slaughter pigs. It appears from the table that the weighted average for commercial premixed feed is 6.0 g/kg which is close to the recommendations by the National Committee, i.e., 5.5-6.0 g total phosphorus per FU_p in commercial premixed feed for slaughter pigs. Since the digestibility of the individual phosphorus sources to a high degree depends on source and quality, it has not been tried to calculate how much digestible phosphorus the feed contains.

The feed content based on supplementary feed is slightly lower than that of commercial premixed feed which also harmonises with the recommendations by the National Committee that states 5.0-5.5 g phosphorus in feed based on supplementary feed. This difference in recommendations is due to the fact that for home-mixed feed, the cereal is not exposed to heat treatment and therefore maintains the phytase activity.

Table 7. Protein content of feed for piglets

	Premixed feed	Supplementary feed	Suppl. feed conv. into premixed feed with wheat*
DAKOFO:			(33% not admix.)
Minimum, %	17.5	38.4	
Maximum, %	21.0	45.0	
Weighted average, %	20.4	39.2	19.9
Weighted average, FU_p/kg	1.16	1.19	1.12
Nat. Ass. of Farm Supply Co-operatives			(31% not admix.)
Minimum, %	18.0	35.0	
Maximum, %	22.0	47.2	
Weighted average, %	19.9	40.0	19.7
Weighted average, FU_p/kg	not reported	not reported	
Total weighted average, %	20.2	39.4	19.8
g digest. protein/ FU_p, g (digest. coeff. = 86%)	150		152

* Wheat contains 10.4% protein and 1.09 FU_p/kg

Table 8. Phosphorus content in feed for slaughter pigs

	Premixed feed	Supplementary feed	Suppl. feed conv. into premixed feed with half barley and half wheat*
DAKOFO:			(29% not admix.)
Minimum, g/kg	4.8	9.4	
Maximum, g/kg	6.4	10.1	
Weighted average, g/kg	6.0	9.8	5.2
Nat. Ass. of Farm Supply Co-operatives			(29% not admix.)
Minimum, g/kg	5.0	7.0	
Maximum, g/kg	8.3	18.6	
Weighted average, g/kg	6.1	11.8	5.8
Total weighted average, g/kg	6.1	10.3	5.4

* A cereal mix consisting of half barley and half wheat contains 3.3 g P/kg ("Foderstoffer til svin", National Committee, Federation of Danish Pig Producers and Slaughterhouses).

Table 9 shows the phosphorus content of sow feed. The content makes out 6.6 and 6.8 g total phosphorus per kg for commercial premixed feed and feed based on supplementary feed which corresponds with the recommendations by National Committee of 6.5 g phosphorus per FU_p for sows.

Table 10 shows the phosphorus content of feed for piglets. The content makes out 8.0 g and 8.5 g phosphorus per kg in commercial premixed feed and feed based on supplementary feed, respectively. The National Committee recommends about 7.5 g phosphorus per FU_p for piglets.

Table 9. Phosphorus content in feed for sows

	Premixed feed	Supplementary feed	Suppl. feed conv. into premixed feed*
DAKOFO:			(24% not admix.)
Minimum, g/kg	6.3	12.8	
Maximum, g/kg	7.8	21.8	
Weighted average, g/kg	6.6	18.2	6.9
Nat. Ass. of Farm Supply Co-operatives:			(23% not admix.)
Minimum, g/kg	5.9	10.0	
Maximum, g/kg	7.6	23.0	
Weighted average, g/kg	6.6	17.9	6.7
Total weighted average, g/kg	6.6	18.1	6.8

* A cereal mix consisting of half barley and half wheat contains 3.3 g P/kg ("Foderstoffer til svin", National Committee for Pig Breeding, Federation of Danish Pig Producers and Slaughterhouses).

Table 10. Phosphorus content in feed for piglets

	Premixed feed	Supplementary feed	Suppl. feed conv. into premixed feed with wheat *
DAKOFO:			(33%)
Minimum, g/kg	6.2	17.5	
Maximum, g/kg	8.8	21.5	
Weighted average, g/kg	8.1	20.3	8.8
Nat. Ass. of Farm Supply Co-operatives			(31%)
Minimum, g/kg	5.7	10.6	
Maximum, g/kg	9.8	21.5	
Weighted average, g/kg	7.9	17.0	7.4
Total weighted average, g/kg	8.0	19.8	8.5

* Wheat contains 3.1 g P/kg ("Foderstoffer til svin", National Committee for Pig Breeding, Federation of Danish Pig Producers, Federation of Danish Pig Producers and Slaughterhouses)

The most important calculated averages of the preceding tables are included in Table 11.

Table 11. Total survey of the protein and phosphorus content in the feed stated as a weighted average of the information provided by the feed distributors of the feed industry

	Protein, %	Phosphorus, g/kg
Slaughter pigs:		
Commercial premixed feed	17.4	6.0
Basis for supplementary feed	17.5	5.4
Standard values	17.5	5.7
Sows:		
Commercial premixed feed	15.8	6.6
Basis for supplementary feed	16.4	6.8
Standard values	16.1	6.7
Piglets:		
Commercial premixed feed	20.2	8.0
Basis for supplementary feed	19.8	8.5
Standard values	20.2	8.0

Discussion

The values stated in Table 11 reflect the expectations regarding the nutrient labelling of the pig feed of the feeding season in question.

The information is compiled and calculated by Statistics Denmark on the basis of the feed raw materials consumed, and the table information about the nutrient content of the raw materials shows that especially the protein content of feed in 1995 was considerable higher than stated in Table 11. In order to overcome this divergence, the Plant Directorate has procured the various nutrient labelling and analysed the composition of the different types of feed for 1995 and for the feed season starting in August 1996. Table 12 shows these values:

Table 12 Protein content, % in pig feed compiled from various statistical material

	LU	Statistics Denmark	Plant Directorate (labelled)	Plant Directorate (analysed)	Plant Directorate (labelled)	Plant Directorate (analysed)
Period	96/97	1995	1995		Sep.- Nov. 1996	
Ready-mixed feed:						
Slaughter pig feed	17.4	19.6	18.4	18.9	17.3	18.0
Sow feed	15.8	16.9	16.5	17.1	15.7	16.7
Supplementary feed:						
Slaughter pig feed	35.3	37.2	36.5	36.5	36.8	36.8
Sow feed	35.7	36.8	35.1	35.0	35.2	35.6

It appears from Table 12 that the values provided by Statistics Denmark 1995 are higher than the corresponding values from the Plant Directorate. This applies both to the labelled and analysed protein content. The development towards a lower protein content is demonstrated by the difference between the statement of 1995 and that of the feed season in question. There is a close correspondence between the results of the National Committee and the protein content stated by the Plant Directorate, while the protein content analysed by the Plant Directorate is higher than that of the commercial premix nutrient labelling.

The Plant Directorate’s material for September-November 1996 is relatively small, so the actual difference may be random.

However, experiences from 1994 and 1995 show that the analysed protein content is about 0.5% higher than that of the nutrient labelling of the feed, but only regarding commercial premixes. There is no difference as regards supplementary feed.

Regarding phosphorus, there are no differences of importance between the data compiled by the National Committee, Statistics Denmark, and the Plant Directorate except for slaughter pigs, where the information provided by National Committee is about 13% lower than that of Statistics Denmark which is in complete harmony with the reduction in the standard values for phosphorus for slaughter pigs that has taken place in 1995.

For practical reasons, the standard values are based on the nutrient labelling of the feed which is easiest checked by means of the enclosed nutrient labelling.

Pigs, Appendix 3

1. **N, P and K deposition per kg live weight and per kg gain in sows, sucking pigs (until 7.5 kg) and piglets (7.5-30 kg)**
2. **Sows' change in weight**
3. **Division of the excretion of P between faeces and urine**

by

Hanne Damgaard Poulsen
National Institute of Animal Science
Research Centre Foulum
Department for Nutrition
P.O. Box 50
DK-8830 Tjele

Conclusion

Re 1: The N, P and K deposition per kg live weight and per kg gain in sows, sucking pigs (until 7.5 kg) and piglets (7.5-30 kg)

In principle, the N and P amounts deposited in sows and sucking pigs are divided between the amount deposited in the sow in the form of gain and the amount deposited in the sucking pigs produced.

Sows
In the references quoted, the N deposition varies between 20 g and 30 g per kg gain, and the P deposition is 4.7-5.1 g per kg body weight. It is estimated that under the present-day breeding combination and production management, the deposition in sows is about 25 g N and 5 g P per kg body gain. The gain represents the sow's own gain, and it is calculated as the difference between the body weight (at mating) between two reproduction cycles.

Sucking pigs (about 7.5 kg)
In the references quoted, the N deposition is about 23-24 g per kg body weight, and the P deposition is between 4.7-5 g per kg body weight. It is therefore estimated that the deposition in sucking pigs (about 7.5 kg) is 24 g N and 5 g P per kg body weight.

Piglets (7.5-30 kg)
The N and P deposition is calculated on the basis of a 7.5 kg pig and the content of a pig of 30 kg. The N and P deposition per kg gain by piglets (7.5-30 kg) is calculated to 26.4 g N and 5.5 g P per kg gain.

K deposition
It is estimated that the K deposition in sows and piglets is about 2.0 and 2.2 g per kg body weight, respectively. The deposition in piglets (7.5-30 kg) is calculated at 2.2 g K/kg gain.

	N	P	K
		g/kg (live weight)	
Per kg body weight:			
Sows	25	5.0	2.0
Sucking pigs (7.5 kg)	24	5.0	2.2
Per kg gain:			
Sows	25	5.0	2.0
Piglets (7.5-30 kg)	26	5.5	2.2

Re 2: Sows' change in weight
The gain by sows is estimated to be about **20 kg per reproduction cycle.** The change in weight per sow per year will be 20 kg multiplied by the number of litters produced.

Re 3: Division of P excretion between faeces and urine
The division of P has not evaporative importance like N, and the division is estimated to deviate heavily in practice, since it depends to a high extent on the P content of the feed and the digestibility of P in the feed. On average, it is estimated that 55% of the P content of feed is excreted in the faeces and [45% of feed P minus deposited P in the pig] is excreted in the urine. The values can be calculated for all categories of pigs.

Documentation

A. Sows and sucking in pigs until 7.5 kg. N and P deposition
During the gestation period, nutrients are deposited in the maternal uterus, in placenta, in the udder tissues and in the embryos. In addition, also nutrients are deposited in the sow's own body gain. The size of this depends on e.g. the age of the sow. After farrowing, the maternal uterus decays whereby nutrients are lost. The same applies to udder tissues after weaning of the sucking pigs. An increased loss of N by urine in connection with farrowing and weaning has been found (Whittemore, 1995). This means that although e.g. N is deposited in the maternal uterus tissue during the gestation period, it may be "lost" when the sow no longer is pregnant. The sucking pigs are supplied with nutrients through the milk, and the nutrients are primarily used for growth. Any supply in excess is excreted by the sucking pig.

The above-mentioned physiologically determined changes are matters of great importance for the establishing of the amounts of nutrients required by sows and sucking pigs. For the purpose of determining the nutrient utilisation by sows and piglets, though, the physiologically determined anabolism and decay of nutrient pools are of no interest. What matters is in the first place how large the body pools are the day, the sow is becoming pregnant and the day she starts a new reproduction cycle, i.e., the change in the size of the body stores over a reproduction cycle. Furthermore, it is important to know how much is deposited in the sucking pig body at the time of its weaning.

In principle, the N and P deposition in sows and piglets is divided into

1. the amount deposited in the sow in the form of body gain and
2. the amount deposited in the piglets produced.

There is scarcely any information in the form of research results concerning the above-mentioned matters, but the results found in the literature will be described in the following. Table 1 shows the results of a Dutch sow experiment.

Table 1. N and P content of sow carcasses (Everts, 1991)

	N	P
At 125 kg body weight	3.07 kg	639 g
At 200 kg body weight	4.72 kg	930 g
Per kg:		
At 125 kg* body weight	24 g	5.1
At 200 kg** body weight	24 g	4.7

* before first mating ** after weaning of the 3rd litter

Proportionately, the N content of the sow body had not changed from the first mating until the weaning of the 3rd litter, but was about 24 g/kg body weight. However, the P content dropped from 5.1 to 4.7 g per kg body weight.

De Wilde, 1980 has compared the protein deposition in pregnant (1st parity litter sows) and non-pregnant animals of the same litter, respectively, (Table 2).

Table 2. The protein content of the body in pregnant and non-pregnant animals (De Wilde, 1989)

	Non-pregnant*			Pregnant		
	Weight kg	Protein kg	N kg	Weight kg	Protein kg	N kg
Start	114	18.3	2.93	114	18.4	2.94
Day 111 in gestation	139	21.5	3.44	155	22.5	3.61
Gain (total)	25	3.2	0.51	41	4.1	0.67
Gain to foetuses, gland tissues etc.	-	-	-	16	0.9	0.16
Per kg weight gain:						
non-pregn.	20 g N					
pregnant	16 g N					

Non-pregnant animals were fed like the pregnant sows.

Non-pregnant animals had a gain of 25 kg body weight and 3.2 kg protein which is equal to 20 g N/kg gain. Similarly, the N deposition in the pregnant animals was 16 g N/kg gain (including body gain, foetuses, maternal uterus, gland tissues etc.).

Walach-Janiak et al., 1986 examined the effect of feeding various protein and energy amounts on 1st parity sows' N deposition in the body and maternal uterus, foetuses etc. (Table 3).

It appears from the above that the N deposition in maternal uterus, foetuses, etc. is interdependent of the protein assignment. The content is about 15 g N/kg (maternal uterus, foetuses etc.). On the contrary, the N deposition in the sow body is somewhat affected by the protein assignment which is connected with the change in the fat content of the body (values not shown). Numerically, the N deposition represents 18-24 g N/kg body gain.

Table 3. The effect of dietary protein content on the N deposition in the body (Walach-Janiak et al., 1986 (in accordance with Table III))

Protein intake, g/day	179	242	303	419	513
Weight at mating	117	116	117	119	117
Gain during gestation	35.3	43.2	67.1	96.6	102.0
in the sow itself *	13.2	23.8	42.3	72.9	75.1
in maternal uterus etc.	22.1	19.4	24.8	23.7	26.9
Protein deposition in:					
Sow body	4.01	4.89	7.56	10.2	11.4
Sow body*	1.99	3.20	5.22	8.00	9.02
N deposition in:					
Sow body	0.64	0.78	1.21	1.64	1.82
Sow body*	0.32	0.51	0.84	1.28	1.44
Maternal uterus with content, kg protein	2.02	1.69	2.34	2.2	2.4
Maternal uterus with content, kg N	0.32	0.27	0.37	0.36	0.38
g N/kg sow gain*	24	21	20	18	19
g N/kg mat. uterus with content	14	14	15	15	14

* Exclusive of maternal uterus with content

In an experiment with various feeding strategies, conditions, and number of sucking pigs, Whittemore & Yang, 1989 found that the differences in protein gain were considerably smaller than those of fat gain measured from 1st mating until weaning of the 4th litter. Table 4 shows the protein and N deposition.

Table 4. Body weight gain, protein and fat content measured in sows from the 1st mating until weaning of 4th litter (Whittemore & Yang, 1989 (Table 5)

	Treatment							
	1	2	3	4	5	6	7	8
Gain, kg	140	135	121	88	114	120	90	70
Protein, kg	26	25	23	17	21	23	18	15
Fat, kg	30	31	24	13	22	21	12	3.5
g protein/kg	186	185	190	193	184	192	200	214
g N/kg	30	30	30	31	29	31	32	34

Calculations showed that sows on non-exaggerated diets deposited about 185-195 g protein/kg body gain which is equal to 30-31 g N/kg.

In the remainder of the experiments referred to, the sows had a deposition of about 20-30 g N/kg body gain. No Danish investigations are available as to N deposition in sows based on slaughter experiment. However, balance tests on sows have been carried out at various times during the gestation period (Table 5). The results show that the deposition and thus the utilisation of both N and P have been rather limited, however, the utilisation of both N and P has increased during the last balance period.

The amount of the N deposition in the Danish experiment is on level with the Dutch results that showed a daily N deposition of 10-16 g measured in the middle of the gestation period and 18-25 g at the end of the gestation period (Everts & Dekker, 1994).

Table 5. Nitrogen and phosphorus deposition established twice during the gestation period of sows that were assigned two different protein levels during the gestation period. (Danielsen, personal information)

	Gestation stage			
	Day 40		Day 90	
Nitrogen:				
Protein intake, g/day	364	279	546	419
Protein deposition, g/day	66	43	170	134
N deposition, g/day	10.6	6.9	27.2	21.4
N utilisation, %	18	15	31	32
Phosphorus:				
Phosphorus intake, g/day	14.1	13.6	21.2	20.4
Phosphorus deposition, g/day	1.3	1.2	5.2	3.2
Phosphorus utilisation, %	9	9	25	16

In summary, it is estimated that the N deposition in reproductive sows is about 24 g per kg gain. Similarly, it is estimated that the P deposition is about 5 g per kg body weight.

B. N and P in sucking pigs

Table 6 shows the N and P content of weaners. The results are provided by the same experiment as that referred to in Table 1.

Table 6. N and P content of weaners (Everts, 1991. Table 44)

	g N	g protein	g P
Weaners:			
7.5 kg body weight	181	1130	35.3
Per kg body weight	24.1	151	4.7

In an older Danish experiment on pigs of Landrace, it was found that new-born pigs had contents of 19 g N and 6.6 g P per kg body weight (Table 7).

Table 7. N and P content of new-born pigs (Nielsen, 1973. Table 13)

Dry matter	20.1%	
Protein	11.9%	equal to 19 g N/kg body weight
Phosphorus	0.66%	equal to 6.6 g P/kg body weight

Similar values are found by Becker et al., 1979, as shown in Table 8.

Table 8. N and P content of foetuses and new-born pigs (Becker et al., 1979. Table 5)

	Foetuses*	Foetuses**	New-born pigs
Dry matter, %	9.9	18.6	20.6
Protein, %	6.3	10.6	11.7
N, g/kg body weight	10.1	17.0	18.7
P, g/kg body weight	2.2	6.7	6.7

* In the middle of the gestation period

** Last third of the gestation period

In a Norwegian investigation using Landrace pigs, it was found that the N content was 20 g/kg body weight at the time of birth and rose to 24 g/kg at the age of 10 weeks (Table 9). Similarly, the values for P were 6 and 5 g/kg body weight. The results show that the N content per kg body weight rises in piglets from birth until weaning while there might be a minor fall in the P content.

Table 9. Chemical composition of sucking pigs from birth until the age of 10 weeks (including the contents of the gastro-intestinal tract) (Berge & Indrebø, 1979. Table 5)

	Dry matter, %	Fat, %	Protein, %	N, g/kg	P, g/kg	Weight, kg
At birth	19.5	1.4	12.4	20	6	1.24
1 week	26.0	8.9	13.8	22	5	2.32
2 weeks	30.7	13.6	14.0	22	5	3.88
3 weeks	30.6	13.6	13.9	23	5	5.52
4 weeks	31.1	13.5	14.3	23	5	6.18
6 weeks	33.3	15.7	14.5	23	5	9.52
8 weeks	33.9	15.4	14.3	23	5	14.7
10 weeks	34.6	15.0	14.7	24	5	24.0
Danish:						
20 kg	26.3	7.3	15.6	25*	5.1*	~ 20
90 kg	35.8	15.7	17.0	27*	5.4*	~ 90

* Fernandez: N, P and K deposition and content of pigs. (Pigs, Appendix 4. Table 3)

As a comparison, Table 9 show more recent Danish results of pigs of 20 and 90 kg (cross-bred pigs) that show that both the N and P content is slightly higher in Danish pigs weighing about 20 kg.

In summary, the results concerning piglets show that the N and P content at weaning (about 7.5 kg) is about 24 g N and 5 g P per kg body weight.

C. Change in sows' weight

The effect of various strategies for energy fed to sows was followed through 5 production cycles where the sows' change in weight was recorded over all 5 cycles. Table 10 shows the results of the change in weight measured from weaning until next weaning both per litter and as an average of the 5 litters.

Table 10. Sows' weight change over 5 litters, 515 farrowings (Danielsen, personal information)

	Gain, kg
1st litter*	45.5
2nd litter	27.0
3rd litter	11.6
4th litter	5.3
5th litter	2.3
1st - 5th litter (average)	20.0

* For 1st parity sows, the weight at the time of mating is used.

It is believed that these values give a good estimate of the gain in reproductive sows. The gain of a sow per year can be obtained by multiplying the average gain (from weaning until weaning) by the number of litters produced per sow.

D. Potassium deposition in sows and piglets

It has not been possible to find specific literature on K deposition in sows and foetuses. The following content has been found in growing pigs:

20 kg body weight:	2.21 g K/kg*
	2.24 g K/kg**
90 kg body weight:	2.24 g K/kg**
90-100 kg body weight	1.98 g K/kg*

* Rymarz et al., 1982
** Danish experiments

The results make probable that the K deposition in sows is about 2 g per kg body weight. The results indicate that the K content is falling with the age. However, the actual K content of the body of sucking pigs is not known. For the purpose of this report, it is therefore estimated that the deposition in sucking pigs is about 2.2 g per kg body weight.

E. Piglets (7.5 kg - 30 kg): N and P deposition per kg gain

Calculated on the basis of the N and P content of pigs of 20 kg and the values for N and P deposition per kg gain (20-90 kg) and an estimate of the contents of the gastro-intestinal tract, the content per kg live pig (including the contents of the gastro-intestinal tract) at 30 kg can be calculated. The values for pigs of 7.5 kg can also be calculated.

Live weight (including the contents of the intestinal region)	N	P
30 kg	774 g	162 g
7.5 kg	180 g	38 g
Deposition (7.5 to 30 kg)	594 g	124 g
Deposition per kg gain	26.4 g	5.5 g
	= 165 g protein	

F. Division of the P excretion into faeces and urine

P in faeces and urine

The division of the P excretion into faeces and urine depends to a wide extent on how much of the phosphorus in the feed that is digestible. That part of the phosphorus that is not digested is excreted directly in the faeces and that part that is digested is used for deposition. If more P is absorbed than the pig is able to deposit, the excess of phosphorus is excreted in the urine. As with N, the amounts excreted together with faeces and urine can be calculated if for the individual categories of pigs, the amount of feed, the P content of the feed, the digestibility of P in the feed, and the amount of P deposition are known.

It is not yet possible to know exactly the digestibility of P in feed mixes. The digestibility of P in feed mix varies a lot and depends on the composition of the feed. In addition, the content of phytase either naturally present or in the form of a microbial phytase added to it is of great importance. The most recent Danish experiments carried out show that the P digestibility varies between 40 and 65% (Poulsen, 1994; 1996).

An estimate of the practice will be that the digestibility of P may be even less than 40% where the feed is being exposed to heat treatment pursuant to the salmonella action plan. It is therefore estimated that the P digestibility is 30-60%, where the P digestibility may probably be higher in home-mixed feed than in heat treated, commercial premixed feed supplied by feed stuff companies. It is estimated that the value for the P digestibility may rise over the years to come as a result of the ongoing research in that field. For the purpose of the revaluation of the standard values for faeces, it is estimated that the P digestibility on average will be about 45% which means that 55% of the P content of the feed ends up in faeces [kg feed P* 0.55]. Of the 45% that is absorbed, some of it is used for deposition and the remainder is excreted as surplus in the urine [kg feed P*0.45 minus kg deposited P in the pig].

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Pigs, Appendix 4

Deposition and content of N, P and K in slaughter pigs

by

José A. Fernández, Senior Researcher
National Institute of Animal Science
Research Centre Foulum
Department for Nutrition
P.O. Box 50
DK-8830 Tjele

Conclusion
The composition of the pig body at 20 kg and 90 kg live weight (LW) respectively, was determined by feeding, balance, and slaughter experiments in a range of experiments carried out at the National Institute of Animal Science. An analysis of the aggregate data makes out the basis of the values concerning the N, P and K content (g/kg live weight) at 30 kg and 100 kg respectively, and the gain at 30-100 kg. The experimentally established values have been corrected on a rough estimate for the N and P content in the gastrointestinal canal, since this fraction of the nutrients, although not utilised, follows the pig when it leaves the farm.

Standard values for the N, P and K content of pigs

Live weight	N, g/kg LW	P, g/kg LW	K, g/kg LW
30 kg	26	5.4	2.2
100 kg	27	5.5	2.2
Gain (30-100 kg)	28	5.5	2.2

Documentation
The present standard values for pig faeces are primarily based on calculations made by Boisen (1993) and latest described by Fernández et al. (1995). Table 1 shows the data on which the standard values have been based.

Table 1. Nitrogen account of the consumption, utilisation, and excess in connection with the production and slaughter pigs

	Consumption	Utilised	Excess	
	N in feed	N in body	N in faeces	N in urine
Sucking pig (0-8.5 kg)	1.41	0.26	0.28	0.87
Piglets (8.5-25 kg)	1.18	0.46	0.24	0.48
Slaughter pigs (25-100 kg)	5.99	1.85	1.20	2.94
Total	8.58	2.57	1.72	4.29
%	100	30	20	50

Preconditions used for the calculations:

Sucking pig: Calculated on the basis of feed consumption of a sow per year that 1) produces 20 pigs, 2) has an annual gain of 30 kg, and 3) has an annual consumption of 1100 FU_p with a crude protein content of 160 g/ FU_p.
Piglets: A consumption of 37 FU_p with a crude protein content of 200 g/FU_p, of which 175 g protein/kg gain is deposited in the empty pig body (LW - gastrointestinal contents).
Slaughter pigs: A consumption of 214 FU_p with a crude protein content of 175 g/ FU_p of which 165 g protein/kg gain is deposited in the empty pig body.
Furthermore, it is estimated in all cases that the digestibility of the protein is 80%.

As will appear from Table 1, the standard values have been based on a wide range of conditions concerning the nutrient supply to the pig and the conversion in the pig. Knowledge of these matters and their variation is a necessary precondition in order for the standard values to function with the desired effect in practical pig management.

Over the last 20 years, a considerable number of experiments have been carried out at the National Institute of Animal Science with the intention to acquire knowledge in the field of nutrient absorption, conversion and utilisation by growing pigs. In addition to keeping an exact account of the nutrients eaten, their digestion and excretion, these experiments have also included studies of the nutrient content in the pig body both at 20 kg and 90 kg live weight and thereby also of the composition of the gain. The results of a number of these experiments were published as a whole by Jørgensen et al. (1985a).

The last 12 years' experiments have been carried out on Landrace and Yorkshire pigs from breeding herds and on cross-bred pigs at the Research Centre Foulum. Part-results of these experiments have been published by Fernández et al. (1985), Just et al. (1985a,b,c.d), Jørgensen et al. (1985b), Jørgensen et al. (1986), Jørgensen et al. (1988), and Oksbjerg et al. (1990 and 1996).

Data on these experiments have been selected so as to form the basis of an evaluation and possible adjustment of the standard values. An important precondition for that is that the animal material is comparable with practice. Table 2 shows the production data on the experiments. As a comparison, the production results of the Efficiency Control for 1995 (Landsudvalget for Svin, 1996) are also shown.

Table 2. Production of slaughter pigs. The results from practice in 1995 (Efficiency Control[1]) and from research (National Institute of Animal Science)

	Efficiency control			Experiments	
	Average	Worst 25%	Best 25%	Average	SD
Feed, FU_p /d	2.17	2.14	2.22	1.91	0.20
Crude protein, g/ FU_p				1.90	22
Phosphorus, g/ FU_p				6.9	1.2
Gain, g/d	744	676	810	687	79
Weight at start, kg	30.4	29.8	31.5	21.1	2.5
Weight at slaughter, kg	97	99	97	88.2	3.9
Empty body weight, % of LW[2]	-	-	-	94.5	1.2
FU_p/kg gain	2.94	3.17	2.74	2.79	0.30
Deposited, % intake	-	-	-	33.3	5.2
Meat, %	59.8	59.7	59.8	53.2[3]	2.4

[1)]National Committee for Pig Breeding, 1996; [2)] Empty body weight = weight at the time of slaughter - gastrointestinal contents, [3)] % of weight at slaughter; Meat % = determined by anatomical dissection, % of empty body weight

Table 3 shows the nutrient composition of piglets, slaughter pigs and of gain. The nutrient content is calculated as the accumulated amount in the entire body after the cleaning of the gastrointestinal canal, divided by kg live weight.

Table 3. Chemical composition[1)] of piglets (n = 37), slaughter pigs (n = 151), and of gain

	Piglets		Slaughter pigs		Gain	
	Average	Sd	Average	Sd	Average	Sd
Weight at slaughter, kg	21.4	2.8	88.2	3.9	-	-
Empty body weight, % of LW	89.9	2.3	94.5	1.2	-	-
Dry matter, g/kg LW	263	18	358	24	388	31
Ash, g/kg LW	32	2	32	3	32	5
Protein, g/kg LW	156	7	170	7	174	9
Fat, g/kg LW	73	17	157	30	184	38
Calcium, g/kg LW	8.0	0.8	8.2	0.6	8.2	0.8
Phosphorus, g/kg LW	5.1	0.3	5.4	0.3	5.4	0.4
Potassium, g/kg LW	2.2	0.4	2.2	0.1	2.2	0.1
Energy, MJ/kg LW	6.61	0.66	10.28	1.09	11.46	1.38

[1)] Total amount of nutrients in the body/kg LW

The factors in protein conversion are correlated

The above-mentioned experiments (Tables 2 and 3) also provided information about the factors related to protein conversion (feed protein consumption, daily gain, feed conversion, protein deposition in percentage of the amount eaten and per kg gain, meat percentage determined by dissection etc.) The degree of mutual dependence between the factors was studied by a correlation analysis. The results are stated in Table 4. Since the material consists of the results of various experiments with different treatments, the correlation coefficients are calculated after adjusting for experiments, sex and treatment within experiments.

Table 4. Partial correlation coefficients[1)] between factors related to the protein conversion by growing pigs

	Protein g/d	Protein g/kg feed	Weight g/d	Feed/ gain	Deposited protein, % consumed	Meat, %	Deposited protein g/kg gain
Protein, g/kg feed	0.17						
Gain, g/d	0.68	0.29					
Feed/gain	0.02	-0.28	-0.71				
Protein deposited, % consumed	-0.13	0.16	0.49	-0.80			
Meat, %	-0.56	-0.10	-0.41	0.03	0.24		
Protein, deposited, g/kg gain	-0.22	0.05	-0.11	-0.08	0.60	0.40	
Fat deposited, g/kg gain	-0.46	-0.01	0.13	0.27	-0.51	-0.55	-0.60

[1)] Multivariate variation analysis: Sex, experiment, treatment within experiments, empty body weight

The detected correlation (Table 4) were subsequently described quantitatively by regression analysis (Table 5). It appears from the tables that the feed utilisation (feed/gain) and protein utilisation (deposited protein in percentage of the amount eaten) are inter-dependent to a very high degree.

Table 5. Prediction of protein deposition in gain and protein and feed utilisation

Equat. No.	Y	Int.	B	X	R^2	CV
1	Depos. prot. g/kg gain	208	-0.07	g prot./d	0.41	4.3
2	"	130	0.28	g prot./kg feed	0.38	4.4
3	"	191	-0.01	g gain/d	0.38	4.4
4	"	190	-3.12	Feed/gain	0.38	4.4
5	"	85	1.81	Meat %	0.47	4.0
6	Depos. prot., % of cons.	-1.6	0.19	Depos. prot., g/kg gain	0.87	6.2
7	"	41.9	-0.05	Depos. fat, g/kg gain	0.85	6.6
8	"		0.15	Depos. prot., g/kg gain		
		10.9	-0.02	Depos. fat, g/kg gain	0.88	6.0
9	"	64.0	-10.72	Feed/gain	0.93	4.6
10	Feed/gain, kg	4.9	-0.06	Depos. prot., % cons.	0.90	4.0
11	"		0.003	Depos. prot., g/kg gain		
		1.9	0.002	Depos. prot., g/kg gain	0.74	6.4

This result offers the possibility of estimating the protein utilisation in actual cases by its relation (Equation 9) to the feed utilisation which is usually known in practice. On the other hand, the reciprocal relation (Equation 10) shows that an improvement of protein utilisation (i.e. by making a fine adjustment of the amino acid composition of the feed protein) of 1%, saves 60 g feed for every kg gain which is equal to 4.2 kg less feed for the production of one pig from 30 to 100 kg. Although these equations are not inconditionally valid for general application, they show, however, that there is a potential economic gain by improving the protein utilisation.

These results also show that a change detected in one or several of these factors will inevitably be followed by a similar change in one or several of the other factors. This is of special importance when trying to calculate the consequence of, e.g., N loss in the pig production caused by a change in the factors of production.

Consequences of a 10% change in the production factors for the protein loss

Nitrogen and phophorus turnover in slaughter pig production was described in the preceeding section by the average of the results from experiments and from the Efficiency Control. In the following, the relative importance of the N loss for the variations in selected production factors is explained by means of a consequential calculation. The correlations detected (Tables 4 and 5) between relevant factors were as far as possible incorporated in the calculations. For this purpose, first the N loss was calculated on the basis of a reference pig subject to preconditions primarily based on the values stated in Tables 2 and 3. Then the N loss was calculated again after consecutive changes (10%) in individual selected factors (1-6) as follows:

Preconditions:	Reference	Change	±10%
Feed, kg/day	1.95		
Protein, g/kg feed	187	1st	-18.7 g
Total gain, 25-100 kg	75	2nd	- 7.5 kg
Protein digestibility, %	77		
Feed utilisation, kg feed/kg gain	2.87	3rd	- 0.29 kg
Gain, g/day	687	4th	+68.7 g
Deposited protein, % of intake	33.3	5th	+3.3 %
Deposited protein, g/kg gain	181	6th	-18.1 g

Protein account concerning a reference pig: Gain 25-100 kg		
Days before slaughter:	75/0.687	= 109 days
Feed consumption:	75*2.87	= 215 kg
Protein consumption:	215*0.187	= 40.21 kg
Digested protein:	40.21*0.77	= 30.96
Faeces protein:	40.21*0.23	= 9.25 kg
Deposited protein:	75*0.181	= 13.58 kg
Utilised protein:	13.58/40.21*100	= 33.8%
Protein in urine:	40.21-9.25-13.58	= 17.38 kg
Protein loss:	9.25+17.38	= 26.63 kg

Table 6. Calculation of the consequences for the protein loss caused by changes in production factors (1-6)

		Change					
	Reference	1	2	3	4	5	6
Consumption	40.21	36.19	37.57	36.20	36.19	37.43	40.21
Loss in faeces	9.25	8.32	8.64	8.33	8.32	8.61	9.25
Deposited	13.58	13.58	12.67	13.79	13.58	13.71	12.22
Loss in urine	17.38	14.29	16.28	14.08	14.29	15.11	18.74
Total loss	26.63	22.61	24.90	22.41	22.62	23.72	27.99
Relative	100	84.9	93.5	84.2	84.9	89.1	105.1

As already shown, the various parameters, which were included in the protein account are more or less dependent on each other. The following considerations were taken into account in the above calculations:

1. Reduction of feed protein

In the case in question, it is estimated that the change is alone a reduction in the protein amount, which by an unchanged production result will mean that protein was in excess. In some cases, the change may also result in an increase in the protein quality, though. Thereby a more efficient feed utilisation is achieved and probably also fewer days until slaughter with an extra reduction of the protein loss as a consequence. The above-mentioned consequence should therefore be considered as underestimated.

2. Reduction in total gain

This can be achieved by a higher starting weight than 25 kg or a lower slaughter weight than 100 kg. The difference in the protein utilisation between small and large pigs has not been included in the calculation.

3. Improved feed utilisation
The feed utilisation is of course determined by the interaction between other factors like e.g. the animal's genetically determined capability, protein quality, health, management etc. Other things being equal, the protein quality is considered the most important factor for the feed utilisation. Changes in the feed efficiency will thus be subject to a change in the protein utilisation. Regard has been taken to this by calculating a protein utilisation that correspond to the change in the feed utilisation by means of Equation 9. Since the feeding conditions are not otherwise changed, it causes an increased protein deposition.

4. Increase in daily gain
Daily gain is also a result of the correlation between various factors. Therefore, it may also affect the feed efficiency etc. This has been offset by calculating the number of days until slaughter (75/0.687/1.1) and by applying the reference value for feed/day and protein in feed.

5. Improved protein utilisation
As with Subsection 3 above, the same considerations apply here. Therefore, the feed utilisation has been calculated by Equation 10.

6. Reduced protein deposition/kg gain
In this case, the precondition is a pig that is unable to utilise the protein to the same degree as the reference pig.

The results stated in Table 6 show that under the given conditions, feed protein level, daily gain and feed efficiency are the most important factors for the protein loss. The results also show that these three factors affect the protein loss to almost the same extent.

Variation in the nitrogen and phosphorus loss for pig production
The above section describes the present-day knowledge of the most important factors for the consumption, utilisation and loss of nitrogen and phosphorus in pig production. By combining the data material from practice concerning the conditions of production (the Efficiency Control) with information about the protein and phosphorus content in pig feed and in addition with data provided by experiments concerning the digestibility and utilisation of nutrients, calculation models concerning total N and P loss can be formed. The gain by sows is estimated at 20 kg/litter with an N and P content of 25 and 5 g/kg respectively. The sucking pigs (7.5 kg) are estimated to contain 24 g N and 5 g P/kg (Appendix 3). The N and P content in gain by piglets (7.5-30 kg) is estimated to be the same as that for slaughter pigs (Table 3).

The calculations shown in Tables 7, 8 and 9 show the N and P loss by a production efficiency that is equal to the average of the Efficiency Control for 1995 and the averages of the worst 25% and the best 25%.

Table 7. Nitrogen and P account of consumption, utilisation and excess in connection with the production of slaughter pigs. Average of the Efficiency Control

	Consumption		Utilisation		Excess			
	Feed		Deposited		Faeces		Urine	
	N	P	N	P	N	P	N	P
Sucking pigs (0-7.5 kg)	1.29	0.34	0.23	0.05	0.26	0.19	0.79	0.11
Piglets (7.5-30 kg)	1.23	0.30	0.63	0.12	0.18	0.16	0.42	0.02
Slaughter pigs (30-100 kg)	5.33	1.12	1.95	0.39	1.07	0.62	2.31	0.11
Total	7.85	1.76	2.81	0.56	1.51	0.97	3.52	0.24
%	100	100	36	32	19	55	45	13

Preconditions used for the calculations:
Sucking pig : Calculated on the basis of the feed consumption by a sow per year, that 1)produces 21.66 pigs; 2) has a gain of 20 kg/litter with 25 g N and 5 g P/kg; 3) has an annual consumption of 1178 FU_p (1111 kg) with a crude protein content of 162 g and 6.8 g P/kg; 4) the sucking pig contains 24 g N and 5 g P/kg.
Piglets: Consumption of 43.6 FU_p (37.6 kg) with a crude protein content of 204 g and 8 g P/kg, of which 27.8 g N and 5.4 g P/kg live weight gain are deposited. Slaughter pigs: Consumption of 206 FU_p (190 kg) with a crude protein content of 175 g and 5.9 g P/kg, of which 27.8 g N and 5.4 g P/kg live weight gain are deposited (Table 3).
In addition it is assumed that the protein digestibility is 80% for sows and slaughter pigs and 85% for piglets. Phosphorus digestibility is in all cases assumed to be 45%.

Table 8. Nitrogen and P account of the consumption, utilisation and excess in connection with the production of slaughter pigs. The worst 25% of the Efficiency Control

	Consumption		Utilisation		Excess			
	Feed		Deposited		Faeces		Urine	
	N	P	N	P	N	P	N	P
Sucking pigs (0-7.5 kg)	1.53	0.40	0.24	0.05	0.31	0.22	0.98	0.13
Piglets (7.5-30 kg)	1.48	0.36	0.63	0.12	0.22	0.19	0.63	0.05
Slaughter pigs (30-100 kg)	5.76	1.21	1.95	0.39	1.15	0.67	2.66	0.15
Total	8.77	1.97	2.82	0.56	1.68	1.08	4.27	0.33
%	100	100	32	28	19	55	49	17

Preconditions used for the calculations:
Sucking pig : Calculated on the basis of the feed consumption by a sow per year, that 1) produces 19 pigs; 2) has a gain of 20 kg/litter with 25 g N and 5 g P/kg; 3) has an annual consumption of 1247 FU_p (1176 kg) with a crude protein content of 162 g and 6.8 g P/kg; 4) the sucking pig contains 24 g N and 5 g P/kg.
Piglets: Consumption of 52.6 FU_p (45.44 kg) with a crude protein content of 204 g and 8 g P/kg, of which 27.8 g N and 5.4 g P/kg live weight gain are deposited.
Slaughter pigs: Consumption of 222 FU_p (205 kg) with a crude protein content of 175 g and 5.9 g P/kg, of which 27.8 g N and 5.4 g P/kg live gain are deposited (Table 3).
In addition it is assumed that protein digestibility is 80% for sows and slaughter pigs and 85% for piglets. Phosphorus digestibility in assumed to be 45%.

Table 9. Nitrogen and P account of the consumption, utilisation and excess in connection with the production of slaughter pigs. The best 25% of the Efficiency Control

	Consumption		Utilisation		Excess			
	Feed		Deposited		Faeces		Urine	
	N	P	N	P	N	P	N	P
Sucking pigs (0-7.5 kg)	0.96	0.25	0.23	0.05	0.19	0.14	0.54	0.06
Piglets (7.5-30 kg)	0.90	0.22	0.63	0.12	0.14	0.12	0.13	-0.02
Slaughter pigs (30-100 kg)	5.07	1.07	1.95	0.39	1.01	0.59	2.11	0.09
Total	6.93	1.54	2.81	0.56	1.34	0.85	2.78	0.13
%	100	100	41	36	19	55	40	9

Preconditions used for the calculations:
Sucking pig : Calculated on the basis of the feed consumption by a sow per year, that 1) produces 23.7 pigs; 2) has a gain of 20 kg/litter with 25 g N and 5 g P/kg; 3) has an annual consumption of 949 FU_p (895 kg) with a crude protein content of 162 g and 6.8 g P/kg; 4) the sucking pig contains 24 g N and 5 g P/kg.
Piglets: Consumption of 32.1 FU_p (27.7 kg) with a crude protein content of 204 g and 8 g P/kg, of which 27.8 g N and 5.4 g P/kg live weight gain are deposited. Slaughter pigs: Consumption of 195 FU_p (181 kg) with a crude protein content of 175 g and 5.9 g P/kg, of which 27.8 g N and 5.4 g P/kg live weight gain are deposited (Table 3).
In addition, it is assumed that protein digestibility is 80% for sows and slaughter pigs and 85% for piglets. Phosphorus digestibility is in all cases assumed to be 45%.

Faeces and urine volume

An estimate of the amounts of faeces and urine produced can be achieved by analysing the data provided by the digestibility and balance tests carried out at the National Institute of Animal Science over the latest 15 years. The data comprises 48 feed mixtures fed to pigs in the weight range 20-90 kg. Two to 5 experiments were carried out with each pig. In total 769 experiments were carried out.

In Table 10, the averages and variations in the chemical composition of feed, faeces and urine are stated.

Table 10. Amount and chemical composition of feed, faeces and urine determined by digestibility and balance experiments with growing pigs (35-90 kg)

Name	Average	s	Min	Max
			Feed:	
Feed, kg/d	1.885	0.45	0.96	2.678
Dry matter, g/kg feed	878	6	863	888
Ash, g/kg dry matter	61	9	47	101
Crude Protein, g/kg dry matter	220	23	178	273
Fat, g/kg dry matter	39	15	27	81
Crude fibre, g/kg dry matter	66	29	35	162
Nitrogen-free extract (NFE), g/kg dry matter	614	45	471	702
FU_p/kg dry matter	1.12	0.1	0.94	1.41
FU_p/kg feed	0.99	0.1	0.83	1.24
Protein, g/FU_p	197	24	152	251
Digestible protein, g/FU_p	152	17	122	197
Crude protein digestibility, %	77	4	72	92
Organic matter digestibility, %	81	4	71	92
Dry matter digestibility, %	79	4	69	90
			Faeces:	
Faeces, kg/d	1.145	0.39	0.270	1.929
Faeces, kg/kg feed	0.615	0.171	0.212	1.081
Dry matter, g/kg	307	30	263	414
Ash, g/kg dry matter	163	32	110	267
Crude protein, g/kg dry matter	244	35	172	313
Fat, g/kg dry matter	82	15	50	109
Crude fibre, g/kg dry matter	218	49	162	363
NFE, g/kg dry matter	293	31	228	357
			Urine:	
Urine, kg/d	3.019	0.684	1.534	4.502
Urine, kg/kg feed	1.630	0.217	1.283	2.173
N in urine, g/kg	7.9	1.9	4.7	14.8

For technical reasons, all pigs in the experiments were given the same amount of water in relation to the amount of feed (approx. 2.5 l water/kg feed). This limits the suitability of the material especially with respect to clarifying the variations in the urine volume.

The volume and composition of the faeces are though primarily dependent on the chemical composition of the feed. Statistical analyses show that the volume of the faeces (kg faeces/kg feed) depends to a high extent on the chemical composition of the feed. Multiple regression of the nutrient content of the feed **(g/kg dry matter)** on the volume of the faeces (g/kg feed) or dry matter in faeces (g/kg faeces) resulted in the following equations:

Equation 12: Faeces, g/kg feed = 594.5-0.10*fat* crude fibre+0.05*crude fibre^2
$R^2 = 0.74$ CV = 14.5
Equation 13: Faeces, g/kg feed = -487.9 + 46.7*fat-0.51*fat^2 + 0.03*crude fibre^2
$R^2 = 0.80$ CV = 12.9
Equation 14: Faeces, g/kg feed = -33.3-51.3*crude fibre+0.05*ash*protein
+0.07*crude fibre*NFE+0.1*crude fibre^2
$R^2 = 0.81$ CV = 12.8
Equation 15: Faeces, g/kg feed = -191+16.6*crude fibre-0.4*fat^2+ 0.2*fat*protein
-0.08*protein*crude fibre+0.04*crude fibre^2
$R^2 = 0.87$ CV = 10.7
Equation 16: Dry matter, g/kg faeces = 425+0.1*fat^2-0.03*fat*protein
+0.01*protein*crude fibre-0.04*fat*crude fibre-0.003*crude fibre*NFE
$R^2 = 0.81$ CV = 4.3

The urine volume may be indirectly estimated by calculating the water balance in the following way:
1.- Water intake, g/kg feed = water content in feed, g/kg feed + drinking water
2.- Water loss in faeces, g/kg feed = g faeces/kg feed (*Equations 12-15*)/1000
*(1000-dry matter in faeces, g/kg (*Equation 16*))
3.- Absorbed water, g/kg feed = water intake - water loss in faeces
4.- Deposited water, g/kg feed = (1000-deposited dry matter, g/kg gain (*Table 3*))
/feed, conversion kg/kg gain
5.-Water loss in urine, g/kg feed = absorbed water-deposited water

Calculation of standard values for the N, P and K content in pigs including the content of the gastrointestinal canal
Total loss is normally calculated as the difference between intake with feed and deposition in the body. The amounts deposited and stated in Table 3 are as already stated calculated as the accumulated amount in the entire body after cleaning of the gastrointestinal canal divided by kg live weight. The loss calculated in that way is not identical with the loss ex farm, since at the time of delivery the part of the loss deriving from the content of the gastrointestinal canal is removed from the farm at the time of delivery. Based on the average values stated in Table 3 and the crude protein and phosphorus content of the feed (Pigs, Appendix 1), the standard values can be calculated, assuming that the pigs eat 1.3 and 4.0 kg feed/day at 30 kg and 100 kg live weight respectively. It is further assumed that the digestibility of the crude protein is 85 and 80%, respectively, and of phosphorus 45%.

Content of gastrointestinal canal:
N, 30 kg: 1.3 x 204/6.25 x (1-0.85) = 6.4 g N
P, 30 kg: 1.3 x 8 x (1-0.45) = 5.7 g P

N, 100 kg: 4.0 x 175/6.25 x (1-0.80) = 22.4 g N
P, 100 kg: 4.0 x 5.9 x (1-0.45) = 13.0 g P

Content in the pig including the content of the gastrointestinal canal:
<u>30 kg:</u>
N: (21.4 x 156/6.25 + 8.6 x 170/6.25 + 6.4)/30 = 25.8 g N/kg live weight
P: (21.4 x 5.1 + 8.6 x 5.4 + 5.7)/30 = 5.4 g P/kg live weight

<u>100 kg:</u>
N: (100 x 170/6.25 + 22.4)/30 = 27.4 g N/kg live weight
P: (100 x 5.4 + 13.0)/30 = 5.5 g P/kg live weight

<u>30-100 kg:</u>
N: (100 x 27 - 30 x 25.8)/70 = 28.1 g N/kg live weight
P: (100 x 5.5 - 30 x 5.4)/70 = 5.5 g P/kg live weight

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Cattle, Appendix 1

The amount and composition of cattle faeces and urine and the excretion of N, P and K in faeces and urine

by

Verner Friis Kristensen[1] and Troels Kristensen [2]
National Institute of Animal Science
[1]Department for Nutrition
[2]Department of Agricultural Engineering and Production Systems
P.O. Box 50
DK-8830 Tjele
&
Ole Aaes and Ole Klejs Hansen
The Agricultural Advisory Centre
Department of Cattle Husbandry
15 Udkærsvej, Skejby, DK-8200 Aarhus N

Introduction

This report has been prepared as a documentation of the values for the excretion of faeces and urine and the amounts of the nutrients N, P and K in faeces and urine excreted by cattle. The documentation is based on both model calculations and on analyses of data provided by the Periodic Feed Control that are conducted on cattle farms in practice. The individual sections describe first the model preconditions, elements and results. For each group of animals, the results are then compared with the analytical results provided by the Periodic Feed Control. Further, the effects of variations in certain factors are being illustrated by calculations performed by means of the model SAMSPIL (Hansen et al., 1996) that has been developed for the purpose of describing the nutrient flow and utilisation on cattle farms.

Materials and methods

The initial model is based on a combination of data provided by the Ydelseskontrollen (milk recording) and feed planning in practice, results and connections established by means of feeding experiments and standard feeding plans and table values. The calculations in the model are constructed in principle on the basis of balances for dry matter, N, P and K calculated on the basis of information about the content in feed, body, milk and embryos and on the digestion and the conversion of these matters. Concerning the nutrients N, P and K, the balances are expressed as in the example set out in the following equation:

$$N_{feed} = N_{gain} + N_{embryo} + N_{milk} + N_{faeces} + N_{urine}$$

The model preconditions and calculations are also described in the individual sections.

The analysis of the information from practice is based on data provided by the Periodic Feed Control. The Periodic Feed Control is used for an analysis of the feed management and feed utilisation in practice. The Periodic Feed Control is partly based on One-day Feed

Controls and partly on the stocktaking of the herd and the purchase of commercial feeds. By the One-day Feed Control, all feed rations assigned to the various groups of animals in the herd are weighed. In many cases, also the refusals of the feed is weighed. In calculating the nitrogen intake, the analytic results or recorded values belonging to the feeds of the herd are used. If no analytic results or recorded values are available, the table value from local files is used if such files are available, otherwise the values from the general feed table are used. Mineral values are always table values. A One-day Feed Control is carried out 8-10 times per year. Approx. four times, an extended One-day Feed Control is made thereby making a stocktaking of the herd. In those cases, the animals are weighed or measured. 'Newcomers', births and leavers from the herd and transfers within the herd are recorded with prices and weight. Approx. 50% have information transferred directly from the data base concerning the Ydelseskontrollen (yield recording). In connection with these extended control records, the purchase and stocks of feed mixes and mineral matter are recorded. The milk production is calculated on the basis of dairy accounts and the consumption by calves and household.

All this information is used to calculate the Periodic Feed Control for the period between two stocktaking dates. The consumption of home-grown feeds (roughage and cereals) is calculated on the basis of the One-day Feed Control in the period in question and on information about the dates for the change of feeds. The consumption of commercial feeds is calculated in the same way, but this consumption is corrected on the basis of the stocktaking. The division of a correction among the animal groups occurs on the basis of the individual One-day Feed Controls. In a few cases, a similar correction for home-grown cereals may occur.

Weighing/measuring, leavers and newcomers form the basis of the calculation of the gain. The number of animals and newcomers and leavers are also used for the calculation of feeding days.

The data provided by the Periodic Feed Control, i.e. crude data provided by the One-day Feed Control and stocktaking, are currently stored in a database at The Agricultural Advisory Centre for the immediately preceding period of two years. These data are used in this analysis for a comparison between the results measured in practice and the results calculated by the models.

Measurements within the Periodic Feed Control are of course subject to a high degree of uncertainty which results in great variations. Results beyond a range of variation that can be considered a normal cattle production are not included in the calculations. The same applies to herds with a feed efficiency below 65 or above 110%. Concerning young bulls, the results have not been included if the feed ration assigned was less than 2 FU per animal per day or if the gain was less than -1 kg or above +2 kg per animal per day in any of the groups.

All further description of materials and methods are including in the following sections.

Dairy cows

Amounts of feed, faeces and urine and the dry matter content in faeces and urine by dairy cows

The model calculations of required feed are based on results of the Ydelseskontrollen (milk recording) for the recording year 1995-96 when between 85 and 90% of all dairy cows were recorded (Hansen, 1997) (Table 1). In order to calculate the feed required for this yield, the lactation period is divided into three phases of 24, 11 and 10 weeks, while a dry period of 50 days (Table 2) has been included. The 24 weeks at the beginning of the lactation period is equal to the period with fixed feeding strategy that is used in the management of most herds. Hence a replacement of approx. 40% has been estimated with the leavers distributed over the lactation phases. This gives a distribution of feed and milking days on lactation phases as shown in Table 2.

Table 1. Average yield by controlled cows of various breeds in the recording year 1995/96 (Hansen, 1997)

		g/kg milk			
Breed	kg milk	fat	protein	N	kg ECM
RDM*	6930	42.5	35.6	5.58	7222
SDM**	7532	41.6	33.5	5.25	7645
Jersey	5228	61.3	40.8	6.40	6857

(*Red Danish cattle breed ** Danish Holsteins)

Table 2. Distribution of cow-per-year feeding days and yield in lactation periods

Lactation phase		Feeding and	Kg ECM per cow per day		Total ECM	
No.	No. of days	milking days	Heavy breed	Jersey	Heavy breed	Jersey
1	168	192	25.4	22.9	4877	4397
2	77	79	21.8	19.3	1722	1525
3	70	60	16.8	15.8	1008	948
Dry	50	34				
Per cow per year	365	365			7607	6870

Table 3. FU requirements by dairy cows of heavy breed calculated on the basis of standard values

Lactation phase	Maintenance	Milk	Gain	Embryo	Totalling
1	883	1951	0		2834
2	363	689	81		1133
3	276	403	48	21	748
Dry	156		31	45	232
Per cow per year	1678	3043	160	66	4947

Table 4. FU requirements by Jersey calculated on the basis of standards

Lactation phase	Maintenance	Milk	Gain	Embryo	Totalling
1	691	1758	0		2449
2	284	610	50		944
3	216	379	30	17	642
Dry	122		20	31	173
Per cow per year	1313	2747	100	48	4208

Finally an average yield has been established for the individual lactation phases that is based on standard lactation curves (The Agricultural Advisory Centre, 1996). Based on this, energy requirements have been measured in FU calculated on the basis of standard norms (Studsholm et al., 1992) (Tables 3 and 4).

Feed efficiency
The calculated energy value of the feed cannot be utilised 100%, first and foremost because the energy value of the feeds is not additive as originally assumed. Primarily, the utilisation of the feed is reduced with a growing feed level due to a decreasing digestibility of the feed. In practice, there are other matters that can affect the feed efficiency, e.g., feed wastage, illness, housing environment, management quality, and feeding. In order to get an impression of the energy utilisation, the feed efficiency is calculated as the total energy requirements (FU) for maintenance, gain, the production of embryos, and milk production on the basis of the standard norms in proportion to the calculated intake of energy in the total amount of feed. The energy utilisation calculated on cattle farms in practice varies to a high degree as will appear from the reports from pilot farm studies with cattle (e.g. Kristensen et al., 1991; Kristensen & Kristensen, 1991). On the basis of the observations on pilot farms, it is estimated that the average feed efficiency is 87%. In addition, a graduation of the feed utilisation has been used during the lactation period that is based on the correlation between the feed level and the feed efficiency (Kristensen & Aaes, 1989).

Table 5 shows the results of the correction for feed efficiency of the feed required.

Table 5. FU requirements of dairy cows after correction for feed efficiency

		Corrected FU requirements			
		Heavy breeds		Jersey	
Lactation phase	Efficiency, %	Totalling	Per day	Totalling	Per day
1	85	3334	17.4	2881	15.0
2	89	1273	16.1	1061	13.4
3	91	828	13.7	705	11.8
Dry	91	255	7.5	190	5.6
Per cow per year	87	5690		4837	

Feed intake
The next step is to estimate the dry matter intake. This estimate is established on the basis of the FU requirements via the establishing of an energy concentration (EC = FU/kg dry matter) in the feed which again is calculated on the basis of a recorded correlation between the energy concentration and feed intake when fed according to appetite:

$$Y = 25.3\ EC - 5.4$$ (Kristensen, 1983)

Results are shown in Table 6.

Table 6. Calculated dry matter absorption per cow per year

Lactation phase	FU/kg dry matter	Dry matter intake, kg Heavy breeds	 Jersey
1	0.94	3547	3065
2	0.91	1399	1166
3	0.85	974	829
Dry	0.70	364	271
Per cow per year	0.91	6284	5331

Digestibility of the feed

Based on the amounts of feed, the amounts of faeces are estimated accordingly via a pre-set dry matter digestibility. For that purpose, an analysis was made of the digestibility determination by a total of 220 cows in 65 different experimental treatments (3-4 cows per treatment) over 10 experiments carried out at the National Institute of Animal Science (Table 7). The material was versatile regarding types of diets and roughages. All experiments were carried out at an early stage in the lactation period and in most cases, the feed level was high.

Table 7. Materials concerning digestibility determination in cows

Experiment	Number of units	Number of cows	Roughage	Supplementary feed
128	6	24	Clover grass silage	Beets/cereals/concentrates
150	6	24	Clover grass silage	Beets/cereals/concentrates
169	8	23	Clover grass silage	Beets/concentrates
170	3	12	Whole-crop silage/peas/ oat/broad beans	Beets/cereals/concentrate
188	8	21	Clover grass silage/straw	Beets/concentrates
189	6	18	Whole-crop silage/ wheat/broad beans	Beets/cereals/concentrates
200	12	46	Grass silage/NH_3-straw	Beets/concentrates/grass cubes or grass pellets
201	6	18	Whole-crop silage/wheat/peas	Beets/cereals/concentrates
216	6	18	Whole-crop silage/wheat	Beets/beet refuse/ cereals/concentrates
262	4	16	Whole-crop silage/ clover grass silage	Beets/cereals/concentrates
Totalling	65	220		

The average digestibility of the feed dry matter was 71% with a standard deviation of 3% points. The individual standard deviation within experiment was in the area of 2-3% points.

The digestibility of a given ration declines with an increased feed intake (Kristensen & Aaes, 1989). In the late lactation period and in the dry period, there is a lower feed level than in the above-mentioned experiments. On the other hand, a decreased amount of easily digestible feeds is fed. The effects of a lower feed level and less easily digestible feeds are estimated to almost offset each other. When house-fed, a dry matter digestibility of 71% is therefore generally assumed. When fresh grass, particularly in controlled large-scale corral, makes out the most important part of the roughage (>7FU), then a slightly higher dry matter digestibility (73%) is estimated, since this roughage is very easily digestible.

Based on these preconditions, the amount of dry matter in faeces ex animal can be established.

Dry matter content of faeces
The amount of solid faeces is determined on the basis of the values for the dry matter content of the faeces.
To appraise the dry matter content of faeces, the data provided by the same experiments as those for estimating the digestibility (Table 7) were applied. The analysis showed an average of 14.5% dry matter with a standard deviation between the individual determinations (220 cows) in the entire material of 1.5% point. The average dry matter content of the faeces in almost all experiments has been in the range of 14 to 16% and the individual standard deviation within experiment has been 0.8 to 1.7% point. Easily digestible grass silage may result in a lower dry matter content of the faeces. One of the experiments on eight cows fed on clover grass silage showed a dry matter content of the faeces of 12.3±0.6%. In addition to that, the dry matter content of the faeces has in all cases been about the average whether or not the basic feed consisted of grass silage or silage consisting of various whole-crops and whether or not cereals/concentrates were replaced wholly or partly with grass cubes or dried beet pulp. A replacement of 5.5 FU beets with a similar amount of dried beet pulp (basic feed: winter wheat whole-crop) resulted in a rise in the dry matter content of the faeces of approx. 1% point from 13.5 to 14.4%. An experiment where straw was fed as roughage yielded a higher dry matter content in the faeces (16.5%) than grass silage (13.8%) when the supplementary feed consisted of concentrates. When part of the concentrates was replaced by grass cubes or grass pellets, the result did not show a similar difference between straw and silage. On the basis of these data, the dry matter content in faeces by house-fed dairy cows is estimated to be at 15%.

Amounts of urine
Over the recent years, the amounts of urine have been measured in 7 experiments on house-fed dairy cows carried out at the National Institute of Animal Science. The material comprises 100 observations. 13 of them have been carried out on dairy cows during the dry period, while the remaining observations were at an early stage or in the middle of the lactation period. The result is stated in Table 8.

Table 8. Amounts of urine by dairy cows

Exp.	Feed ration	No. of cows	Physiological status	Amounts of urine/day kg	s
245	Clover grass silage + concentrates	5	Dry period	17	2.7
245	Clover grass silage + concentrates	8	Dry period	10	3.3
245	Clover grass silage + beets + concentrates	7	Early lactation	21	4.7
245	Clover grass silage + beets + concentrates	8	Early lactation	14	4.4
262	Whole-crop silage (wheat) + beets + conc.	8	Early lactation	10	1.4
262	Clover grass silage + beets + concentrates	7	Early lactation	24	2.8
281	Clover grass-/pea silage + concentrates	12	Early lactation	13	3.3
282	Whole-crop silage (wheat) + beets + conc.	12	Early lactation	13	8.0
308	Clover grass-/pea silage + concentrates	12	Early lactation	16	5.9
309	Whole-crop silage (wheat) + beets + conc.	12	Early lactation	18	8.4
312	Clover grass silage	3	Early lactation	27	11.8
312	Fresh clover grass	3	Early lactation	45	20.0
312	Fresh rye-grass	3	Early lactation	35	8.8
308	Clover grass-/pea silage + concentrates	12	Early lactation	16	5.9
309	Whole-crop silage (wheat) + beets + conc.	12	Early lactation	18	8.4

There are extremely great variations in the amounts of urine both among cows within experiment and among individual experiments or experimental treatments. The most important reasons for variations in the amount of urine may be differences in the water content of the feed and the amount of ions or molecules that are to be excreted via the kidneys and for which limits are set for the ratio of concentration in the urine. But the individual variation when feeding the same ration is also extremely great. Table 8 shows the standard deviation between cows within experiment or experimental treatments.

A weighted average of the results set out in Table 8 that are connected with rations consisting of silage, beets and concentrates at an early state of the lactation period, is 16 kg urine per cow per day. The results indicate that the amount of urine may be even considerably larger when the intake of fresh grass is high. This applies most probably also to the intake of great amounts of other watery feeds. The amount of urine by the cows was approx. equal to the amount of faeces/2.2.

Dry matter content in urine

Of available Danish results concerning the dry matter content of urine, only analyses on the urine from 8 cows in the dry period have been found and from the same 8 cows shortly after calving (Weisbjerg, 1996, not published). These data are from experiment No. 245 that is among the experiments set out in Table 8. The results were 4.87% dry matter with a standard deviation of 1.16% point in the dry period and 5.03% dry matter with a standard deviation of 0.87 after calving. Thus, there is also great variation concerning the dry matter content in the urine which in this material showed a range of distribution of 3-7%. This is also related to the high degree of variations in the amount of urine. When collecting the urine, it was obvious at the mere sight of it that the dry matter concentration in the urine from the individual animals varied to a high degree which is related to the great differences in volume. In addition to salts, first and foremost Na^+ , K^+ and $C1^-$, urine contains among other things a wide range of nitrogenous waste matter like e.g. creatinine, purine derivatives, hippuric acid and urea. In the model calculations, a dry matter concentration in the cow urine of 5% is assumed.

Nitrogen excretion by cows

Calculation of the N absorption by dairy cows

The estimation of the N absorption by cows is based on statistical surveys of data on feed planning in practice. The Department of Cattle Husbandry analyses each year the feed plans that have been stored in the electronic control systems. The statistical survey for the winter season of 1995-96 is based on 2918 feed plans that are updated during the period October-December and which includes approx. 26% of the herds controlled. In winter feed plans for cows in the early lactation period, the average protein content over the recent years has currently been 134 g digestible crude protein per FU (Kjeldsen, 1996). This value is used in the model for the first phase (24 weeks) of the lactation period (Table 9). Concerning the other two phases of the lactation and for the dry period, the protein level in the form of g digestible crude protein per FU is estimated on the basis of the level of the first period.

The digestible crude protein content in the feed ration is hence calculated into feed dry matter content by means of the energy concentrations that are found in Table 6. Hence a conversion into total crude protein in the feed dry matter is made by means of the following equation:

g digestible crude protein/kg feed dry matter = 0.93 x g crude protein/kg feed dry matter - 30 (Thomsen, 1979) (2)

that in practice is used for the calculation of the digestible crude protein content based on the total crude protein content in the feed. The calculated values for total crude protein content and N in the feed rations are also shown in Table 9.

Table 9. Protein content in feed rations

Lactation phase	g digestible crude protein/FU	g digestible crude prot./ kg dry matter	g crude protein per kg dry matter	g N per kg dry matter
1	134	126	168	26.9
2	130	118	159	25.5
3	125	106	146	23.4
Dry	104	73	111	17.8

Calculation of the N digestibility/N excretion in faeces

The equation illustrated above (Thomsen, 1979) shows the correlation that is found when the cows are fed maintenance rations (low feed level). For cows that are fed a higher feed level, the crude protein digestibility is lower. In order to correct for this difference, an analysis has been made on data concerning N digestibility.

The analysis is based on the data on the digestibility experiments on cows from the National Institute of Animal Science. This analysis includes results from 8 experiments that were made with the purpose of investigating the effects of different protein supplies where the nitrogen content in the rations was spread over a relatively broad interval and in which the nitrogen digestibility was determined. The results are from an experiment that was published in 1973 and from experiments carried out within the most recent years. The experiments were as follows:

1. The influence of various carbohydrates on the utilization of urea for dairy cows (Møller, 1973)
2. Nitrogen fertiliser influence on the protein value of grass silage for dairy cows and on the quality of the milk (Kristensen et al., 1987).
3. Rumen, intestine and total digestibility of carbohydrates, nitrogen and fatty acids by cows fed rations with a high fat-and-non-degradable protein content (Palmquist et al., 1993).
4. Soya bean meal or urea for cows fed barley whole-crop (Weisbjerg et al., 1994)
5. A comparison between wheat whole-crop and clover grass on two levels of AAT (Kristensen et al., 1994). Not published.
6. Determination of critical minimum requirements for PBV (Weisbjerg et al., 1994). Not published.
7. Reducing the input and loss of nitrogen and energy on dairy farms (Kristensen & Ohlsson, 1996).

Project 1 consisted of three experiments each with two units of 4 cows that during 5 subsequent periods were fed various experimental mixes. Thus a total of 30 different experimental treatments were carried out. Experiments 2, 3, 4 and 6 were Latin square analyses with 4 cows, 4 test periods and 4 experimental treatments. In experiment No. 2, there were two repetitions over two years so that the experiment included a total of 8 units. The experiments Nos. 5, 7 and 8 were continuous, i.e., an experimental unit is treated during a test period. Thus each of the units consisted of 4 cows. The experiments included 4, 3 and 3 experimental treatments. Thus the material comprises a data material of 60 average values each based on 4 observations.

These average values are analysed by means of a multiple regression equation with the following result:

$$y = 0.96(\pm 0.02)x - 0.18(\pm 0.04)z - 2.00(\pm 0.57)$$
$$R^2 = 0.98;\ P \text{ for } b_1 \text{ and } b_2 < 0.0001$$
$$S_{y/x} = 0.5 \qquad (3)$$

where
y = % digestible crude protein in feed dry matter
x = % crude protein in feed dry matter
z = kg dry matter intake per cow per day.

The average dry matter intake by the individual experimental treatments varied from 12.0 to 21.1 kg, and the crude protein content of the feed varied from 11.4 to 29.7% of the dry matter. A simple regression of the digestible crude protein content of the dry matter (y) on the percentage content of total crude protein in the dry matter (x) showed the following result:

$$y = 0.94(\pm 0.02)x - 4.40(\pm 0.37)$$
$$R^2 = 0.97;\ P \text{ for } b < 0.0001$$
$$S_{y/x} = 0.6 \qquad (4)$$

This connection is in principle equal to the equation made by Thomsen (1979) on the basis of digestibility experiments on sheep fed maintenance rations. The slope in such an equation can be considered an expression of the true digestibility of the crude protein in the feed, while the intercept value expresses the amount of faecal metabolic protein. This equation is in good harmony with many similar equations calculated on various materials (Swanson, 1977, NRC 1985). These calculations show that the true digestibility of the feed protein is well above 90%. The excretion of faecal metabolic protein varies, since it e.g. increases with the content of cell wall matters in the feed and with rising feed level. The most important reason for that is probably an increased excretion of microbial protein in faeces that is caused by fermentation of large amounts of carbohydrates in the hindgut. The true digestibility (the slope) in Equations (2) and (4) are almost the same. But the amount of faecal metabolic protein (the intercept value) is higher in the experiments behind Equation (4) than in Equation (2) which is due to the generally higher feed level in the experiments on cows. In an experiment on cows fed maintenance rations, Susmel et al. (1993) found an intercept value that was slightly lower than the value in Equation (2), i.e., 2.7 against 3.0, i.e., at the same level as the experiments on sheep. In cows fed a high feed level, much lower digestibility coefficients for N have been detected (57-64) than those estimated on the basis of Equation (2) (73-76) (Valk et al., 1990). For the rations that form the basis of the lactation period in this model, the N digestibility was reduced from approx. 75% to approx. 65% by applying Equation (3) instead of Equation (2).

In the data set from the 8 experiments that are analysed and that resulted in Equation (4), there were considerable differences in feed level between experiments. Although there is a risk that there may be other factors than the feed level that may have contributed to differences between experiments, it is chosen to base the following calculations on Equation (3).
The daily N excretion in faeces can be calculated directly by paraphrasing Equation (3) by using the daily dry matter absorption in kg per cow (DM) and the daily N absorption in g per cow (N):

$$\text{g N}_{\text{faeces}} = 0.04 \text{xN} + \frac{\text{DM}^2 \text{ x } 1.8}{6.25} + \frac{\text{DM x } 20}{6.25}$$

The amount of faecal N is hence converted into kg N per lactation phase and cow per year as shown in Table 10. The N excretion is calculated in the same way for Jersey cows as for heavy breeds.

Table 10. N excretion in faeces, kg per cow per year

Lactation phase	Heavy breeds	Jersey
1	34.1	27.1
2	13.0	9.9
3	8.6	6.7
Dry	2.5	1.7
Per cow per year	58.2	45.4

N in milk, gain and embryo
The excretion of N in milk is calculated on the basis of the yield by recorded cows as the amount of milk protein/6.38.

The N amount in new-born calves and in own gain is determined as follows:

Heavy breeds:	0.6 calf of 40 kg with 185 g protein per kg ~ 0.7 kg N
	40 kg gain with 160 g protein per kg ~ 1.0 kg N
Jersey:	0.6 calf of 25 kg with 185 g protein per kg ~ 0.4 kg N
	25 kg gain with 160 g protein per kg ~ 0.6 kg N

Total N balance
Hence standard values for total N balance per cow per year for house-fed cows can be made, since the N excretion in urine is calculated as the difference between absorbed N and N in milk, gain, embryo and faeces. The result is shown in Table 11.

The result shows that the utilisation of feed N has improved compared with earlier results (Laursen, 1994), since 26% of N in feed is found again in products (milk and meat) against 24% in the earlier model calculation. This is due to the fact that in practice, the protein content of feed has been reduced, but at the same time, the yield and thus the amount of N in milk protein has increased.

Table 11. N balance per cow per year at 0 grazing

	Heavy breeds		Jersey	
	kg	%	kg	%
N absorbed in feed	160.0	100	136.0	100
N in milk	39.4	25	33.5	25
N in gain + embryo	1.7	1	1.0	1
N in faeces	58.2	36	45.4	33
N in urine	60.7	38	56.1	41
N in faeces + urine	118.9	74	101.5	74

N excretion by grazing cows

Fresh grass often has a high protein content. Great amounts of grass may therefore result in an excess of easily degradable protein that is being excreted in the urine. The extent of the grazing or the amount of fresh grass in the feed fed to the herds may vary from 0 to 12-14 FU per cow per day, and also there may be great difference in the length of the period where fresh grass makes out the major constituent of the diet.

Analyses on updated summer feed plans in the 'FTD' system at The Department of Cattle Husbandry (Landskontoret for Kvæg) show a great proportion of fresh grass, since fresh grass in 90% of the plans makes out an average of approx. 8.5 FU. It is most probable that summer plans are especially planned on cattle farms staking relatively much on using fresh grass, and that the average mentioned is therefore well above the general level of the amount of fresh grass during the summer season. In analyses of the Periodic Feed Control data, the results of the summer season 01.05.-31.10. 1995 for 511 herds are included. There fresh grass made out approx. 4 FU per cow per day on average concerning heavy breeds. Also this amount is uncertain, since for grazing cows, it is determined indirectly. But it may most probably come close to a realistic average when considering the whole season from May to October.

The protein content in fresh grass may vary a lot depending on the species of plant, N-fertilising, growing conditions, grazing system, season etc. Analyses carried out on fresh, chopped grass from grazing areas on pilot farms (Nielsen & Thøgersen, 1993; Nielsen et al., 1995) show that the crude protein content of clover grass is higher by continuous grazing with regulated size of the grazing area than by ration grazing (with continous grazing, very young growth of grass is being grazed all the time). In addition, the protein content is high during late summer and autumn, from August and onwards, and lower and more varying on "non-irrigated" than on irrigated soil. On average over the entire season, the crude protein content is estimated at 21% of the dry matter by ration grazing and 23% by controlled large-scale corral. During late summer and autumn, the grass from controlled large-scale corral may often contain 25-27% crude protein.

Table 12. N excretion by dairy cows during the summer season depending on the amount of fresh grass in the feed ration. Analysis of data provided by the Periodic Feed Control of the summer 1995. Divided into three groups where <1 FU, between 1 and 6 FU and >6 FU grass per cow per day were fed. Yield and N excretion converted into per cow per year, heavy breeds

FU grass	No. of herds	Kg ECM	g digest. crude protein/FU	Feed efficiency	Kg N
0.4	102	7300	135	83	125
3.8	309	7227	137	83	129
7.2	100	7282	143	82	136

Due to these variations, the N excretion in urine may vary a lot during the summer season. The material provided by the above-mentioned Periodic Feed Control analysis was divided in proportion to the proportion of fresh grass into 3 groups, one group that during the summer season was fed <1FU fresh grass, another group that was fed 1-6FU fresh grass and one that was fed >6FU fresh grass (Table 12). For the group in the middle, total N excretion was estimated at the same level as those from the assessments of winter feeding (129 kg N converted into cow per year). By the low proportion of grass, an N excretion of 125 kg was found, and by the high proportion, 136 kg N was found, i.e. a difference of 11 kg.

Nielsen et al. (1997) established a connection between the absorption of grass per cow per day and the excretion of nitrogen in urine and faeces by grazing experiments in practice. The experiment showed on average approx. the following converted into kg N per cow per year (Table 13):

Table 13. Relation between grass intake and N excretion in practice (Nielsen et al, 1997)

FU grass/cow/day	Kg N/ cow/year
4	130
6	138
8	146

These values show a relatively close correspondence with the Periodic Feed Control data, though with a greater rise in the N excretion with a rising proportion of grass. By approx. 4 FU grass, the levels of the two experiments are coincident.

On the basis of that, it is estimated that by an average grass absorption of 4 FU per cow per day during the grazing season, the N excretion is on the same level by summer feeding and winter feeding. No proper statistical material is available for the evaluation of how large amount of grass dairy cows are fed in practice. Grazing experiments carried out on pilot farms and study farms showed that fresh grass made out an average of 6.2 FU per day on 17 conventional farms and 9.1 on 10 ecological farms with heavy breeds (Nielsen et al., 1997). Based on the connection shown in Table 13, these values are equal to an average N excretion of 138 kg on conventional farms and approx. 148 kg on ecological farms when converting the values into whole year. On conventional farms, there is a difference between summer and winter feeding of 8 kg excreted N subject to estimating as mentioned above that the summer level at 4 FU grass is the same as that of house-fed cows. If in addition a grazing season of 150 days is estimated, the difference in excreted N per cow per year will be 3 kg (8/365 x 150) between cows that eat fresh grass during the summer and cows that are permanently house-fed. The values for ecological farms (approx. 9 FU grass) show the similar difference between grazing cows and permanently house-fed cows, i.e., 7.4 kg N per cow per year. For the national average, it is estimated that the amount of grass will be max. 6 FU per cow per day during the entire grazing season. It is therefore estimated that on average, there is a minor difference in the N excretion depending on whether or not the cows are permanently house-fed or grazing during the summer. There are considerable differences among the various farms due to varying grass amounts.

During grazing, part of the faeces is excreted in the field and not collected in the faeces storage. It has been assumed that the proportion of faeces that is excreted while in the field is almost proportional to the time spent outside the housing system.

Phosphorus excretion by dairy cows

The phosphorus excretion is calculated on the basis of the standards in force concerning the P requirement of dairy cows (Strudsholm et al., 1995), since it is estimated that no excess of P is fed. In addition, the same preconditions with regard to milk yield, gain and embryo production as those concerning the N calculations have been applied. The P content in milk is established at 0.96 g per kg milk for the heavy breeds and 1.08 g for Jersey (Hermansen, 1997, personal information). Concerning gain and embryo, 8 g per kg (ARC, 1980) has been estimated. The same source states a minimum excretion in the urine of 2 mg/kg live weight/day. Here, it has been established at 3 mg/kg/day. The calculated P balance is shown in Table 14.

Table 14. P balance per cow per year at the present yield level

	Heavy breeds		Jersey	
	kg	%	kg	%
P in feed	24.2	100	19.3	100
P in milk	7.2	30	5.6	29
P in gain + embryo	0.5	2	0.3	2
P in faeces	15.8	65	13.0	67
P in urine (min.)	0.7	3	0.4	2
P in faeces and urine	16.5	68	13.4	69

Potassium excretion by dairy cows

The preconditions used for the calculation concerning feed level, milk production, embryo production and gain are the same as those applying to the N calculations. The K intake is far beyond the requirements. There are great variations in the K content in various feeds, it is usually considerably higher in roughages than in concentrates. In order to estimate the K absorption, it is therefore necessary to initially base the calculations on a given composition of the feed ration. For this purpose, the average composition of feed rations for dairy cows in the first phase of the lactation period that is based on the updated feed plans from practice (Kjeldsen, 1996a and b)(Table 15) is used. The K content of the feeds has been taken from the feed table (Strudsholm et al., 1995) There are no similar statistical material of the ration composition in the other phases of the lactation and dry periods. Usually, the roughage proportion rises over the lactation period. For the purpose of house-feeding, it has been estimated that the K content rises from 19 g per FU during the first phase of the lactation period to 21 g in the middle phase, and 24 g in the last phase and the dry period (Table 16).

The K excretion in milk is established at 1.6 g per kg, and the deposition is 1.8 g per kg gain and 2.1 g per kg embryo (ARC, 1980).

There is not much information on the K excretion in faeces and urine. ARC (1980) states that some investigations have shown a connection between the absorption of the feed dry matter and the excretion of K in faeces. On the basis of the results of a range of investigations, ARC established the K excretion in faeces at 2.6 g per kg feed dry matter absorbed. Many of the basic experiments are rather outdated. In the meantime, a considerable rise in the feed level and not the least in the K content in many feeds has taken place. A positive correlation has been found between the K absorption and the K excretion in faeces. In the following, an excretion in faeces of 3.0 g K per kg feed dry matter intake has been estimated. The excretion in urine is hence calculated as the difference.

The model-calculated average K balance for house-fed cows is shown in Table 17. With a great amount of grass during the summer, the K intake (Table 13) and thus the excretion may be slightly higher.

Table 15. Potassium intake during the summer and winter season based on updated feed plans from the 'FTD' system at The Department of Cattle Husbandry

	No. of feed units		K content	K absorption, g	
Feed	Summer	Winter	g/FU	Summer	Winter
Concentrates	5.3	5.9	13	69	77
Oil cakes/soy meal	-	0.3	12	-	4
Cereals	1.4	1.4	4	6	6
By-products (molasses etc.)	1.4	1.0	26	36	26
Beets	0.1	3.3	19	2	63
Beet crowns	0.1	0.1	40	4	4
Fresh meadow crops	7.5	-	30	225	-
Preserved meadow crops	0.7	2.2	35	25	77
Corn (Maize)	0.8	0.6	18	14	11
Whole-crop	0.3	2.7	20	6	54
Straw	0.2	0.4	50	10	20
Totalling	17.6	17.9		397	342

Table 16. FU requirements of dairy cows and the K content of the feed in the various phases of the lactation period

	FU requirements			K intake, kg/year	
Lactation period	Heavy breeds	Jersey	g K/FU	Heavy breeds	Jersey
1	3334	2881	19	63	55
2	1273	1061	21	27	22
3	828	705	24	20	17
Dry	232	190	24	6	5
Per cow per year				116	99

Table 17. K balance per cow per year when house-fed

	Heavy breeds		Jersey	
	Kg	%	Kg	%
K in feed	116.0	100.0	99.0	100.0
K in milk	12.0	10.0	8.4	8.5
K in gain + embryo	0.1	0.1	0.1	0.1
K in faeces	18.8	16.2	16.0	16.2
K in urine	85.1	73.4	74.5	75.3
K in faeces + urine	103.9	89.6	90.5	91.5

Comparison between the model-calculated N, P and K excretion and the excretion in practice by dairy cows

Analyses have been carried out on data provided by the Periodic Feed Control on two winter seasons, 1994-95 and 1995-996. As the data provided by the Periodic Feed Control are only stored for two years, it was not possible to cover the autumn months of 1994. The first winter season comprises therefore only the period from January 1 to April 30. The data on the winter of 95-96 cover the period from November 1 to April 30. The material comprises 220 and 468 herds respectively over the two years. Part of the results from the analysis is listed in Tables 18 and 19 for heavy breeds (Danish Holsteins) and Jersey, respectively, together with the above-mentioned preconditions and results from the model calculations.

Table 18. Comparison between model calculations and the analyses of the data provided by the Periodic Feed Control concerning feed, and the N, P and K conversion by dairy cattle of heavy breed when house-fed

		PFC	Model
kg ECM	94-95	7388	
- -	95-96	7417	7600
FU/day	94-95	16.3	
- / -	95/96	16.1	15.5
kg feed dry matter/day	94-95	17.3	
- - - /-	95-96	17.4	17.1
FU/kg dry matter	94-95	0.94	
- /- - -	95-96	0.93	0.91
Feed efficiency	94-95	81.5	
- -	95-96	82.5	87
g digestible crude protein/FU	94-95	132	
- - - - /-	95-96	131	131
g crude protein/kg dry matter	94-95	166	
- - - /- - -	95-96	162	160
g N intake/day	94-95	460	
- - - /-	95-96	452	438
Total N excretion, kg/cow per year	94-95	129	
- - - - / - - -	95-96	126	119
N utilisation, %	94-95	24	
- - -	95-96	24	26
Total P excretion, kg/cow per year	94-95	23	
- - - - /- - -	95-96	23	16
Total K excretion, kg/cow per year	94-95	99	
- - - - /- - -	95-96	99	104

The yield level of the analysed herds of Danish Holsteins was almost on a level with the average of the controlled herds in 1995-96. The recorded feed level was slightly higher in the Periodic Feed Control herds than that of the model calculation, and the feed efficiency was lower, 82% against 87%. The energy concentration in the feed ration tended to be higher in the Periodic Feed Control than estimated in the model calculations. A difference in that direction is probable, since the model estimates that the animals are fed ad libitum all the time, while in practice, there are some cases where the amount of feed is somewhat restricted due to limitations in the amount of roughage. The effect of that will be that the energy concentration in the feed ration will be slightly higher.

The average protein concentration in the ration was found to be almost identical with the model preconditions. This indicates that the plans in respect of the protein concentration that are designed in the feed planning systems also is followed in practice. There was a minor difference in the recorded N intake and the model calculated N intake, 450-460 g/cow/day and approx. 440 g/cow/day, respectively. The total N excretion based on the recordings in the Periodic Feed Control was in 1995-96 7 kg higher than that of the model calculations.

Table 19. Comparison between model calculations and the analyses of the data provided by the Periodic Feed Control concerning feed, and the N, P and K conversion by dairy cattle of Jersey breed when <u>house-fed</u>

		PFC	Model
kg ECM	94-95	7285	
- -	95-96	7045	6870
FU/day	94-95	14.5	
- / -	95/96	13.9	13.3
kg feed dry matter/day	94-95	15.2	
- - - - / -	95-96	14.6	14.6
FU/kg dry matter/day	94-94	0.95	
- /- - - / -	95-96	0.95	0.91
Feed efficiency	94-95	83.8	
- -	95-96	84.5	87
g digestible crude protein/FU	94-95	136	
- - - - /-	95-96	133	131
g crude protein/kg dry matter	94-95	172	
- - - /- - -	95-96	168	159
g N intake/day	94-95	417	
- - - /-	95-96	392	373
Total N excretion, kg/cow per year	94-95	116	
- - - - /- - -	95-96	108	102
N utilisation, %	94-95	24	
- - -	95-96	25	25
Total P excretion, kg/cow per year	94-95	20	
- - - - /- - -	95-96	19	13
Total K excretion, kg/cow per year	94-95	77	
- - - - /- - -	95-96	75	91

The P excretion is recorded to be much higher than calculated by the model, i.e., a P excretion of 23 kg against the calculated 16 kg. Thus P is much in excess compared with the standards. The K excretion did not differ much in the two calculations. At present, corrections is being prepared in the computerised feed planning systems at The Department of Cattle Husbandry which if the directions are followed will cause a considerable reduction in the phosphorus level in the near future. These corrections will be followed-up by the agricultural advisory service.

Almost the same applies to Jersey herds as that of Danish Holsteins, however, the recorded feed efficiency was slightly higher for Jersey, i.e., approx. 84%, and thereby not much different from the one estimated by the model. The N excretion recorded in 1995-96 was 6 kg higher than that of the model calculation. Concerning P, the same applies as that stated under Danish Holsteins, i.e. there is a very large excess amount compared with the standards. The amount of potassium seems to be somewhat overestimated in the model concerning the Jersey breed. This might be due to the fact that the model estimates the same feed composition for heavy breeds and for Jersey and that the proportion of roughage has been lower for Jersey in practice.

New average values for dairy cow nutrient excretion

When establishing new average values for nutrient excretion by dairy cows, it has been decided to attach great importance to the analytical results of the Periodic Feed Control data and thus the recording of practical conditions. The following tables illustrate a survey of the consequences for the feed amount and N conversion when calculating with the feed efficiencies and energy concentrations of the rations that are equal to the average of the results recorded in practice.

Table 20. Dairy cow FU requirements after correction for feed efficiency

			Corrected FU requirements			
	Heavy breeds	Jersey	Heavy breeds		Jersey	
Lactation phase	Efficiency, %		Total	Per day	Total	Per day
1	80	82	3543	18.5	2845	15.8
2	84	86	1349	17.1	1126	14.1
3	86	88	870	14.5	813	12.3
Dry	86	88	270	7.9	217	5.6
Per cow per year	82	84	6032		5001	

Table 21. Protein content of feed rations

	g digest. cr. prot./ FU	FU/kg DM		g digest. cr. prot./ kg DM		g crude protein/kg DM		g N/kg DM	
Lactation		Heavy breeds	Jersey	Heavy breeds	Jersey	Heavy breeds	Jersey	Heavy breeds	Jersey
1	134	0.96	0.98	129	131	171	173	27.4	27.7
2	130	0.93	0.95	121	124	162	166	25.9	26.6
3	125	0.87	0.89	109	111	149	152	23.8	24.3
Dry	104	0.72	0.74	75	77	113	115	18.1	18.4

Table 22. Calculated N intake per cow per year

	kg dry matter absorbed		kg N absorbed	
Lactation phase	Heavy breeds	Jersey	Heavy breeds	Jersey
1	3691	2903	101	80
2	1451	1211	38	32
3	1000	934	24	23
Dry	375	301	7	6
Per cow per year	6517	5349	170	141

The P excretion is estimated at 23 and 19 kg per cow per year for heavy breeds and Jersey, respectively. The K excretion is estimated at 100 and 75 kg per cow per year for heavy breeds and Jersey, respectively.

Table 23. N balance per cow per year

	Heavy breeds		Jersey	
	kg	%	kg	%
N absorbed in feed	170.0	100	141.0	100
N in milk	39.4	23	33.5	24
N in weight gain + embryo	1.7	1	1.0	1
N in faeces	61.8	36	46.0	32
N in urine	67.1	39	60.5	43
N in faeces + urine	128.9	75	106.5	75

Variations in the N, P and K excretion

The above section describes primarily an estimate of the average excretion of nutrients in animal faeces. In practice, there are great variations depending on production level, efficiency and management etc. This section will discuss variations in relation to yield level, protein level and feed efficiency.

The effect of differences in yield level is examined by analysing the conditions at a yield of 1000 kg energy-corrected milk more than the present average, i.e., 8,600 kg energy-corrected milk for heavy breeds. In model calculations equal to those described in the above section, the energy requirement at higher yield level has been established on the basis of the precondition that the feed efficiency is unchanged at the higher level. It is an estimate that is based on the expectation that a higher yield level at a given time implies a better care etc. and thus also a relatively better feed efficiency. If a change in the yield level of a population is studied over time as a consequence of a combined effect of increased yield capacity and better feeding etc., then a fall in the efficiency has previously been recorded along with time and increase in yield level (Østergaard et al., 1989). The concentration of digestible crude protein in the ration has also been increased with approx. 2 g digestible crude protein per FU which is equal to an unchanged concentration in the production feed (above maintenance) of 158 g digestible crude protein per production feed unit. In addition, a less than 5% increase in the feed intake capacity has been estimated (Kristensen & Ingvartsen, 1985). Thus, the energy concentration of the ration has been established on the basis of that.

These model calculations result in an increase in the N absorption of 14 kg per cow per year and an increase in the N excretion of 9 kg per cow per year at an increase in the yield by 1000 kg energy-corrected milk per cow per year.

Table 24. Variation in N excretion per cow per year expressed by average quantiles. Analysis of data provided by the Periodic Feed Control. Winter season. Heavy breeds.

		No. of herds		kg ECM per cow per year		g digest. crude prot./ FU		Feed eff. %		kg N excreted	
	quantile	94/95	95/96	94/95	95/96	94/95	95/96	94/95	95/96	94/95	95/96
Yield	25	55	117	**6296**	**6424**	129	129	81	82	**117**	**116**
		110	234	**7424**	**7410**	133	131	81	83	**131**	**126**
	75	55	117	**8417**	**8432**	134	131	83	83	**135**	**134**
Protein level	25			7256	7300	**116**	**117**	82	82	**111**	**112**
				7384	7410	**132**	**130**	81	83	**128**	**124**
	75			7300	7556	**154**	**145**	82	83	**147**	**142**
Feed eff.	25			6979	7191	133	131	**73**	**76**	**144**	**136**
				7227	7483	131	130	**81**	**82**	**128**	**125**
	75			7446	7483	132	132	**90**	**90**	**113**	**115**
kg N excreted	25			7139	7081	122	123	**85**	**86**	**108**	**107**
				7519	7504	133	130	**82**	**83**	**127**	**125**
	75			7720	7738	143	142	**77**	**80**	**157**	**149**

In connection with the analyses of the Periodic Feed Control data, the effects of the differences in yield level were also studied (Table 24). The differences are illustrated by dividing into 25 and 75% quantiles. The analyses show a tendency for the protein concentration in the feed to rise with increasing yield level. Also here, the differences in the feed efficiency between levels of yield were very small. In complete harmony with the model calculations, this analyses showed a difference in the total N excretion in animal faeces of 9 kg N per 1000 kg difference in the yield of energy-corrected milk.

The effect of variations in yield level was also estimated with the model 'SAMSPIL' (Hansen et al., 1996). In SAMSPIL, a flat rate strategy period of 24 weeks is applied, and the production is calculated on the basis of the feed ration content of FU, digestible crude protein and fatty acids as described in the 551st Report by National Institute of Animal Science. The feeding in the late lactation phase is planned as described by Kristensen & Hansen (1989) where the feeding is stepped down, and the production of milk and meat is calculated on the basis of the standard requirement.

Table 25 shows the results when the yield capacity varies from 23.0 to 30.0 kg energy-corrected milk per day during the period 1 to 24 weeks after calving, which is equal to approx. 6500 to 8500 kg per year. According to the principles of the 551st Report, the fatty acid content was increased by 100 g per 1000 kg change in the yield capacity. In addition, the proportion of cows at the high feed level has increased from 58% at 23.0 kg in yield capacity to 65% at 30.0 kg in capacity. The reason for that is that a higher yield is estimated to cause a higher degree of mobilisation and a flatter lactation curve, the reason why the cows should be fed the high feed level for a longer period.

Table 25. Milk production and N excretion in animal faeces ex animal per cow per year calculated on the basis of a balanced plan at yield capacities of 23, 26.5 and 30 kg energy-corrected milk/cow/day and various protein levels

g digest. cr. protein/FU		118		132		153	
Relative		86		100		114	
Yield capacity kg ECM/cow/day	g fatty acids/ cow/day	kg ECM	kg N	kg ECM	kg N	kg ECM	kg N
23.0	600	6400	94	6520	111	6350	140
26.5	700	7280	102	7460	116	7510	133
30.0	800	8000	103	8360	120	8510	141

The results show that the feed intake rises from 5131 FU at 23.0 kg yield capacity to 5837 at 30.0 kg. The calculated rise in yield varies from 1600 kg at the low protein content to 2160 kg at the high protein content of the feed. Thus there is a growing marginal efficiency with increasing content of protein in the ration. The reason for that is that in the equations obtained by the 551st Report, there is an interaction between the yield capacity and protein requirement per FU so that requirement per FU is increased with rising yield capacity. Therefore, a difference in yield can also be seen at the high capacity from 8000 kg energy-corrected milk at 118 g digestible crude protein per FU to 8510 kg at 153 g, while the protein content has no influence at the low yield capacity. The N excretion rises by 9 kg at a change in the yield capacity from 23.0 to 30.0 kg at the two lowest N levels of the feed. The N excretion at the high protein level is high at the lowest yield capacity, 140 kg N, which means that at this protein level of the feed, there is almost the same N excretion at low and high yield level. The calculations by means of this model show extremely less variation in the N excretion in proportion to the yield level than in the Periodic Feed Control analysis and the model calculations described above.

The calculations in SAMSPIL show that at production levels that are equal to the variation in Table 20 (25-75% quantile for yield) and the variation in digestible crude protein content per FU (25-75% quantile protein level) the N excretion varies from 94 to 141 kg per cow per year when the energy efficiency is almost constant. The lowest excretion per 1000 kg milk is 12.9 kg N at a low protein level in the feed combined with a high yield level, while the highest excretion is 22.0 kg N at a high protein level combined with low yield level.

The analysis of Periodic Feed Control data shows that a higher yield results in a decrease in the N excretion in relation to the amount of milk. At 7,600 and 8,600 kg energy-corrected milk, the N excretions by animal faeces of 16.8 and 15.9 kg N, respectively, per 1000 kg milk was found.

Table 24 also shows results of a division into quantiles for various protein levels of the feed. Great differences in the recorded protein concentrations of the feed were found in various herds which of course also means great differences in the excreted amounts of N. Thus, differences of 36 and 30 kg N excreted per cow per year between the lowest 25% and the highest 25% respectively over the two years the analysis included. Completely similar estimates are found by varying the protein concentration of the feed in the model SAMSPIL from 117 to 154 g digestible crude protein per FU. In the calculations, the same relations between FE, feed utilisation and N excretions could be achieved within fully realistic feed and nutrient levels.

Differences between groups according to feed efficiency are also shown in Table 24. Certain differences were detected in yield level in relation to differences in feed efficiency. On the other hand, the protein concentration of the feed was completely the same. There was great variation in the feed efficiency from 73-76% in the lowest quarter to 90% in the best quarter. This resulted in a difference in the N excretion of 31 and 21 kg, respectively, per cow per year over the two years. In the area from 90 down to 81-82% efficiency, an increase in the N excretion of approx. 1.5 kg occurred for each unit the feed efficiency decreased. This is in harmony with the difference that was found under Section 3.6 by a comparison between model calculated results and results provided by the Periodic Feed Control. The difference was here 4-5 units in feed efficiency between the 87% that was estimated by the model and the efficiency measured by means of the Periodic Feed Control. The difference in the calculated N excretion was 7 kg N which also is approx. 1.5 kg N per unit difference in the feed efficiency.

In SAMSPIL, the feeding level is increased from 5498 FU per cow per year at a yield capacity of 26.5 kg 1-24 weeks after calving (7500 kg annually) to 6085 FU. The effect of that was that the yield increased from 7461 kg energy-corrected milk to 7772 kg energy-corrected milk. The energy utilisation decreased from 88.9 to 82.4, and the N excretion increased from 116 to 131 kg which is equal to 2.3 kg N per unit difference in efficiency. The reason for the higher effect of the efficiency on the N excretion is that it has been estimated that the yield rises slightly with increased feed assignments. This results in a difference of 587 FU in case of a difference of 6.5 efficiency units. If the yield had not increased, only 434 FU had been necessary to from the initial level reduce the feed efficiency 6.5 units. At a digestible crude protein of 134 g in marginal feed units and 0.94 kg dry matter/FU, 434 FU are equal to 12.4 g N or 1.9 kg N per efficiency unit, while 587 FU are equal to 16.8 kg N. From that, the N content of 311 kg energy-corrected milk of 5.53 g N per kg shall be deducted which is 1.7 kg. The excess of N will thus be increased by 15.1 kg or 2.3 kg N per efficiency unit. Thus SAMSPIL yields a greater effect of varying feed efficiency than does the Periodic Feed Control analysis and the model calculations described above.

Finally, Table 24 shows a division into quantiles directly on kg excreted N. It shows that the average of the furthermost quarters are approx. 107 in the lowest and 150-155 kg N in the highest quarter. But the table also illustrates that the main part of the variation can be explained by the effects of the yield level, protein level and feed efficiency.

No similar analyses have been made on the excretion of P and K. It depends first and foremost on the intake. The comparison between the Periodic Feed Control data recorded in practice and the model calculations showed that in practice, excess amounts of P that are far beyond the standards have been assigned and that the excretion is therefore proportionally larger. As the amount of P in practice is controlled to a certain amount per FU, there will also be a certain variation in proportion to the feed efficiency. The intake and excretion of K varies in practice in proportion to the content of the feeds that are used. By thorough calculation, a difference of 73 kg excreted K has been found per cow per year between a ration with a great amount of clover grass and a ration based on beets/whole-crop.

Heifers, young bulls and steers

Amounts of feed, faeces and urine and the dry matter content of faeces and urine

The calculations concerning young cattle have been made for various age groups, thereby making it possible to make statements for the various age intervals. The model calculations of the feed and nutrient conversion apply primarily theoretical values.

The preconditions in respect of the gain and absorption of energy and protein in the winter feeding plan are set out in Table 26. Energy requirements are established on the basis of "Danske Fodernormer til Kvæg" (Danish Feeding Standards for Cattle) (Strudsholm et al., 1992). On the basis of data provided by from pilot farms (Kristensen et al., 1991), it has been calculated that the feed consumption for breeding is equal to a feed efficiency of 88%. When calculating the feed consumption, this feed efficiency has been applied both to young bulls and heifers and steers (Table 26).

In most cases, the protein content stated is equal to the standards. For young bulls from 6 months until 2 years, the protein content of the feed ration has been established a level that is estimated to be normal for feed rations for these animals in practice which is much in excess of the requirement.

In the following calculations, it is estimated that all heifers and steers above 6 months are grazing during the summer season. It appears from data provided from pilot farms that the breeding stock covers 40% of its energy requirement by fresh grass (Kristensen et al., 1991). Since grass for calves under 6 months is not included in the calculation, it is estimated that all age groups of heifers and steers above 6 months cover 45% of their FU requirements by fresh grass.

Concerning bulls and steer and heifer calves under 6 months, only FU and protein that are stated in Table 26 are included in the calculation. The division into winter and summer feed for the other categories is shown in Tables 27 and 28.

Table 26. Preconditions for the calculation of the N and P excretion by categories of young cattle and heavy breeds

	Daily gain	Weight kg	FU/ day	FU/day 88% eff.	g digest. cr. prot. per FU	P req. g/day
Bull calves, under 6 months	1000	135	3.0	3.4	127	13
Young bulls, 6 months-1 year	1100	324	5.5	6.3	90	23
Young bulls, 1-2 years	1000	475	6.5	7.4	90	32
Heifers and steers under 6 months	600	94	2.1	2.4	152	8
Heifers and steers, 6 months-1 year	600	202	3.1	3.5	112	12
Pregnant heifers 1-2 years	600	364	4.3	4.9	82	21
Non-pregnant heifers and steers 1-2 years	600	364	4.3	4.9	82	21
Pregnant heifers ≥ 2 years	600	544	6.1	6.9	75	38
Non-pregnant heifers and steers ≥ 2 years	600	544	5.5	6.3	67	34

For young bulls, the FU/day is = energy requirement for growth (FU_{max})

For pregnant heifers above 2 years, the calculation has been based on the 7th gestation month.

Table 27. Calculated absorption of FU, dry matter and N per animal per year during the winter season

	FU	kg DM	g cr. prot. per kg DM	kg cr. prot. per year	kg N per year	FU/kg DM
Heifers + steers, 6 mo.-1 year	700	1000	117	117	18.7	0.70
Pregnant heifers, 1-2 years	1000	1430	94	134	21.5	0.70
Non-preg. heifers + steers, 1-2 years	1000	1430	94	134	21.5	0.70
Pregnant heifers ≥ 2 years	1400	1570	104	163	26.1	0.89
Non-preg. heifers + steers, ≥ 2 years	1250	1790	83	148	23.7	0.70

Feed digestibility

Over the recent years, digestibility experiments have been made on sucking calves 2-7 weeks old and fed on various cow milk replacers (Foldager, 1994). In calves that were fed on a skim-milk based cow milk replacer, a digestibility of the dry matter of the feed of 95.4% was found with a standard deviation of 1.7% point.

Table 28. Calculated absorption of FU, dry matter and N per animal per year when grazing during the summer season

	FU	kg DM	g cr. prot. per kg DM	kg cr. prot.per year	kg N per year
Heifers and steers, 6 months - 1 year	600	660	200	132	21.1
Pregnant heifers, 1-2 years	800	880	200	176	28.2
Non-pregnant heifers + steers 1-2 years	800	880	200	176	28.2
Pregnant heifers ≥ 2 years	1100	1210	200	242	38.7
Non-pregnant heifers + steers ≥ 2 years	1000	1100	200	220	35.2

Apart from the above, there are no available data from Danish digestibility experiments on young cattle. The digestibility of the feed dry matter for the various categories and age groups of young cattle has therefore been calculated on the basis of standard feed rations from "Håndbog for kvæghold" (guide to cattle husbandry) and the digestibility coefficients of "Fodermiddeltabel 1995" (feed table) (Strudsholm et al., 1995). The digestibility coefficient of dry matter is estimated 2% point lower than the digestibility of organic matter.

The digestibility values in the feed composition table are based on digestibility experiments on sheep fed maintenance rations. Usually there is a close correspondence between the digestibility of sheep and cattle when fed low-level rations as is the case with replacement heifers. No corrections have therefore been made for these animals. Usually young bulls are fed ad libitum with a very great proportion of easily digestible feeds, primarily cereals and a small proportion of coarse-structured feed. Under these preconditions, a certain inhibition of the digestion of the coarse-structured feed may be anticipated. In the following calculations, a digestibility of straw dry matter of 35% against approx. 43% according to the feed composition table has therefore been estimated.

The values of Tables 29 and 30 apply to heifers and young bulls of heavy breeds. For Jersey, the same digestibility coefficients are used for the similar categories and age groups. Concerning grass for young cattle, a digestibility of 78% has been estimated.

Table 29. Digestibility of dry matter in heifers and steers. House-feeding during the winter season. Amount of feed calculated per animal per year

	kg DM	Digest. coeff.	kg digestible DM
<u>0 - 6 months</u>			
Milk feed	64	95	61
Concentrates	218	78	170
Hay	52	67	35
Beets	198	88	174
NH_3 straw	200	55	110
Soy meal	124	89	110
Barley	102	85	87
Totalling/average	958	78	747
6 months - 1 year			
Beets	482	88	424
NH_3 straw	931	55	512
Soy meal	164	89	146
Barley	188	85	160
Totalling/average	1765	70	1242
<u>1 - 2 years</u>			
Beets	801	88	705
NH_3 straw	1458	55	802
Soy meal	131	89	117
Barley	439	85	373
Totalling/average	2829	71	1997
<u>Above 2 years</u>			
Concentrates	913	78	712
Silage	1971	70	1380
Totalling/average	2884	73	2092

Table 30. Digestibility of dry matter fed to young bulls. Amount of feed calculated per animal per year

	kg dry matter	Digest. coeff.	kg digest. DM
<u>0 - 6 months</u>			
Milk feed	64	95	61
Concentrates	218	78	170
Hay	52	67	35
Soy meal	124	89	110
Barley	516	85	439
Straw	116	35	41
Totalling/average	1090	79	856
<u>6 months - 1 year</u>			
Soy meal	164	89	146
Barley	2004	85	1703
Straw	526	35	184
Totalling/average	2694	75	2033
<u>1 - 2 years</u>			
Soy meal	131	89	117
Barley	2574	85	2188
Straw	683	35	239
Totalling/average	3388	75	2544

Dry matter content in faeces

As described under the section on digestibility, digestibility experiments have been carried out on 80 sucking calves that were fed whole-milk replacer. The average dry matter content of the faeces was found to be 17.1% with a standard deviation of 2.0% point.

For other categories of young cattle, there are no Danish data available. Since such data are seldom published, values are estimated roughly for the various categories. For calves under 6 months, the calculations are initially based on the digestibility experiments on sucking calves, and the dry matter content is estimated at 17%. For young bulls that are fed concentrated feed, the dry matter content is estimated at 17%. For house-fed breeding stock fed at a very low feed level and often with a considerable amount of straw, the dry matter content is estimated at 20%. During grazing, the dry matter content in faeces for these categories of animals is estimated at 16%.

Amounts of urine

There are no Danish measurements of the urine excretion by young cattle. The present standard values of Report No. 82 from the Institute of Agronomy and Fisheries are based on a few data provided by an old German handbook. In literature, the amount of urine is often related to the amount of faeces. Steineck et al. (1991) states that the faeces/urine ratio may vary from 2.2:1 to 3.0:1. The measurements on dairy cows that are described under Section 3.1 give on average a faeces/urine ratio of approx. 2.2:1 In the following, it has been decided to base the calculations on the ratio 2.0:1 for all young animals >6 months and when house-fed. For animals <6 months and for animals that are grazing, the ratio has been estimated at 1.5:1. This conversion of the urine amounts gives a somewhat lower amount than in the previous report on standard values, particularly for heifers and steers (Table 31.).

Dry matter content in urine

Here the same dry matter content of the urine of all young animals of >6 months as that of dairy cows is preconditioned. Kolb (1967) states that the concentration of dry matter in urine is lower by calves than by older animals. Therefore, a dry matter content of 4% is estimated for animals of <6 months.

The data basis for the calculation of the amount of faeces (solid faeces) and the estimated amounts of urine are set out in Table 31.

Nitrogen excretion by young cattle

Total crude protein absorption for bulls has been calculated on the bases of the digestible crude protein content per FU by means of Equation (2), since it is preconditioned that the energy concentration in the feed is 1 FU per kg dry matter. For heifers and steer calves under 6 months, 0.92 FU per kg dry matter has been estimated. The same method has been used for the winter feed for the other categories of animals, since different energy concentrations in the ration have been estimated as stated in Table 27.

Table 31. Factors for the calculation of the amounts of faeces ex animal and the estimated amounts of urine

Category of animals	kg feed DM per animal per yr	DC feed DM	DM % in faeces	kg urine per day	DM % in urine
Bull calves under 6 months, heavy breed	1240	79	17	3	4
Ditto Jersey	930	79	17	2	4
Young bulls, 6 months-1 year heavy breed	2300	75	17	5	5
Ditto Jersey	1725	75	17	3	5
Young bulls, 1-2 years, heavy breed	2700	75	17	5	5
Ditto Jersey	2025	75	17	4	5
Heifers+steer calves under 6 months, heavy breed	950	78	17	2	4
Ditto Jersey	675	78	17	2	4
Heifers+steers, 6 mo.-1 yr, heavy breed, winter season*)	1000	70	20	4	5
Ditto Jersey	750	70	20	3	5
Heifers+steers, 6 mo.-1 yr, heavy breed, grazing season*)	650	78	16	4	5
Ditto Jersey	475	78	16	3	5
Heifers+steers, 1-2 yrs, heavy breed, winter season*)	1400	71	20	5	5
Ditto Jersey	1050	71	20	4	5
Heifers+steers, 1-2 yrs, heavy breed, grazing season*)	900	78	16	5	5
Ditto Jersey	675	78	16	4	5
Pregn. heifers, above 2 yrs, heavy breed, winter season*)	1600	73	20	6	5
Ditto Jersey	1200	73	20	4	5
Pregn. heifers, above 2 yrs, heavy breed, graz. season*)	1200	78	16	7	5
Ditto Jersey	900	78	16	5	5
Non-pregn. heifers+steers ab. 2 yrs, hvy br., win. seas.*)	1800	73	20	6	5
Ditto Jersey	1350	73	20	5	5
Non-pregn. heifers+steers ab. 2 yrs, hvy br., graz. seas.*)	1100	78	16	6	5
Ditto Jersey	825	78	16	5	5

*) For animals that are grazing during the summer, the amount of feed per animal per year and the relevant data are divided into what belongs to the house-feeding season and what belongs to the grazing season. (DC = digestibility coefficient)

For fresh grass during grazing, 1.1 kg per FU and 20% crude protein in the dry matter have been estimated. Thus the digestibility of crude protein has not been corrected for feed level, since it is preconditioned that the feed level for young cattle will never be so high that it will result in an essential reduction in the digestibility.

The protein deposition (including deposition in embryo) is based on information provided by ARC (1980). Table 32 shows the N balance per animal per year for the various categories of young cattle both in absolute amounts and expressed in percentage.

Tables 33 and 34 show the total N balances for the production of a young bull or the breeding of a heifer, respectively. In addition, the values are converted into average amounts per head of breeding stock per year or per bull per year, values that are used in other connections and which are a better expression for the nutrient balance and nutrient excretion at different productions than the more detailed division.

Table 32. N balance per animal per year at various categories of young cattle of heavy breeds

	N intake		Depos.N		N excreted in faeces		N excreted in urine	
	kg	%	kg	%	kg	%	kg	%
Bull calves under six months	33.6	100	10.4	31	8.3	25	14.9	44
Young bulls, 6 months-1 year	47.5	100	9.9	21	14.4	30	23.2	49
Young bulls, 1-2 years	55.7	100	8.8	16	16.8	30	30.1	54
Heifers+steer calves, under six mo.	27.9	100	5.7	19	6.4	23	15.8	57
Heifers+steers, 6 months-1 year	39.8	100	5.1	13	10.7	27	24.0	60
Pregnant heifers, 1-2 years	49.7	100	4.7	9	14.6	29	30.4	61
Non-pregn. heifers+steers 1-2 years	49.7	100	4.7	9	14.6	29	30.4	61
Pregnant heifers≥ 2 years	64.8	100	7.7[1)]	12	17.9	28	39.2	60
Non-pregnant heifers+steers≥ 2 years	58.9	100	4.6	8	18.0	31	36.3	62

[1)] Including N in embryo

Table 33. N balance by the production of a young bull of heavy breed

		N intake		Deposited.N		Excreted N in faeces		Excreted N in urine	
		kg	%	kg	%	kg	%	kg	%
40-220 kg	(182 days)	16.8		5.2		4.2		7.4	
220-440 kg	(200 days)	26.4		5.4		8.0		13.0	
Totalling	(382 days)	43.2		10.6		12.2		20.4	
Per head per year	(365 days)	41.3	100	10.1	24	11.7	28	19.5	47

Table 34. N balance by the production of a replacement heifer of heavy breed with a calving age of 28 months

	N intake		Deposited.N		Excreted N in faeces		Excreted N in urine	
	kg	%	kg	%	kg	%	kg	%
0-6 months (183 days)	13.9		2.9		3.2		7.9	
6 months-1 year (182 days)	19.9		2.5		5.4		12.0	
1-2 years (365 days)	49.7		4.7		14.6		30.4	
24-28 months (122 days)	21.7		2.6[1)]		6.0		13.1	
Totalling (852 days)	105.2		12.7		29.2		63.4	
Per head per yr (365 days)	45.1	100	5.4	12	12.5	28	27.2	60

[1)] Including N in embryo

Table 35 shows estimates of the N balance for Jersey young cattle. The calculations are based on the fact that the standard values make out 75% of the similar values for heavy breeds, since it is estimated that the division of the N intake for deposition, faeces and urine is almost the same for heavy breeds and light breeds and that the feeding is almost the same.

Table 35. N balance per animal per year for various categories of Jersey young cattle

	kg N		kg N excreted in	
	intake	deposited	faeces	urine
Bull calves under 6 months	25.2	7.7	6.2	11.3
Young bulls, 6 months-1 year	35.6	7.2	10.8	17.6
Young bulls, 1-2 years	41.8	6.4	12.6	22.8
Heifer calves+steers under 6 months	20.9	4.3	4.8	11.8
Heifers+steers, 6 months-1 year	29.9	3.9	8.8	17.2
Pregnant heifers, 1-2 years	37.3	3.4	12.2	21.7
Non-pregnant heifers+steers, 1-2 years	37.3	3.4	12.2	21.7
Pregnant heifers ≥ 2 years	48.6	5.8[1)]	16.3	26.5
Non-pregnant heifers+steers ≥ 2 years	44.2	3.2	15.2	25.8

[1)] Including N in embryo

Phosphorus excretion by young cattle

The P deposition is based on information provided by ARC (1980), while the P intake of both young bulls and heifers is calculated on the basis of the standards (Table 26), since it is estimated that only few feed rations will contain more P than recommended by the standards.

The results in Table 36 show the P balance per animal per year for the various categories of young cattle of heavy breeds both in absolute amounts and expressed as percentage.

Table 36. P balance per animal per year for various categories of young cattle of heavy breeds

	P intake		P deposited		P excreted in			
					faeces		urine	
Category	kg	%	kg	%	kg	%	kg	%
Bull calves under 6 months	4.7	100	2.6	54	2.1	45	0.1	2
Young bulls, 6 months-1 year	8.4	100	2.6	30	5.6	67	0.2	2
Young bulls, 1-2 years	11.7	100	1.8	16	9.6	82	0.3	2
Heifer calves+steers under 6 mo	2.9	100	1.8	63	1.1	38	-	-
Heifers+steers, 6 mo-1 yr	4.4	100	1.8	42	2.5	57	0.1	2
Pregnant heifers, 1-2 years	7.7	100	1.8	24	5.6	73	0.2	3
Non-pregn. heifers+steers, 1-2 yrs	7.7	100	1.8	24	5.6	73	0.2	3
Pregnant heifers ≥ 2 years	13.9	100	2.6	18	11.0	79	0.3	2
Non-pregn. heifers+steers ≥ 2 yrs	12.4	100	1.8	15	10.2	82	0.4	3

Tables 37 and 38 show in a similar way the P balance by the production of a young bull of 440 kg and a heifer in calf at the age of 28 months. Table 39 shows the P balance of young cattle of Jersey breed. The calculations are based on the estimation that the amount of feed makes out 75% of the amount of feed for heavy breeds, and that the feed composition is otherwise the same.

Table 37. P balance by the production of a young bull of heavy breed

	P intake		P deposited		P excreted	
Category	kg	%	kg	%	kg	%
40-220 kg (182 days)	2.4		1.3		1.1	
220-440 kg (200 days)	4.6		1.4		3.2	
Totalling (382 days)	7.0		2.7		4.3	
Per young bull per year	6.7	100	2.6	38	4.1*)	62

*) 2% of the P absorbed is considered excreted in urine ~ 0.1 kg per animal per year, the remainder in faeces

Table 38. P balance (intake according to standard) by rearing a heifer of heavy breed

	P intake		P deposited		P excreted	
	kg	%	kg	%	kg	%
0-6 months (183 days)	1.5		0.9		0.5	
6 months-1 year (182 days)	2.2		0.9		1.3	
1-2 years (365 days)	7.7		1.8		5.8	
24-28 months (122 days)	4.6		0.9		3.8	
Totalling 852 days	15.9		4.5		11.4	
Per head per year	6.8	100	1.9	28	4.9*)	72

*) 2% of the amount absorbed is considered excreted in urine ~ 0.1 kg per animal per year, the remainder in faeces

Table 39. P balance per animal per year for various categories of young cattle of Jersey breed

	P intake		P deposited		P excreted			
					in faeces		in urine	
Category	kg	%	kg	%	kg	%	kg	%
Bull calves under 6 months	3.5	100	1.9	54	1.5	43	0.1	3
Young bulls 6 months-1 year	6.3	100	1.9	30	4.2	67	0.2	3
Young bulls 1-2 years	8.8	100	1.4	16	7.1	81	0.3	3
Heifer calves+steers under 6 mo.	2.2	100	1.4	63	0.8	36	-	-
Heifers+steers, 6 months-1 year	3.3	100	1.4	42	1.9	58	-	-
Pregnant heifers, 1-2 years	5.8	100	1.4	24	4.3	74	0.1	2
Non-preg. heifers+steers 1-2 yrs	5.8	100	1.4	24	4.3	74	0.1	2
Pregnant heifers ≥ 2 years	10.4	100	1.9	18	8.3	80	0.2	2
Non-preg. heifers+steers ≥ 2 yrs	9.3	100	1.4	15	7.6	82	0.3	3

Potassium excretion by young cattle

The K deposition is based on data provided by ARC (1980). Since almost all feed rations contain more K than recommended by the standards, the absorption has been calculated on the basis of the estimated K content of the feed ration. For young bulls that are normally fed primarily concentrates, the estimation is thus 15 g K/FU. For all categories of females that are normally fed large amounts of grass products, molasses and straw, the estimate is 30 g K/FU. Regarding the excretion of K in faeces and urine, see the explanation under Section 3.5.

The results of the calculations are shown in Tables 40, 41, 42 and 43. For Jersey, again an amount of feed of 75% of the amount of feed for heavy breeds has been estimated with the same feed composition.

Table 40. K balance per animal per year for various categories of young cattle of heavy breeds

	K intake		K deposited		K excreted			
					in faeces		in urine	
Category	kg	%	kg	%	kg	%	kg	%
Bull calves under 6 months	18.6	100	0.8	4	3.7	20	14.1	76
Young bulls, 6 months-1 year	34.5	100	0.8	2	6.9	20	26.8	78
Young bulls 1-2 years	40.5	100	0.7	2	8.1	20	31.7	78
Heifer calves+steers under 6 months	14.8	100	0.5	3	2.9	20	11.4	77
Heifers+steers, 6 months-1 year	34.3	100	0.4	1	4.9	14	29.0	85
Pregnant heifers, 1-2 years	53.5	100	0.4	1	7.9	15	45.2	84
Non-preg. heifers+steers 1-2 years	53.5	100	0.4	1	7.9	15	45.2	84
Pregnant heifers ≥ 2 years	75.9	100	0.9	1	8.7	11	66.5	88
Non-preg. heifers+steers ≥ 2 years	68.4	100	0.4	1	8.7	13	59.3	87

Table 41. K balance by the production of a young bull of heavy breed

	K intake		K deposited		K excreted			
					in faeces		in urine	
	kg	%	kg	%	kg	%	kg	%
40-220 kg (182 days)	9.3		0.4		1.9		7.0	
220-440 kg (200 days)	19.1		0.4		3.8		14.9	
Totalling (382 days)	28.4		0.8		5.7		21.9	
Per head per year	27.1	100	0.8	3	5.4	20	20.9	77

Table 42. K balance by rearing of a heifer of heavy breed

	K intake		K deposited		K excreted			
					in faeces		in urine	
Category	kg	%	kg	%	kg	%	kg	%
0-6 months (183 days)	7.4		0.2		1.5		5.7	
6 months-1 year (182 days)	17.2		0.2		2.5		14.5	
1-2 years (365 days)	53.5		0.4		7.9		45.2	
24-28 months (122 days)	25.4		0.1		2.9		22.4	
Totalling (852 days)	103.5		1.0		14.8		87.8	
Per head per year	44.3	100	0.4	1	6.3	14	37.6	85

Table 43. K balance per animal per year for various categories of young cattle of Jersey breed

	K intake		K deposited		K excreted			
					in faeces		in urine	
Category	kg	%	kg	%	kg	%	kg	%
Bull calves under 6 months	14.0	100	0.5	3	2.8	20	10.7	76
Young bulls, 6 months-1 year	25.9	100	0.6	2	5.2	20	20.1	78
Young bulls 1-2 years	30.4	100	0.4	1	6.1	20	23.9	79
Heifer calves+steers under 6 mo	11.2	100	0.4	2	2.2	20	8.6	77
Heifers+steers, 6 mo-1 yr	25.8	100	0.3	1	3.7	14	21.8	84
Pregnant heifers, 1-2 yrs	40.1	100	0.3	1	5.9	15	33.9	85
Non-preg. heifers+steers 1-2 yrs	40.1	100	0.3	1	5.9	15	33.9	85
Pregnant heifers ≥ 2 years	56.9	100	0.5	1	6.5	11	49.9	88
Non-preg. heifers+steers ≥ 2 yrs	51.3	100	0.3	1	6.5	13	44.5	87

Comparison between the model calculations of the N, P and K excretion by young cattle and the excretion measured in practice

Concerning the Periodic Feed Control analysis, the general remarks appear from Section 3.6.

The results of the comparison concerning young bulls are shown in Table 44. The results show that the gains measured in practice were close to the values estimated by the model. It seemed as though the feed consumption was slightly higher than estimated by the model that was based on a feed efficiency of 88%. A higher protein content of the feed than the one estimated by the model was detected. The differences mean as a whole that a somewhat larger N excretion by young bulls was measured in practice than estimated by the model calculations.

As with dairy cows, liberal amounts of phosphorous may probably have been assigned to the young bulls.

For the replacement heifers, a statement and a comparison have been made based on house-feeding alone (Table 45). The gains that have been recorded in practice were relatively low, on average 537 and 565 g daily over the two years. On the other hand, the feed absorption measured in FU was exactly on a level with the model estimate. As with the dairy cows, it indicates a relatively low feed efficiency. The recorded protein content of the feed was in practice somewhat higher than that of the model estimate. In the model, it was equal to the standards. The result is that the N excretion per animal per year was found to be 5-6 kg larger than calculated by the model. The P excretion by the heifers was in practise of the same size as estimated by the model. The K amount seems to be overvalued by the model compared with the values measured in practice.

Table 44. Comparison between the model calculations and analyses of the data provided by the Periodic Feed Control concerning the feed, N, P and K conversion by young bulls of heavy breeds when house-fed

		Periodic Feed Control	Model
g daily gain	94-95	1038	
- - -	95-96	942	1050
FU per day	94-95	5.3	
- - -	95-96	5.1	5.0
g digestible crude protein per FU	94-95	113	
g digestible crude protein per FU	95-96	110	102
kg N excreted per animal per year	94-95	37	
kg N excreted per animal per year	95-96	35	31
kg P excreted per animal per year	94-95	7	
kg P excreted per animal per year	95-96	7	4
kg K excreted per animal per year	94-95	20	
kg K excreted per animal per year	95-96	20	26

Table 45. Comparison between the model calculations and analyses of data provided by the Periodic Feed Control concerning the feed, N, P and K conversion by replacement heifers of heavy breeds when house-fed

		Periodic Feed Control	Model
g daily gain	94-95	537	
g daily gain	95-96	565	600
FU per day	94-95	4.3	
FU per day	95-96	4.2	4.3
g digestible crude protein per FU	94-95	122	
g digestible crude protein per FU	95-96	122	96
kg N excreted per animal per year	94-95	38	
kg N excreted per animal per year	95-96	37	32
kg P excreted per animal per year	94-95	6	
kg P excreted per animal per year	95-96	6	5
kg K excreted per animal per year	94-95	35	
kg K excreted per animal per year	95-96	36	44

New standard values for young bulls are based on the following. It is preconditioned that the feed consumption is equal to the basic estimate of the model. The crude protein content of the feed for the entire feeding period is estimated at 112 g digestible crude protein per FU. It is estimated that the protein content of the feed for the animals during the first 6 months of their life is 127 g digestible crude protein as estimated by the model. In order to arrive at an average content of 112 g per FU, the content of the feed for bulls > 6 months must be 105 g digestible crude protein per FU instead of the previously estimated 90 g per FU. This give the following preconditions divided into shares of a young bull of 440 kg produced.

	FU	g digestible crude protein per FU	g crude protein per FU
0-6 months	620	127	169
6 months-382 days	1280	105	145

Hence the N balance for a young bull of heavy breed produced will be:

46.5 kg N absorbed
10.6 kg N deposited
12.5 kg N excreted in faeces
23.4 kg N excreted in urine

The P excretion by young bulls is estimated at 7.1 kg excreted in faeces and 0.2 kg in urine per young bull produced. Correspondingly, the K excretion is estimated at 5 kg in faeces and 15 kg in urine.

The N content of the feed for house-fed heifers is raised slightly compared with the model. The following preconditions are used divided into shares of 1 head of breeding stock.

	Shares	FU	g digest. crude protein per FU	g crude protein per FU
0-6 months	0.2148	190	152	199
6 months-calving	0.7852	1410	108	160

The N balance per head per year of heifers of heavy breed when house-fed is as follows:

42.0 kg N absorbed
5.4 kg N deposited
13.3 kg N excreted in faeces
23.3 kg N excreted in urine

The K excretion during house-feeding is lowered somewhat compared with the model and is fixed at 7 kg in faeces and 29 kg in urine per head of heifers per year.

Suckler cows

No changes have been made concerning suckler cows compared with the basis for the values of Report No. 82 from Danish Institute of Agricultural and Fisheries Economics. They are summed up in the following section.

Table 46 shows the preconditions for the calculations of the N balance. Concerning the winter feeding season, the calculations are based on the standards provided by (Håndbog for Kvæghold) (guide to cattle husbandry), while for the grazing season (May-October 184 days), an absorption of grass with an energy value equal to 1.1 kg dry matter per FU and a protein content of 20% has been estimated. The conversion between digestible crude protein and total crude protein and a division of excreted N between faeces and urine has been made by means of Equation (2). When calculating the P balance, the same preconditions as those for dairy cows have been applied with the exception of the maintenance standard that for suckler cows is estimated at 0.03 g per kg live weight per day against 0.05 by dairy cows. When calculating the K balance, the same preconditions as those for dairy cows have been applied. The K content of the feed is estimated at 30 g per FU as with replacement heifers.

Table 46. Preconditions for the calculation of the N balance by suckler cows

Period	FU/day	FU/kg DM	kg DM per day	g digest. crude protein per day	g crude protein per kg DM
November (30 days)	4.2	0.5	8.4	500	96
December-February (90 days)	5.3	0.6	8.8	650	112
March-April (61 days)	8.7	0.8	10.9	1000	131
May-October (184 days)	7.5	0.9	8.0	1295	200

Table 47. Nutrient balance for suckler cows per animal per year

	N		P		K	
	kg	%	kg	%	kg	%
Intake	80.9	100	9.1	100	75.0	100
Deposited	2.2	3	0.7	7.7	0.1	0.1
In milk (1000 kg)	5.4	7	1.0	11.0	1.6	2.1
In faeces	21.2	26	7.0	76.9	9.7	12.9
In urine	52.1	64	0.4	4.4	63.6	84.9
In faeces + urine	73.3	90	7.4	81.3	73.3	97.8

It is estimated that suckler cows are grazing from May - October, 184 days. Subject to this precondition and the application of the above-mentioned feed requirements and feed qualities, it is estimated that the following nutrient amounts are excreted in the pasture (Table 44).

Table 48. Amounts of N, P and K excreted in the pasture by grazing suckler cows, kg per animal per year

N		P		K	
Faeces	Urine	Faeces	Urine	Faeces	Urine
11	34	3.5	0.2	5	37

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Poultry, Appendix 1

Categories of poultry

by

Henrik Bang Jensen
The Danish Poultry Council
5 Trommesalen, 4th floor
DK-1614 Copenhagen V

This report describes 12 categories of poultry. The grouping has taken place according to both species and production management. The following table shows the 12 categories, thereby giving information about the places of production and the number of animals. It should be noticed that part of the information is based on estimates.

The categories of poultry, the of number poultry farms and number of animals

Category of poultry no.	Production management	Poultry farms 1996[1)]	Annual prod./ Stock 1996 (1000)[2)]
1	Layer hens in battery cage systems	135	3000
2	Layer hens floor management (deep litter hens)	122	570
3	Layer hens, free-range management	68	290
4	Layer hens, ecological management	70	300
5	Parent stock for broiler production	70	950
6	Pullets, layer type	85[3)]	4300
7	Pullets, parent stock for broiler production	30	1000
8	Broilers	290	112446
9	Turkeys, young *	<5	25
10	Turkeys, heavy **	60	1250
11	Ducks	15	2098
12	Geese	1	10

Notes: 1. Estimated
2. Category 1-6 are stated as the total stock, the other categories in heads produced hereof
3. Approx. 5 only with pullet breeding and approx. 80 with concurrent egg production

Poultry, Appendix 2

Layer type hens

by

Henrik Bang Jensen
The Danish Poultry Council
5 Trommesalen, 4th floor
DK-1614 Copenhagen V

When preparing the N, P and K standard values ex animal for layer hens, The Danish Poultry Council's standard values have formed the basis of the calculations. The reason for that is that for certain production types, relatively few stock are included in the Efficiency Control, and thus it is not considered reasonable to base the calculations on the average values of the Efficiency Control. A comparison between the standard values applied and the data provided by the Efficiency Control is shown below.

NOTE: Since the Efficiency Control only includes feed information as from the hens are 20 weeks, the standard feed consumption in the table below has also been based on 20 weeks. When stating the key figures for the calculation of the N, P and K ex animal under Section 3.3.1, the calculations are based on 17 weeks. Corrections for 80 g feed per day are made, the reason why the standard values for the feed intake shown are 1.68 kg below the standard values for the feed intake under Section 3.3.1. The values for the egg production are identical, since the egg production before the hens attain the age of 20 weeks is unimportant.

Feed intake. Kg per hen introduced at the age of 20 weeks.

			Prod.		Efficiency control data: Averages and quantiles				
Type	Category	No. of stock	time, days	Standard	10%	25%	Average	75%	90%
Battery hens	1	43	392	44.34	40.65	41.77	42.99	44.07	44.25
Deep-litter hens	2	33	364	44.75	40.39	42.43	43.27	44.38	45.52
Free-range hens	3	11	346	39.94	37.54	37.61	39.9	41.55	43.47
Organic hens	4	14	346	43.37	39.21	41.67	42.53	43.93	44.64

Egg production. Kg per hen introduced at the age of 20 weeks.

			Prod.		Efficiency control data: Averages and quantiles				
Type	Category	No. of stock	time, days	Standard	10%	25%	Average	75%	90%
Battery hens	1	43	392	20.18	19.13	19.75	20.22	20.80	21.29
Deep-litter hens	2	33	364	17.14	15.27	16.27	16.68	17.55	18.01
Free-range hens	3	11	346	15.85	15.16	15.17	15.82	16.67	16.87
Organic hens	4	14	346	15.14	13.9	14.08	14.85	15.3	15.59

Poultry, Appendix 3

Broilers

by

Henrik Bang Jensen
The Danish Poultry Council
5 Trommesalen, 4th floor
DK-1614 Copenhagen V

The data basis is a set of data provided by the Efficiency Control with information on 3058 stock of broilers, equal to 95.0 million broilers. There are only information available on the feed consumption of the 1825 stock, equal to 58.9 million broilers. The stock are slaughtered during the period from October 1, 1995 to September 30, 1996.

In the set of data used, the broilers are divided according to age, weight and feed intake, as shown below.

Broilers. Division into stock and into number of broilers slaughtered at different slaughter ages

	All stock		With info. on feed consumption	
Slaughter age, days	Observations (stock)	No. of broilers slaughtered	Observations (stock)	No. of broilers slaughtered
33	2	28,360	2	28,360
34	74	1,994,922	58	1,593,034
35	367	11,680,299	284	9,203,804
36	394	12,113,748	284	8,854,784
37	285	9,131,946	185	6,146,259
38	350	10,817,118	196	6,312,500
39	312	9,764,165	154	5,158,473
40	302	10,005,983	170	5,927,744
41	384	12,021,831	203	6,770,480
42	332	9,668,456	164	5,011,733
43	151	4,190,755	78	2,273,952
44	62	2,024,964	34	1,160,222
45	37	1,329,516	11	375,813
46	6	215,114	2	74,773

Broiler weight and feed intake. Data provided by the Efficiency Control

Age,	Weight at slaughter, kg				Feed intake, kg per broiler slaughtered			
days	Obs.	1st quantile	Average	3rd quantile	Obs.	1st quantile	Average	3rd quantile
33	2	1.509	1.544	1.633	2	2.419	2.471	2.598
34	74	1.481	1.510	1.561	58	2.446	2.504	2.581
35	367	1.499	1.543	1.600	284	2.525	2.588	2.679
36	394	1.534	1.587	1.648	284	2.606	2.689	2.779
37	285	1.581	1.637	1.712	185	2.707	2.798	2.905
38	350	1.646	1.703	1.765	196	2.839	2.942	3.050
39	312	1.726	1.775	1.852	154	2.996	3.087	3.187
40	302	1.816	1.873	1.945	170	3.208	3.308	3.422
41	384	1.882	1.935	2.002	203	3.357	3.454	3.5489
42	332	1.935	1.988	2.058	164	3.482	3.590	3.726
43	151	1.979	2.044	2.123	78	3.617	3.738	3.868
44	620	2.030	2.090	2.175	34	3.787	3.878	3.986
45	37	2.073	2.120	2.186	11	3.998	4.053	4.126
46	6	2.168	2.181	2.272	2	4.192	4.203	4.215

As will appear, the development in the field of feed consumption is not progressing steadily due to haphazard variations. In order to overcome the effects of haphazard variations, the weight and feed intake are calculated as a function of age. The results appear from Equations 1 and 2:

Equation 1: The weight of the broilers as a function of age:
Weight (g) = -822.127 + 67.1862* age (days)

Equation 2: The feed intake of the broilers as a function of age:
Feed consumption (kg) = -2.5243 + 0.1453* age (days)

<u>Admixture of whole-crop wheat into broiler feed</u>

In the production of broilers, it is ordinary practice to admix whole-wheat into the purchased feed. This mix has of course an influence on the N, P and K content of the feed. Wheat and purchased feed is mixed on a weighing-machine immediately before feeding the chickens. Usually, the wheat feeding starts when the chickens are 1 week old. At this time, 5% wheat is admixed. The admixture percentage rises with the age of the chickens and when 30-35% of the chickens are 5 weeks old. Based on the same set of data as that on which Equations 1 and 2 are based, the whole-wheat percentage of total chicken feed as a function of age can be calculated.

Equation 3: Whole-wheat percentage of total chicken feed as a function of age:
Weight (kg) = 11.73 + 0.225* age (days)

According to Equation 3, the whole-wheat percentage of total chicken feed will only rise by 0.2% point per day. A so modest age dependence makes it reasonable to for practical reasons calculate on one and the same wheat percentage regardless of the age. In this report, it has been chosen to calculate on a wheat percentage of 20.5%.

Mink, Appendix 1

N input and output on a mink farm

by

Steen H. Møller
National Institute of Animal Science
Research Centre Foulum
Department for Health and Welfare
P.O. Box 50
DK-8830 Tjele

At the request of the Danish Environmental Protection Agency (Miljøstyrelsen), standard values for the N excretion by normally fed mink were calculated in 1992 with the purpose of establishing conversion factors ex animal. It was intended for the standard values to form the basis of a statement concerning the nutrient content in faeces. Total N in the feed for a mink female with 5.32 kits per litter (4.8 kits per mated female) and 1/6 male were calculated. The excreted amount of N was hence calculated on the basis of what can be recovered by means of digestibility and balance tests. In this statement, the N intake has been calculated in the same way, while the N excretion is calculated by deducting the deposited amount of N in body, pelt and hair.

The largest proportion of fur animal feed is produced at fur animal feed factories that are also included in "the voluntary feed control". The knowledge of the N content of the feed is therefore well-documented. The composition of the mink feed is changed concurrently with the various production periods over the year. The energy and N content in the feed is therefore calculated individually for each of the periods. The energy and protein content is an average of the analyses results of weekly samples from all feed factories under the feed control. The average values are calculated for the weeks 1-13, 14-22, 23-28, 29-35, and 36-52. The material is calculated and placed at the disposal of Dansk Pelsdyr Foder A/S, Analyselaboratoriet (Danish Fur Animal Feed, Test Laboratory). The amount of energy in kcal assigned per animal is calculated on the basis of the quantity of feed supplied and the number of animals on each farm included in the control panels under Midtjyllands Peldyravlerforening (Fur Breeders Association of Central Jutland). The control panels include 59 mink farms with a total number of 64,000 females. The data are calculated and placed at the disposal by the consultant who is the head of the control panels. Since the number of animals in the data bank is not updated concurrently with the pelting, a calculated feed assignment has been used for the breeding stock for the last half of November and for December. All data used are from 1995.

Assignment of N in the feed
In order to illustrate the dynamics of a herd over the year, 1000 mink females were used as a unit in order to describe the number of animals and the assignment of N over a year of production.

The preconditions for these calculations have changed slightly as compared with 1992, since the calculations include fewer unmated and barren females, more kits and fewer males for keeping after the mating season.

Hence the preconditions for the calculations are based on a farm with: 1000 females, 0.5% unmated females, 8.0% barren females, and 5.22 kits per mated female (figures from the 1995 production). The unmated bitches and 90% of the breeding males are skinned at April 1, while barren females are kept for skinning in November. Since the records of the number of puppies may give rise to misunderstanding, it has been changed to the number of kits weaned per mated female. The total amount of animals over the year is thus calculated on the basis of 1000 females at July 1, when the number of animals is recorded by the national association of fur breeders (Dansk Pelsdyravlerforening). The results are stated in Table 1.

Table 1. Number of animals over the year on a mink farm with 1000 females at July 1

Period	Number	Females	Males	Kits	Total
15.11.-31.03.	Introduced	1005	168	0	1173
01.04.-30.04.	Mated	1000	17	0	1017
01.05.-15.06.	In pup	1000	17	0	1017
16.06.-15.11.	Kept	1000	17	5220	6237

The results of the calculation of N supplied with the feed on a farm are shown in Table 2.

Table 2. Feed assignment, energy and protein and N content in feed rations for mink calculated per animal per day and for total mink population per month on a farm with 1000 females at July 1

Month	Days	g/ animal/day	kcal/ 100 g	kcal/ animal/day	% protein	g N/ animal/day	Number	kg N total
Jan	31	170	119	202	17.4	4.73	1173	172
Feb	28	161	119	191	17.4	4.47	1173	147
Mar	31	192	119	228	17.4	5.33	1173	194
Apr	30	173	120	207	17.4	4.80	1017	147
May	31	253	120	303	17.4	7.03	1017	222
Jun	15	377	149	562	16.6	5.92	1017	153
Jun	15	120	149	179	16.6	5.92	6237	299
Jul	15	164	149	245	16.6	4.37	6237	409
Jul	16	132	186	245	16.2	3.41	6237	341
Aug	31	151	186	280	16.2	3.90	6237	754
Sep	30	156	183	285	16.2	4.04	6237	755
Oct	31	155	183	283	16.4	4.06	6237	785
Nov	15	153	183	280	16.4	4.01	6237	376
Nov	15	104	183	190	16.4	2.72	1173	48
Dec	31	104	183	190	16.4	2.72	1173	99

The total amount of feed supplied makes out 185218 kg containing 309095 Mcal or on average 167 kcal/100 g for a year's production. This is equal to 35.5 kg feed and 59.2 Mcal per pelt produced. The amount of N supplied is divided between wastage of feed and eaten feed. The amount of N absorbed in the feed is either deposited or excreted in faeces or urine. The excreted amount of N is calculated as the difference between the amount of

N absorbed and the amount of N deposited in the mink body. The N that is not deposited is divided into N in urine and N in faeces. The results appear from Table 3.

Table 3. The content of N in mink feed, feed wastage, carcasses, faeces and urine from a farm with 1000 mink females at July 1. The estimated amount of N excreted per female and per pelt produced has also been calculated

N supplied in feed for a farm with 1000 females as at July 1 and 5220 puppies	4898 kg
N in wastage feed (1)	392 kg
N intake	4506 kg
N in carcass, pelt, fur etc. (2)	310 kg
N excreted in faeces and urine	4196 kg
N of this in faeces (3)	676 kg
N of this in urine (4)	3520 kg

g N excreted in faeces and urine per female per year	4196 g
g N in feed wastage per female per year	392 g
Total g N per female per year	4588 g
g N excreted in faeces and urine per pelt produced (5220 pelts)	804 g
g N in feed wastage per pelt produced (5220 pelts)	75 g
Total g N of this in faeces (3)	879 g

(1) The feed wastage is estimated at 8% (Nielsen, 1993).

(2) At the time of skinning, the mink kits contain approx. 18.3% protein (Enggaard Hansen and Glem-Hansen, 1982). In the light of that, the N content in the male and female kits, body weights at 1200 and 2300 g is estimated at 53 g N on average per animal. In addition to that, the summer pelt contains approx. 4.5 g N (Glem-Hansen & Enggaard Hansen, 1981) per animal, while it is estimated that the winter pelt contains the same amount. The total amount of N is 5220 puppets of 4.5 g N in summer pelt and 53 g N at the time of skinning and 1173 + 1017 breeding animals of 4.5 g N at the time of shedding hair.

(3) The protein digestibility is almost constantly 85%, i.e., 15% of the N intake is excreted in the faeces.

(4) In order to get the most correct impression of the N excretion ex animal, the calculations are contrary to previously based on the N intake minus the content in hair at the time of shedding hair and in pelt and body at the time of skinning. The N excretion in urine is therefore calculated as the proportion of the excreted N amount that is not excreted in the faeces. Contrary to previous calculations, these calculations have not been corrected for the fact that a considerable amount of urinal N evaporates (Elnif, 1992), and only some of the excreted urinal N is possible to find again in faeces gutters etc. under farming conditions.

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Mink, Appendix 2

Phosphorus in mink faeces and urine

by

Niels Enggaard Hansen
Royal Veterinary and Agricultural University
Department of Animal Science and Animal Health
23 Rolighedsvej
DK-1870 Frederiksberg C

First it should be mentioned that among the constituents of fur animals' feed, trash fish, fish offal and poultry offal make out a considerable proportion where especially the two last-mentioned groups have a considerable content of bones and thereby of ash. This causes a similar content of phosphorus, and contrary to what is usually known from other livestock, there is no need for supplementing the natural phosphorus content of the feed with a phosphoric mineral mix.

Over the recent approx. 10 years, a considerable increase in the energy content of the fur animals' feed has been achieved primarily by adding increased amounts of fat at the same time resulting in a relative decrease in the content of specific nutrients, including phosphorus. In Enclosure 2a, the calculated phosphorus contents of the feed supplied by 5 feed factories is shown which together represent approx. 45% of the annual production of mink pelts (1). The above-mentioned reduction is obvious, since at the same time it should be pointed out that approx. 75% of the consumption of feed occurs over the last half of the year during which the puppets are growing.

Based on the fact that the phosphorus content of the various types of feed covers the phosphorous requirement of the animals as mentioned above, no digestibility experiments have been carried out apart from the relatively few that form part of the various research projects. Thus, it not possible at present to state the phosphorous digestibility for the individual types of feed and thereby not possible either to state safeguarded values for the excretion of phosphorus in faeces and urine, respectively.

Based on slaughter experiments also at the time of skinning (2), the phosphorus content of the mink body can thus be stated with substantial certainty, and it is therefore possible to calculate total phosphorus in faeces and urine on the basis of the intake of feed and the content of the feed. A calculation has been made for the production year 1995/96 for the 5 feed factories (Enclosure 2b) similar to the calculation that was made for N (Normtal for N-input og -output på en Minkfarm, SH) (standard values for N input and output on a mink farm by the National Institute of Animal Science) with reference to Tables 1 and 2 concerning preconditions, number of animals, and feed intake, in particular.

Further, the appendix illustrates the result of a similar calculation carried out for the same feed factories during the production year 1985/86, since the puppet result that year was

4.69. The same standard has been used for the daily energy supply in both production years despite the minor overestimation that occurs in 1985/86 in May-June due to the lower puppet result and the fact that the animals usually were slightly smaller. Also the total amount of phosphorus excretion in faeces and urine is stated per pelt produced over the two years.

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Enclosure 2a

COMPARISON BETWEEN THE PHOSPHORUS CONCENTRATION IN FUR ANIMAL FEED

THE PRODUCTION YEARS 1985/86 AND 1995/96

Feed factories	Phosphorus in feed, g per 100 kg							
A, 1985/86	15/12: 522	1/2: 631	18/4: 613	20/6: 536	15/7: 524	10/8: 509	15/9: 518	15/10: 518
A, 1995/96	13/12: 660			25/6: 494	15/7: 406	14/8: 426		1/10: 433
B, 1985/86	13/12: 644		24/3: 627	7/5: 636	4/7: 456		1/9: 488	
B, 1995/96	15/12: 653				11/7: 505			1/10: 419
C, 1985/86	12/12: 700		18/4: 599		10/7: 519	1/8: 519	20/9: 548	
C, 1995/96	12/12: 659		19/4: 635	14/6: 544	2/7: 411		23/9: 431	
D, 1985/86	17/12: 718		8/4: 668	13/5: 626	15/7: 563	6/8: 586		
D, 1995/96	4/12: 615		20/4: 641		15/7: 484		14/9: 438	
E, 1985/86	9/12: 668	25/2: 659	22/4: 648	18/6: 562	10/7: 574 28/7: 513	20/8: 504		
E, 1995/96	12/12: 626		20/4: 592	26/6: 492	12/7: 447		1/9: 399	

Enclosure 2b

COMPARISON BETWEEN THE PHOSPHORUS METABOLISM BY MINK IN THE PRODUCTION YEARS 1985/86 AND 1995/96

1985/86: 4,690 kits/1,000 females
1995/96: 5,220 kits/1,000 females

P content of males at pelting: 10.4 g/animal
P content of females at pelting: 6.0 g/animal

Feed factories	P intake, g	P contained in animals at the time of skinning, g	P in faeces + urine, g	P in feed wastage, g	P in faeces + urine + feed wastage, g	Per female with kits per year, g	Per pelt produced, g
A, 1985/86	992,430	38,458	953.972	86,298	1,040,270	1,041	222
A, 1995/96	844,674	42,804	801,870	73,450	875,320	877	168
B, 1985/86	922,122	38,458	883,664	80,184	963,848	966	206
B, 1995/96	884,978	42,804	842,174	76,955	919,129	919	176
C, 1985/86	1,095,999	38,458	1,057,541	95,304	1,152,845	1,154	246
C, 1995/96	876,169	42,804	833,365	76,189	909,554	908	174
D, 1985/86	1,122,881	38,458	1,084,423	97,642	1,182,065	1,182	252
D, 1995/96	920,800	42,804	877,996	80,070	958,066	960	184
E, 1985/86	1.011,448	38,458	927,990	87,952	1,060,942	1,060	226
E, 1995/96	798,581	42,804	755,777	69,442	825,219	825	158
Average, weighted in proportion to share of production						1995/96: 895	1995/96: 171

Technology, Appendix 1

Survey of housing systems - dairy cows, averages and variation:

Housing type	Manure type	Distribution between deep litter and slurry, %	Bedding, kg/day per animal	Waste water in housing system		Loss in housing system		Loss in housing system		DM in manure
				Drinking water waste, m³ per cow per year	Cleaning water, m³ cow per year	Dry matter %	N loss %	Dry matter %	N loss %	Deep litter, manure
Tie-up housing system with dung channel	Manure + liquid manure	-	1.5 1-3	0.1	0	0	5 5	5 0	15 2	-
Tie-up housing system with floor grating	Slurry	100	1.5 0.5-2	0.1	0	0	5	0	2	
Cubicles with solid floor	Slurry	100	1.5 1-3	0.1	3 2.5-5.0	0	10	0	2	
Cubicles with slatted floor	Slurry	100	1.5 0.5-2	0.1	3 2.5-5.0	0	5	0	2	
Deep litter throughout area	Deep litter	100	14 9-14	0.1	2** 0-2.5	20	7	10*	10*	30 26-31
Deep litter + long feeding area, solid floor	Deep litter, slurry	50/50	8 8-12	0.1	3 2.5-5.0	20	5	20*	2*	31 28-35
Deep litter + long feeding area with slatted floor	Deep litter, slurry	50/50	8 8-12	0.1	3 2.5-5.0	20	5	20*	2*	31 28-35
Straw-bedded sloped floor	Deep litter	100	5 3.5-6	0.1	3 2.5-5.0	0	7	5	15	24 21-26

* If the bedding mat is hauled into battery

** If the house is designed with milking booths, there will be no cleaning water (milking centre waste water from cleaning)

Survey of housing systems - calves (0-6 months both cow- and bull calves) -averages and variation:

Housing type	Manure type	Distribution between bedding and slurry, %	Bedding, kg/day	Water waste in housing system		Loss in housing system		Loss in storage system	
				Drinking water waste, m³ per place unit	Cleaning water m³ per animal per year	Dry matter, %	N loss %	Dry matter, %	N loss, %
Tie-up housing system**									
Dung channel									
Housing system with floor grating									
Cubicles with solid floor									
Cublicles with slatted floor									
Deep litter (throughout area)	Deep litter	100	1.5 1-2	0.05	0	20	7	10*	10*
Deep litter + short feeding area, solid floor	Deep litter	100	1.5 1-2	0.05	0	20	7	10*	10*
Deep litter + large feeding area, solid floor									
Deep litter + long feeding area with slatted floor									
Straw-bedded sloped floor									

* If the straw bedding is hauled in battery

** According to executive order, the construction of tie-up buildings is no longer legal. Existing buildings shall be taken out of production not be used after January 1, 2004.

Survey of housing systems - heifers (6 months until calving) - averages and variation:

Housing type	Manure type	Distribution between deep litter and slurry, %	Bedding, kg/day	Water waste in housing system		Loss in housing system		Loss in storage system		Dry matter in manure
				Drinking water waste, m³ per place unit	Cleaning water	Dry matter, %	N loss, %	Dry matter, %	N loss, %	Deep litter manure
Tie-up housing system with dung channel	Manure, liq. manure	-	0.7 0.5-1.0	0.25 0.15-0.4	0	0 0	5	5 0	15 2	
Tie-up housing system with floor grating	Slurry	100	0.5	0.25 0.15-0.4	0	0	5	20	2	
Cubicles with solid floor	Slurry	100	0.5	0.25 0.15-0.4	0	0	10	20	2	
Cubicles with slatted floor	Slurry	100	0.5	0.25 0.15-0.4	0	0	5	20	2	
Deep litter (throughout area)	Deep litter	100	4.8 1.5-7.0	0.25 0.15-0.4	0	20	7	10*	10*	28
Deep litter + short feeding area, solid floor	Deep litter	100	5.0 2-6	0.25 0.15-0.4	0	20	7	10*	10*	28
Deep litter + long feeding area, solid floor	Deep litter slurry	50/50	2.4 1.5-8.0	0.25 0.15-0.4	0	20	5	20*	10*	28
Deep litter + long feeding area with slatted floor	Deep litter slurry	50/50	2.5 1.5-8.0	0.25 0.15-0.4	0	20	5	20*	10*	28
Straw-bedded sloped floor	Deep litter	100	2.6 1.5-3.9	0.25 0.15-0.4	0	0	7	5	15	24
Crates with slatted floor	Slurry	100	0	0.25 0.15-0.4	0	0	8	20	2	-

* If the faeces is hauled in battery.

** Average weight per animal: 300 kg.

Survey of housing systems - slaughter calves -average and variation:

Housing type	Manure type	Distribution betw. deep litter and slurry, %	Bedding, kg/day	Waste water in housing system		Loss in housing system		Loss in storage system		Dry matter in manure
				Drinking water waste, m³ per cow per year	Cleaning water, m³ per cow per year	Dry matter, %	N loss, %	Dry matter, %	N loss, %	Deep litter, manure
Tie-up housing system with dung channel	Manure, liq. manure	-	0,7 0,5-1,0	0,25 0,15-0,4	0	0 0	5 ?	5 0	15 2	-
Tie-up housing system with floor grating	Slurry	100	0,5	0,25 0,15-0,4	0	0	5	20	2	
Cubicles with solid floor	Slurry	100	**							
Cubicles with slatted floor	Slurry	100	**							
Deep litter (throughout area)	Deep litter	100	4,8 1,5-7,0	0,25 0,15-0,4	0	20	7	10*	10*	28
Deep litter + short feeding area, solid floor	Deep litter	100	5,0 2-6	0,25 0,15-0,4	0	20	7	10*	10*	28
Deep litter + long feeding area, solid floor	Deep litter – slurry	50/50	2,4 1,5-8,0	0,25 0,15-0,4	0	20	5	10*	10*	28
Deep litter + long feeding area, with slatted floor	Deep litter slurry	50/50	2,5 1,5-8,0	0,25 0,15-0,4	0	20	5	10*	10*	28
Straw-bedded sloped floor	Manure	100	2,6 1,5-3,9	0,25 0,15-0,4	0	0	7	5	15	24
Crates with slatted floor	Slurry	100	0	0,25 0,15-0,4	0	0	8	20	2	-

* If the faeces is hauled in battery.

** Only very few herds use cubicles for slaughter calves (see under the Section on heifers).

Survey of housing systems - suckler cows including breeding stock -averages and variation:

Housing type	Manure type	Distribution betw. deep litter and slurry, %	Bedding, kg/day	Water waste in housing system		Loss in housing system		Loss in storage system		Dry matter in manure
				Drinking water waste, m³ per cow per year	Cleaning water, m³ per cow per year	Dry matter, %	N loss, %	Dry matter, %	N loss, %	Deep litter manure
Tie-up housing system with dung channel**	Manure, liqu. manure	-	1.5 1-3	0.1	0	0 0	5 -	5 0	15 2	-
Housing system with floor grating										
Cubicles with solid floor										
Cubicles with slatted floor										
Deep litter (throughout area)	Deep litter	100	14 9-14	0.1	0	20	7	10*	10*	30
Deep litter + short feeding area, solid floor	Deep litter	100	15 9-15	0.1	0	20	7	10*	10*	
Deep litter + long feeding area, solid floor	Deep litter slurry	50/50	10 8-10	0.1	0	20	5	20*	10*	31
Deep litter + long feeding area, with slatted floor	Deep litter slurry	50/50	8 8-12	0.1	0	20	5	20*	10*	31
Straw-bedded sloped floor	Deep litter	100	5 3.5-6	0.1	0	0	7	5	15	24

* If the straw bedding is hauled in battery.

** By far the majority of suckler cows are confined in deep litter systems. Some of them are confined in tie-up houses previously used for dairy cows.

Technology, Appendix 2

Survey of housing systems with pigs, averages and variation:

			Water waste in housing system		Loss in housing system		Loss in storage system	
Housing type:	Manure type	Bedding straw, kg/place unit/year	Drinking water waste	Cleaning water	Dry matter loss, %	Ammonia+ denitrificat., %	Dry matter, %	Ammonia + denitrificat., %
Sows, gestation housing systems:								
Housing w. partially slatted floor	Slurry	0	0	0	0	14 12-16	20	2
Housing with solid floor	Manure, liqu. manure	75 50-100	0 0	0 0	0 0	20 16-24	30	30 20-40 2
Group penning, partially slatted floor	Slurry	0	0	0	0	14 12-16	20	2
Group penning, deep litter	Deep litter	800 700-900	0	0	30	20 15-25	20	10 5-15
Electronic sow feeding	Deep litter	1000 1000	0	0	30	20 15-25	20	10 5-15
Electr. sow feeding, subdiv. lying area	Deep litter + Slurry	350 350-400	0	0	30 0	20 15-25 14 12-16	20 20	10 5-15 2
Feeding stalls and pens with sub-divided lying area	Deep litter + Slurry	350 350-400	0		30 0	20 15-25 14 12-16	20 20	10 5-15
Sows, gestation housing:								
Farrowing pens w. fully slatted floor	Slurry	0	0	litres per litter 150 100-200		15 13-17	20	2
Farrowing pens w. part. slatted floor	Slurry	0	0	150 100-200		10 8-12	20	2
Solid floor	Manure, liquid manure	450 300-600	 0	0 0		15 10-20 15 10-20	30	30 20-40 2
		Kg straw per pig prod.	Litres per produced pig	Litres per produced pig				
Weaner housing: Fully slatted floor	Slurry	0	0.3 0-0.6	15 10-20		14 12-16	20	2
Two-climate housing w. part. slatted floor	Slurry	1	0.3 0-0.6	20 15-25		10 8-12	20	2
Solid floor	Manure, liquid manure	2,5 2-3	 0.3 0-0.6	0 0		25 20-28 25 20-28	30	30 20-40 2
Two-climate housing with deep litter	Deep litter	13 10-15	0.3 0-0.6	0	30	25 15-30	20	25 15-35
Slaughter pig housing: Fully slatted floor	Slurry	0	0.75 0-2.5	30 20-40		14 12-16	20	2
Partially slatted floor	Slurry	3 0-5	0.75 0-2.5	25 15-35		14 12-16	20	2
Solid floor	Manure, liquid manure	13 10-15	 0.75 0-2.5	 0		18 14-22 18 14-22	30	30 20-40 2
Deep litter with subdivided lying area	Deep litter Slurry	35 25-50	 0.75 0-2.5	 0	30	25 15-30 14 12-16	20 20	25 15-35 2
Deep litter	Deep litter	70 50-100		0	30	25 15-30	20	25 15-35

Technology, Appendix 3

Survey of housing systems with poultry, horses, sheep and fur bearing animals, averages and variation:

					Waste water in housing system		Loss in housing system			Loss in storage		
Housing type	Manure type	Distribution of manure, %	Type of manure	Bedding, kg straw/ place unit/year	Drinking water waste	Cleaning water	Weight loss, %	Ammonia + denitrification, %		Dry matter, %	Ammonia + denitrification, %	
Poultry for slaughter: Broilers		100	Deep litter	Per unit prod. 0.1			55	19	15-24	20	25	15-35
Turkeys, heavy		100	Deep litter	0.6			55	19	15-25	20	25	15-35
Turkeys, young		100	Deep litter	0.3			55	19	15-26	20	25	15-35
Ducks		100	Deep litter	2.5			55	19	15-27	20	25	15-35
Geese		100	Deep litter.	2.5			55	19	15-28	20	25	15-35
Hens: Layer type, floor management with outdoor area	Deep litter area Droppings pits Outdoor area	30 60 10	Deep litter Manure	0.12			55 30	28 40	20-35 30-50		25 15 15	15-35 10-20 10-20
Layer type, floor management without outdoor area	Deep litter area Droppings pits	33 67	Deep litter Manure	0.12			55 30	28 40	20-35 30-50		25 15	15-35 10-20
Layer type, aviary	Droppings belt Deep litter area Manure heap shelter	75 25 0	Manure Deep litter Manure	 0.12			30 55 30	10 28 12	8-12 20-35 9-15		15 25 15	10-20 15-35 10-20
Layer type, battery cage systems	Manure cellar	100	Manure				30	12	9-15		15	10-20
Layer type, battery cage systems	Manure channel Slurry tank	100 100	Manure Slurry				30 0	12 12	9-15 9-15		15 2	10-20
Layer type, battery cage systems, Drop pits belt	Droppings belt Manure heap shelter	100 100	Manure Manure				30 30	10 12	8-12 9-15		15 15	10-20 10-20
Par. stock broiler prod., floor management	Deep litter	100	Deep litter	0.36			55	19	15-24		25	15-35
				Kg per year (Housed all year)	l per unit per year	l per unit per year	Dry matter loss, %					
Sheep per female ewe	Deep litter			550	0	0	10	15		20	10	
Horses, per horse	Deep litter			1825	0	0	20	15		20	10	
Mink, per breeding female	Solid faeces Slurry			5 5	 120	 0		25 65			15 2	
Foxes and finnracoon	Solid faeces Liquid faeces			0 5	0 300	0 0		25 65			15 2	