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Grete Thorbek

Studies on Energy Metabolism in Growing Pigs

II. Protein- and Fat Gain in Growing Pigs Fed Different Feed Compounds. Efficiency of Utilization of Metabolizable Energy for Growth

Studier over energiomsætningen hos voksende svin

II. Protein- og fedtaflejringen hos voksende svin fodret med forskellige foderblandinger. Udnyttelsesgraden af omsættelig energi til vækst

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The carrying out of respiration experiments demands both extensive analytical work with CO_2 – and O_2 determinations, adn also frequent calibration of the installations and instruments used. In this work I have had great support from *Lise Neergaard,* cand. agro., who has also been responsible for working up the carbon analyses. I wish to express my great gratitude for an outstandingly large amount of work performed through the years, and for many good discussions.

Since the Department had not yet, in 1964–66, developed an E.D.P. programme for the treatment of the observed data, all calculations for the main tables were carried out by hand. For the carefully excuted revision work I offer *E. W. Karlsen, Mimi Wilstrup* and *Rita Ibsen* my best thanks. I owe many thanks to *Gertrud Henriksen* for making fair copies of the main tables and preparing code tapes for printing.

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The great amount of statistical material in the main tables could not be treated immediately through existing E.D.P. programmes, for which reason it was necessary to have a programme system specially developed for regression analyses. This task was completed in an excellent way by stud. stat. *Søren Henckel,* who supplied a programme which provides a clear and easily read output. In connection with this work I wish to express my great gratitude to *Søren Henckel* for the many inspiring and fruitful discussions which we have had in recent years about the statistical evaluation of biological experimental data, and I would finally offer thanks for the preparation of the statistical appendix to this report.

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Copenhagen, March 1975 *Grete Thorbek*

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CHAPTER 1

Introduction

In 1958 the National Institute of Animal Science, Department of Animal Physiology received from the Ministry of Agriculture an appropriation to build a new respiration plant for pigs. The construction started in 1959 and in 1961 a general description of an open air circuit system was given at the 2nd. Symposium on Energy Metabolism, *Thorbek* (1961). During the period of building a digestibility experiment was carried out with 12 growing pigs from 20 to 50 kg live weight in order to establish a technique concerning the type of metabolic crates, feed intake and length of collection time to be used in future balance- and respiration trials, the results of which are given in chapter 2 in this paper.

At the end of 1963 all the technical tests and calibrations of the plant were concluded and the first respiration experiment was started with growing pigs from 20 to 90 kg live weight. The aim of the experiment was partly to evaluate the technique applied and partly to estimate whether the gas exchange measured in the animals would be influenced by different CO_2-concentrations in the chamber. No influence on the gas exchange could be found by a variation from 0.4 to 1.5% CO_2, *Thorbek & Neergaard* (1965), but it was decided to keep the mean CO_2-concentration below 1% in the future respiration trials.

From the first experiment it was concluded that the air-conditioning system, the pumps and instruments for measuring air flow as well as the system for taking aliquote gas samples worked satisfactory and needed little attendance. At the same time it was found that the pigs seemed to be comfortable in the chamber, with the same pattern of behaviour as in the pigsties. The system applied for the security of the animals was safe, so no attendance for the sake of the pigs or for the functioning of the instruments was necessary in the evening- or night hours. With a maximum capacity of six 24-hours measurements of the gas exchange per week 200 balance experiments could be conducted yearly and the running cost could be kept at a low level caused by the high degree of automatization and the little attendance needed. The respiration plant has been described in detail by *Thorbek* (1969 a).

Since the work of *Breirem* (1935, 1936, 1939) with his systematic investigation concerning energy metabolism in growing pigs of Danish Landrace, and heat production in pigs starved at different live weight, no systematic work of that kind has been carried out during the following 30 years. Therefore, in planning the experiments in 1964, it was decided to start a series of experiments with growing pigs of Danish Landrace in order to determine digestibility, gas exchange, heat production and protein-fat gain in pigs from 20–90 kg live weight.

The experiments included 48 barrows fed 6 different feed compounds of barley, maize or sorghum in combination with skim-milk powder or protein mixture, being feed compounds commonly used in Denmark. The experimental work was concluded in 1966 and as the computer programme for basal-output was not yet finished, all the basal results were handcalculated. The figures are given in the main tables in this paper.

By means of a regression programme developed later, the figures from the basal output have been used to estimate the relationship between the different parameters. The results from the digestibility experiments, including the energy losses in urine, have been used to estimate the digestibility and the metabolizable energy in the feed compounds and in the different feed components. The results are discussed in chapter 5. From the respiration trials the values have been used to estimate the relationship between CO_2-production, O_2-consumption and heat production in relation to live weight or metabolic live weight and functions have been given and compared with results from other investigators in chapter 6.

The nitrogen retention has been determined in 381 balance periods through the growth period in question and in chapter 7 the results obtained are compared with results from the literature, and it is discussed whether the nitrogen retention in growing animals should be considered as a function of external factors such as nitrogen and energy intake or as a function of internal factors e.g. the capacity of the cells to form protein.

Finally the results from the nitrogen-carbon balances have been used to estimate the proportion of protein and fat formation during the growth period. The results obtained have been compared in chapter 8 with results from the literature in relation to intake of metabolizable energy and degree of confinement in the respiration chamber. The function for energy requirement for maintenance in pigs at different age and live weight has been discussed, and the efficiency of utilization of metabolizable energy available for growth and for protein-fat formation has been estimated.

CHAPTER 2

Investigations concerning techniques applied to balance experiments with growing pigs

2.1. Introduction

In digestibility and balance trials with pigs the conventional technique is to keep the animals on a constant ration for a certain length of time, and by means of metabolic crates to collect, for a number of days, the excreted amounts of faeces and urine. The daily samples of faeces and urine are weighed, and after thorough mixing, aliquot samples are taken, kept under cover, and stored at a temperature of about 3 to 7°C. At the end of the collecting period the daily samples are mixed and taken for chemical analysis.

It is obvious that the degree of accuracy for all determinations in the procedure should be as high as necessary, but it is just as important that the results obtained, being values for digestibility or retention, should be applicable to animals kept under normal conditions. Several problems could be discussed in that connection, but this chapter will deal only with questions concerning *type of metabolic crates, the length of collection time* and different *feeding techniques.*

Metabolic crates

During recent decades different types of metabolic crates have been developed, as described by *Allen, Barber, Braude & Mitchell* (1963). There seems to be tendencies either to keep the animals in confined cages restricting their movements rather much, or to keep them in larger cages with the possibility of some movement.

Confined cages with adjustable bars for digestibility and balance trials with pigs from 20 to 110 kg have been constructed and described by *Farries & Oslage* (1961). In his studies concerning digestibility in pigs *Madsen* (1963) used confined cages, at first with adjustable sides; but finding it unpractical, as the animals could turn around even in a very confined space, he gave up using the adjustable sides, giving the animal more space for movement.

A type of confined metabolic crate, combined with a harness suitable for male growing pigs up to bacon weight, has been constructed at Shinfield and described by *Allen* et al. (1963) and *Braude & Mitchell* (1964).

At the National Institute of Animal Science in Copenhagen, cages with more space have been used for experiments with pigs. The first type was constructed and described by *Spildo* (1933) and used with satisfactory results in his experiments concerning calcium and phosphorus balances in growing pigs. The standing grate measured 120 × 45 cm equalling to 0.54 m^2 and the cages were used for pigs from 20 to 60 kg liveweight.

The same type of crate was used by *Breirem* (1935) in his measurements of energy metabolism in pigs. Two different sizes of cage were used. One, measuring 140 × 45 cm or 0.63 m^2, was used for pigs from 20 to 100 kg, while for pigs from 100 to 200 kg liveweight, the size of the cage was 200 × 75 cm or 1.5 m^2.

With some minor improvements, crates in two different sizes of about 0.5 and 0.7 m^2 for pigs from 10 to 90 kg liveweight were used by *Ludvigsen & Thorbek* (1955), giving the animals some space in which to move. It was found, that for heavier pigs the excretion curve for faeces had a tendency to decline in the collecting period, and when the pigs were transferred to the pens they immediately excreted a large amount of faeces, indicating that they had »stored« faeces in their large intestines.

It is obvious that in cages with more space some contamination between faeces and urine can occur, thereby influencing the accuracy of the digestibility coefficients obtained, but not the balances observed, because faeces as well as urine are collected.

Even if it is possible, by using confined cages, to obtain values with a low standard deviation for the digestibility of the different nutrients, the validity of the mean value is questionable. As was pointed out by *Cole, Duckworth & Holmes* (1967) pigs in confined cages have very little exercise, which may affect muscle tonus, thereby reducing the rate of passage in the intestines, and resulting in digestibility coefficients being higher than in pigs kept in pens. This indicates the necessity of caution in applying results obtained from pigs kept confined, to pigs under normal conditions.

Length of collection time

In his thesis *Madsen* (1963) has given an extensive review of the variation in collection time used by different investigators, ranging from 5 to 21 days in the preliminary period, and from 4 to 10 days in the collecting period. In his own experiments concerning digestibility in pigs, *Madsen* used a preliminary period of 8 days, and a collecting period of 6 days.

In measuring the energy metabolism in growing pigs *Breirem* (1935) used a preliminary period of 10–19 days, followed by a collecting period of 4–9 days.

Feeding techniques

During the preliminary and collecting periods the animals are commonly kept on a constant feed ration. At the end of the collecting period the ration is increased to the next level, kept constant again for the following preliminary and measurement periods, and so on during the whole experimental time. In trials with fast growing animals, such a method implies that the measurements will be carried out in periods where the growth is somewhat lower than in the preliminary periods, because an increasing amount of feed is used for covering the maintenance requirements for nitrogen as well as for energy.

In an earlier investigation concerning the maximum nitrogen retention in artificially reared baby pigs, this method of increasing the ration stepwise was found unsatisfactory for young pigs with their great capacity for growth, and the technique was changed to that of feeding the animals according to a daily increasing scale (*Ludvigsen & Thorbek,* 1960). The scale was laid down according to experience, and the animals were given as much feed as they could eat without any feed-residues, and with no risk of digestive disturbances. In the following years this technique of feeding according to a daily increasing scale was applied in further experiments with baby-pigs (*Thorbek, Boza & Engelender,* 1967).

In 1963, before the newly built respiration plant for determining the energy metabolism in growing pigs was taken into use, it was decided to carry out an experiment in order to evaluate the accuracy of results obtained by using the two different methods of feeding, combined with different lengths of collection time, and using only one type of metabolic crate having a size of 1 m^2.

As the results obtained from this investigation constitute the basis of the experimental design used in our first energy measurements from 1964 to 1966, and as it was applied by *Nielsen* (1970) in his energy measurements from 1966 to 1969, the experiment is described and the results discussed in the following section.

2.2. Experimental design

The experiment, series A, 1963, was carried out with 12 growing pigs in the live weight-range from 25 to 50 kg. In period I the pigs received a constant ration of feed and water during the time of measurement, while in period II the amount of feed and water was increased daily.

As any contamination between faeces and urine will chiefly influence the validity of the values for nitrogen digestibility, because of the relatively high content of nitrogen in urine, this nutrient was chosen as an indicator of the accuracy obtained by the two different feeding techniques combined with different lengths of collection time.

Each period consisted of 14 days of collection, and for every day the amounts of nitrogen excreted in the faeces by the individual pigs were determined. Thus the material in each period consisted of 168 observations for nitrogen excretion in faeces.

Animals

4 barrows from 3 different cross-breed litters were used for the experiment and the numbers and breeds are given below:

No. 3- 4- 5- 6	Yorkshire Boar, Juul	×	Black-and white sow no. 58
No. 7- 8- 9-10	Yorkshire Boar, Juul	×	Black-and white sow no. 60
No. 11-12-13-14	Danish Landrace, Birch	×	Black-and white sow no. 22

Feed-compound

The feed-compound, consisting of 80% grain-mixture and 20% skim-milk powder, was kept constant during the whole experimental time. The grain-mixture consisted of 67.5% barley + 20.0% wheat + 10.0% wheat-bran + 2.5% lucerne meal. Calculated according to the Scandinavian feed unit system, the energy in the feed compound was 1.05 Sc. f.u. with 150 g crude protein per kg.

The mineral requirement was covered by giving a mixture of 80% $CaCO_3$ + 20% NaCl according to liveweight and amount of feed, and the pigs received a daily supply of 10 ml soya-oil with 2000 i.u.A + 500 i.u. D_2.

Feeding plan

According to liveweight, 25 kg in average, pigs nos. 3, 6, 7, 8, 12, 14 received in period I a constant amount of 700 g grain-mixture + 175 g skim-milk powder, while nos. 4, 5, 9, 10, 11, 13 with an average liveweight of 30 kg were fed a constant ration of 900 g grain-mixture + 225 g skim-milk powder. The nitrogen intake was respectively 21.4 and 27.9 g.

In period II the ration was increased daily by 20 g grain-mixture and 5 g skim-milk powder. At the same time the amount of water was increased by 100 g daily. All 12 pigs with an average liveweight of 46 kg received the same amount of feed starting at 1240 g grain-mixture + 310 g skim-milk powder. During the period the daily intake of nitrogen increased from 37.5 to 46.3 g.

Technique of sampling faeces and urine

During the collecting periods the animals were kept in metabolic crates with a standing grate of 140 × 70 cm or nearly 1 m^2 of space, so that the pigs were allowed some movement.

The animals were brought into the cages two days before the collecting period started. They were fed at 7.00 and 15.00 and the collecting time was from 8.00 to 8.00 next morning. During the daytime faeces were collected at intervals of about 4 hours, and stored in a cooling room until next morning, when the total amount of faeces for each pig for the 24 hour period was weighed out. The faeces were mixed carefully in a Bjørn-Wodschow-Mixer before an average sample was taken for the determination of nitrogen.

With constant intake of nitrogen, a constant output of nitrogen in faeces would be excepted, while an increasing intake of nitrogen would be expected to cause an increasing output of nitrogen.

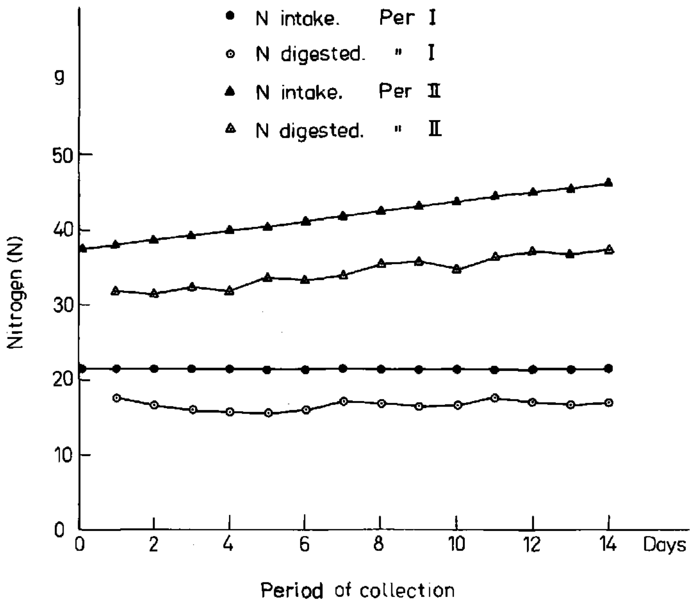

Figure 1.
Daily variations in nitrogen digested during periods of constant (I) or increasing (II) feeding. Pig no. 7.
Daglige variationer i fordøjet kvælstof i perioder med konstant (I) eller stigende (II) fodring. Svin nr. 7.

In figure 1 the results obtained using pig number 7 as a model clearly indicate that the figures for nitrogen digested are distributed around a constant line in period I with constant feeding, and around a line with a certain slope in period II with increasing feeding.

In evaluating the accuracy obtained in determining the digestibility of nitrogen by these two methods of feeding, giving two different types of curves, the usual method of calculating the standard deviation is not applicable. A statistical model given by *G. Rasch* and described in the following section has therefore been used to evaluate the results obtained.

2.3. Statistical model

(Professor Dr. phil. G. Rasch)

Plotting any ND (Nitrogen digested) against the corresponding NI (Nitrogen intake) we obtain the pictures indicated in Figure 2:

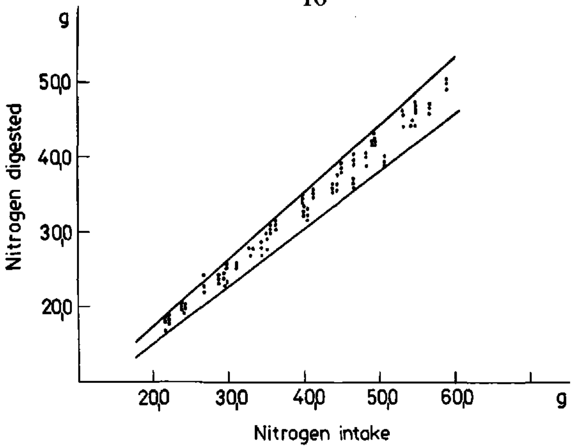

Figure 2.

An example of the relation of nitrogen digested to nitrogen intake for 12 pigs in 8 balance periods.

Eksempel på fordøjet kvælstof i relation til optaget kvælstof. 12 svin i 8 balance-perioder.

which show that ND is largely proportional to NI and that the random variation of ND for given NI increases with NI.

On closer inspection it is found that this increase is also largely proportional to NI as demonstrated in Figure 3:

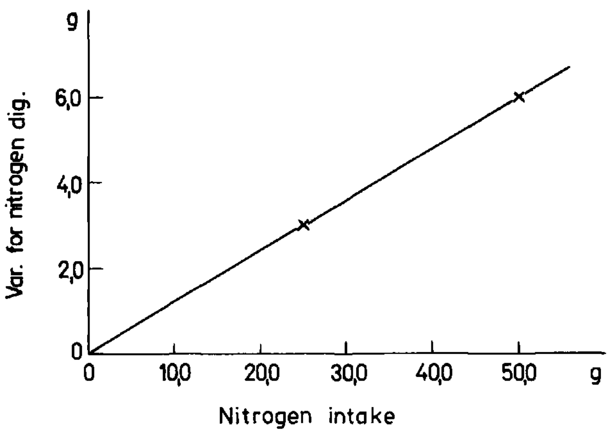

Figure 3.

Variation for nitrogen digested, indicated by the distance between the upper and the lower limit in Figure 2, plotted against the nitrogen intake.

Variation for fordøjet kvælstof angivet ved afstanden mellem øverste og nederste grænse i figur 2, i relation til optaget kvælstof.

Thus we may tentatively write:

$$(1)\ ND = \alpha \cdot NI + u \cdot NI$$

where α is the all over ratio of ND to NI, i.e. the coefficient of apparent digestibility, and $u \cdot NI$ represents the random variation with a standard deviation proportional to NI.

In statistical terms ND would then be represented by a weighted linear regression on NI, though passing through the origin. And u would ordinarily be taken to follow a normal distribution with constant standard deviation (σ).

Alternatively we may, on dividing through by NI, obtain

$$(2)\ \frac{ND}{NI} = \alpha + u$$

thus the mean value α, and the variance σ^2, of the variables ND/NI are estimated in accordance with rules for normal distributions.

For variations as relatively small as in the present case the representation (1) or (2) to all intents and purposes is equivalent to

$$(3)\ \log ND - \log NI = \log \alpha + v \text{ (log with 10 as base)}$$

where

$$(4)\ v = \log \left(1 + \frac{u}{\alpha}\right)$$

is very close to

$$(5)\ v = 0.4343 \cdot \frac{u}{\alpha}$$

and therefore could also be taken to be normally distributed with

$$(6)\ \tau = 0.4343 \cdot \frac{\sigma}{\alpha}$$

as its standard deviation.

That the transformation (3) really works in that way may be demonstrated graphically by plotting log ND against log NI as shown in Figure 4, where almost all of the points lie within a band of constant width and with unit slope.

The coefficient of variation

A final remark as regards the so called »coefficient of variation«. This quantity is defined as the ratio of the standard deviation of a variable to its mean value. ND being the variable, its mean value and standard deviation are, according to (1), respectively $\alpha \cdot NI$ and $\sigma \cdot NI$. Thus the coefficient of variation becomes

$$(7)\ C.V. \left\{ ND \right\} = \frac{\sigma \cdot NI}{\alpha \cdot NI} = \frac{\sigma}{\alpha}$$

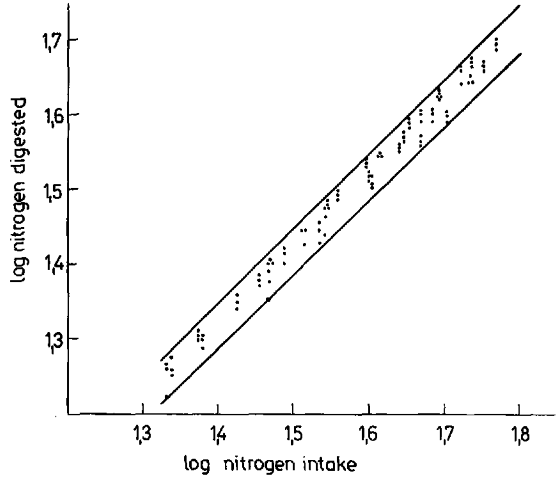

Figure 4.
The example of Figure 2 expressed in terms of the relation of the logarithms of nitrogen digested and of nitrogen intake.
Eksemplet i figur 2 udtrykt ved logaritmiske værdier for fordøjet og optaget kvælstof.

which according to (6) is proportional to the standard deviation of log ND, viz. Υ. The proportionality constant (0.4343) comes from using $\log_{10}$ instead of the natural logarithm.

This formula, it should be noted, only holds good for the theoretical values of C.V., σ and α, while the numerical value of the estimated Υ may very well deviate somewhat from 0.4343 × the ratio of the estimated standard deviation and the average of (ND/NI).

For theoretical reasons calculations based on log (ND/NI) – when they may be taken to follow a normal distribution – have the advantage that the usual tests (t, χ^2, f) are directly at disposal whereas the distribution of the direct estimate of C.V. {ND} is by no means simple, even if the ND's are normally distributed.

2.4. Results

For each period, consisting of 14 days of collection, the quantitative daily excretion of nitrogen in faeces from the 12 experimental animals was determined, giving a total number of 168 observations for each period.

According to the statistical model given and described above by *Rasch* and by means of a computer programme (A/S Regnecentralen, Copenhagen), the average coefficients of digestibility and standard deviation (S.D.) expressed in logarithmic values are calculated for the different periods of collection and for the different feeding technique. The antilogarithms are taken and the results are presented in Table 1 and 2.

Table 1. Digestibility of nitrogen in relation to days of collection by constant feeding. Series A. 1963. Mean of 12 pigs

Tabel 1. Fordøjelighed af kvælstof i relation til antallet af opsamlingsdøgn ved konstant fodring. Serie A. 1963. Middeltal for 12 svin

Periods of collection	Number of days	Digestibility of nitrogen %	S.D.	Periods of collection	Number of days	Digestibility of nitrogen %	S.D.
0– 1	1	82.6	3.8	0–14	14	80.1	4.6
0– 2	2	81.6	3.6	1–14	13	79.9	4.6
0– 3	3	81.0	3.5	2–14	12	79.9	4.8
0– 4	4	80.1	4.8	3–14	11	79.9	4.9
0– 5	5	79.3	5.8	4–14	10	80.1	4.6
0– 6	6	78.9	5.6	5–14	9	80.6	3.7
0– 7	7	79.4	5.5	6–14	8	81.1	3.4
0– 8	8	79.5	5.3	7–14	7	80.9	3.3
0– 9	9	79.7	5.1	8–14	6	81.0	3.4
0–10	10	79.8	5.0	9–14	5	80.9	3.4
0–11	11	80.0	4.8	10–14	4	80.8	3.6
0–12	12	80.1	4.7	11–14	3	80.5	4.0
0–13	13	80.0	4.7	12–14	2	80.0	4.5
0–14	14	80.1	4.6	13–14	1	82.0	3.6

Table 2. Digestibility of nitrogen in relation to days of collection by increasing feeding. Series A. 1963. Mean of 12 pigs

Tabel 2. Fordøjelighed af kvælstof i relation til antallet af opsamlingsdøgn ved stigende fodring. Serie A. 1963. Middeltal for 12 svin

Periods of collection	Number of days	Digestibility of nitrogen %	S.D.	Periods of collection	Number of days	Digestibility of nitrogen %	S.D.
0– 1	1	83.2	2.2	0–14	14	83.1	2.5
0– 2	2	83.0	2.7	1–14	13	83.1	2.5
0– 3	3	82.7	2.5	2–14	12	83.2	2.4
0– 4	4	82.9	2.6	3–14	11	83.3	2.5
0– 5	5	83.0	2.5	4–14	10	83.2	2.4
0– 6	6	82.9	2.4	5–14	9	83.2	2.5
0– 7	7	83.0	2.4	6–14	8	83.3	2.6
0– 8	8	83.0	2.5	7–14	7	83.3	2.6
0– 9	9	83.0	2.5	8–14	6	83.3	2.5
0–10	10	83.0	2.5	9–14	5	83.3	2.6
0–11	11	83.0	2.4	10–14	4	83.5	2.6
0–12	12	83.1	2.5	11–14	3	83.7	2.7
0–13	13	83.1	2.4	12–14	2	83.3	2.7
0–14	14	83.1	2.5	13–14	1	83.6	3.3

In accordance with usage the S.D.'s in the tables are estimates of what in the model is called σ. In this context it does not matter because of the small variation in the average nitrogen digestibility, but in cases where widely varying digestibilities are to be compared it would matter.

As the nitrogen intake and nitrogen digested have been determined for all 12 pigs and for each day in the total collection period of 14 days, it is possible to arrange the observations in two columns. One column starts with the observations from the first day, indicated as 0–1 in the tables, and then adding one day more until the calculations include all 14 days of collection, indicated as 0–14. The second column is arranged by starting with the total period of collection and then excluding the foregoing days from the calculations, ending with the last day of collection, indicated as 13–14.

The results are shown graphically in Figures 5 and 6 indicating the digestibility coefficients of nitrogen with constant or increasing feeding in relation to periods of collection.

2.5. Discussion

In period I with constant feeding the feed intake was increased by one step the day before starting the collection of faeces. The graph in Figure 5 demonstrates clearly, that it has taken about 5–7 days before the excretion of nitrogen was stabilized at a new level corresponding to the change in nitrogen intake.

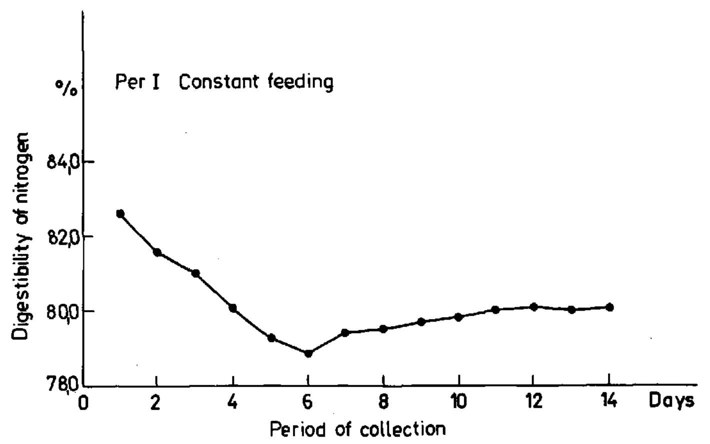

Figure 5.

Digestibility of nitrogen in relation to days of collection. Series A. 1963. Constant feeding. Mean of 12 pigs.

Fordøjelighedskvotienter for kvælstof i relation til antallet af opsamlingsdøgn. Serie A. 1963. Konstant fodring. Middel af 12 svin.

In period II with a small daily increased intake of nitrogen the excretion of nitrogen in faeces was following the intake, thereby giving a very constant level for the digestibility coefficients from the first day of collection as shown in Figure 6.

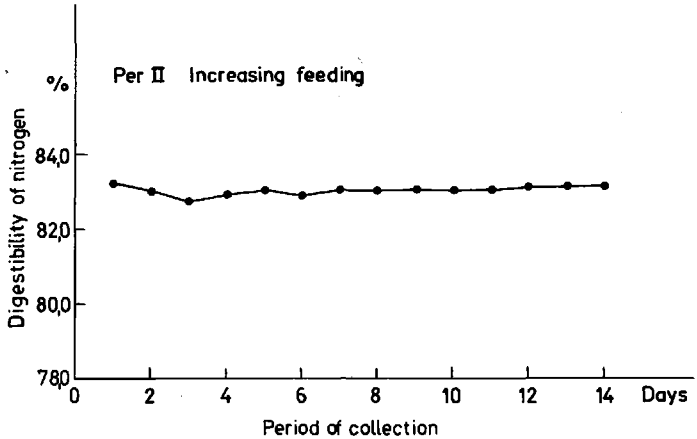

Figure 6.
Digestibility of nitrogen in relation to days of collection. Series A. 1963. Increasing feeding. Mean of 12 pigs.
Fordøjelighedskvotienter for kvælstof i relation til antallet af opsamlingsdøgn. Serie A. 1963. Stigende fodring. Middel af 12 svin.

With constant feeding the standard variation of the digestibility of nitrogen was of the same magnitude by collecting 5 days after a preliminary period of 9 days as by collecting 7–8 days after a preliminary period of 7–6 days, as demonstrated in the second column of Table 1.

With daily increased intake of nitrogen the standard deviation was constant after 5 days of collecting, and no higher accuracy in the determination was found on extending the number of days of collection to 14 days, as demonstrated in the first column of Table 2.

Comparing the technique of constant with that of increasing feeding it was found that the accuracy in determining the coefficients of nitrogen digestibility was somewhat higher with increasing feeding than with constant feeding, the standard deviation being about 2.5% and 3.4% respectively.

No comparative studies have been made between results obtained in confined or non-confined crates, but it was observed in the experiment described, that defecation was unimpeded and no decline in excretion of faeces during the collecting time was observed.

2.6. Conclusions

On the basis of the results described in this chapter it was decided, in our investigation concerning energy metabolism in growing pigs, to use the following technique regarding crates, method of feeding and length of collection time:

Metabolic crates: Only one type of a rather large metabolic crate, the size of the standing grate being 140 × 70 cm or nearly 1 m^2 should be used. With a range in liveweight from 15 to 90 kg the smaller pigs could move around rather freely, and even the heavier pigs would have space enough to feel comfortable.

Feeding technique: During the whole experimental time, preliminary as well as collecting periods, the pigs should be fed according to a daily increasing scale. The scale should be established according to our experience as to how much the pigs could eat without feed-residues or risk of diarrhoea.

Length of collection time: The pigs should be brought into the metabolic crates in the afternoon and the collecting period should start next morning. For practical reasons the lenght of collection time should be 7 days with a 24 hour respiration measurement placed in the middle of the collection period.

CHAPTER 3

Methods and materials applied in series C-D-E-F. 1964–66

3.1. Outline of experimental plan

In order to evaluate the efficiency of metabolizable energy for growth in pigs 4 experimental series, C-D-E-F, with 48 barrows, were carried out from 1964 to 1966. The protein- and energy metabolism as well as the digestibility of different nutrients were determined 8 times for each pig at constant intervals during the growth period from 20 to 90 kg.

In order to facilitate the general application of the results obtained, it was sought to have a rather large variation between animals. To meet this requirement 4 barrows from 12 different litters from different farms were bought for the experiments.

Having regard to the possibility that the efficiency of metabolizable energy for growth is influenced by the origin of the metabolizable energy, 6 different types of feed compounds were used, as shown in Table 3. As barley in combination with skim-milk or with protein mixture are commonly used compounds for feeding bacon pigs in Denmark it was decided that these two compounds, no. 1 and 2, should be tested in all four experimental series.

Table 3. Composition of the experimental feed compounds
Tabel 3. Forsøgsfoderets sammensætning

Number	Composition	Abbreviation
1	Barley + skim-milk powder	BA + MI
2	Barley + protein mixture	BA + PR
3	Maize + skim-milk powder	MA + MI
4	Maize + protein mixture	MA + PR
5	Sorghum + skim-milk powder	SO + MI
6	Sorghum + protein mixture	SO + PR

Protein mixture: 67% soyabean meal + 33% meat-bone meal.

3.2. Experimental animals

12 barrows from 3 different litters were used for each of the four series, C-D-E-F. In series C cross-bred litters of Danish Landrace boar × Black-and-White sow were used, while litters of pure Danish Landrace were applied in the other series.

All pigs were fed for the first fortnight with a compound of grain mixture, skim-milk powder and protein mixture, together with minerals and A + D vitamin. During that period the pigs were dewormed twice with piperazin-dihydrochloride, weighed at intervals of 4–5 days, numbered consecutively from 1–12 and allocated to the different types of feeding as shown in Table 4.

Table 4. Allocation of pigs in the different series and feed compounds
Tabel 4. Fordeling af svin i de forskellige forsøgsserier og foderblandinger

Year exp.	Series no.	Litter no.	BA+MI Pigs no.	BA+PR Pigs no.	MA+MI Pigs no.	MA+PR Pigs no.	SO+MI Pigs no.	SO+PR Pigs no.
1964	C	I-III	1-2-3	4-5-6	7-8-9	10-11-12		
1965	D	IV-VI	1-2-3	7-8-9			4-5-6	10-11-12
1965	E	VII-IX	1-2-3	7-8-9	4-5-6	10-11-12		
1966	F	X-XII	1-2-3	7-8-9			4-5-6	10-11-12

The pigs were numbered according to liveweight with numbers 1–6 as the heaviest group and numbers 7–12 as the lightest group. With a maximum capacity at the laboratory of 6 balance-periods per week, the group numbered 1–6 was always measured a week before the group numbered 7–12. With this sequence in time the liveweight for all 12 pigs should be as equal as possible for each period, thereby avoiding an otherwise necessary correction for differences in liveweight.

In all series the pigs were allocated in such a way that numbers 1-4-7-10, 2-5-8-11, and 3-6-9-12 were always litter mates. After numbering, the pigs were fed their experimental feed compounds, and the first period of collection usually started 2–3 weeks later.

Journal of animals

The experiments were completed with comparatively few disturbances, and from the main tables (p. 159) it will appear that out of the 384 planned balance periods only 3 periods were not carried out, two for technical reasons, and one for reasons relating to the condition of the animal, the causes of which will be described later. In each series some of the animals had a day or two with a tendency to slight diarrhoea; the details will be given below. By excluding from feeding but allowing access to water for one day the diarrhoea was stopped. Otherwise no diseases appeared among the animals, and apart from the treatment with piperazindihydrochloride before the trials started, no animals received any kind of medicine.

Series C: After the conclusion of period V, the liveweight being about 50 kg, most of the animals suddenly lost their appetite, but after exclusion from feeding for one day, the appetite was fully restored. Pig. no. 3 (BA + MI) is excluded from the calculations in period VII, as for technical reasons no respiration measurements were carried out.

Series D: In periods III and IV, pig no. 4 (SO + MI) when placed in the metabolic crate in the afternoon, ate somewhat more slowly, but as there was no feed-residue next morning at the start of the collection period, the measurements were carried out as usual. Pig no. 6 (SO + MI) was excluded from period VIII as the faeces were abnormally dry and lumpy in the preliminary period, and when the animal was placed in the metabolic crate there were feed-residue for the first two days. Pig no. 9 (BA + PR) had a brief attack of vomiting on the first day of period III, and this day was excluded from the collection period.

Series E: After conclusion of period III the litter mates Nos. 2-5-8-11 had difficulties in eating their rations, the faeces had a looser consistency and some cases of diarrhoea occured. As the mean liveweight of this group was 7 kg lower than the mean liveweight of the other pigs, it was decided to keep nos. 2-5-8-11 on a lower ration for an intermediate period of 14 days without measurements before starting period IV. After this interval no disturbances occured in the following experimental periods. Pig no. 2 (BA + MI) is excluded from the calculation in period IV as for technical reasons no respiration measurements were carried out.

Series F: No. 3 (BA + MI) and no. 9 (BA + PR) had a small residue in the preliminary periods before collecting periods III and VIII, and no. 6 (SO + MI) had a brief attack of vomiting before period IV. By excluding one day of feeding the animals were fully restored, and no periods of measurements were excluded from series F.

3.3.Feeding plan

As mentioned above, six different feed compounds consisting of barley, maize or sorghum combined with skim-milk powder or protein mixture (67% soyabean meal + 33% meat-bone meal) were used for the trials. In accordance with the results obtained in series A, 1963, and discussed in chapter 2 (p. 20) it was decided to keep all animals on a daily increasing scale of feed. In each period the grain rations were increased by 10 g daily and the milk/protein rations by 5 g until the protein supply reached a level of 350 g, when it was kept constant; from that period the grain rations were increased by 20 g daily. The figures given in Table 5 and 6 are average values for feed intake in the collecting periods of 7 days.

In series C the rations of barley were about 14% lower than in the following series, because some uncertainty existed about how much the animals could eat

Table 5. Feeding plan. Series C and D
Tabel 5. Foderplan. Serie C og D

Period	Barley		Maize	Sorghum	Sk.milk or Prot. mix.	
no.	Ser. C g	Ser. D g	Ser. C g	Ser. D g	Ser. C g	Ser. D g
I	490	590	460	580	245	240
II	640	740	605	730	320	295
III	790	890	745	870	350	345
IV	985	1180	935	1160	350	350
V	1280	1480	1205	1450	350	350
VI	1580	1780	1490	1750	350	350
VII	1780	2080	1680	2040	350	350
VIII	2080	2380	1960	2330	350	350

without any feed residue. However, as we found that the pigs were able to eat somewhat more, the rations in series D-E-F were increased as indicated in the tables.

The rations of maize and sorghum in Series C and D (Table 5) were estimated according to the Scandinavian feed unit system to provide the animals with the same amount of energy as the group receiving barley. Thus, expressed in terms of grams, the rations of maize were reduced by about 6% while the reduction of sorghum was about 2% compared with barley in the respective series.

Table 6. Feeding plan. Series E and F
Tabel 6. Foderplan. Serie E og F

Period	Barley		Maize	Sorghum	Sk.milk or Prot. mix.	
no.	Ser. E g	Ser. F g	Ser. E g	Ser. F g	Ser. E g	Ser. F g
I	590	590	520	540	240	240
II	740	740	650	670	295	290
III	890	890	785	810	345	345
IV	1180	1180	1050	1080	350	350
V	1480	1480	1310	1340	350	350
VI	1780	1780	1580	1610	350	350
VII	2080	2080	1870	1880	350	350
VIII	2380	2380	2110	2160	350	350

In the following two series, E and F (Table 6), the energy content was calculated on the net energy basis according to the equation established by *Nehring, Hoffmann & Schiemann* (1963). On reducing the amount of maize by 11% and the sorghum by 9%, the net energy should be the same as in the barley ration.

From Tables 5 and 6 it will be found that the supply of skim-milk powder or protein mixture was identical in terms of grams during the experimental periods. With the higher protein content in protein mixture the intake of crude protein was higher for the pigs receiving this supply, but with a lower digestibility of the protein mixture the difference in digested protein was diminished.

In order to meet the requirements for A- and D-vitamin, each pig received daily 10 ml soyaoil with 2000 i.u.A. + 500 i.u.D_2.

The requirement for calcium and phosphorus was estimated as follows:

Liveweight, kg	20	30	40	50	60	70	80	90
Ca, g daily	8.5	10.5	12.5	14.0	15.0	16.0	17.0	18.0
P, g daily	6.0	7.5	9.0	10.0	10.5	11.0	11.5	12.0

In accordance with the content of Ca and P in the feedstuffs analyzed for each period, the rations were balanced by means of $CaCO_3$ and Na_2HPO_4. A daily supply of 6, 9 or 12 g NaCl was given in periods I–III, IV–VI and VII–VIII, respectively.

The daily water supply was increased from 2.6 litres in period I to 8.2 litres in period VIII, being thus approximately 3 times the intake of feed.

3.4. Techniques used for feeding and sampling of faeces and urine

Having regard to the desired rate of growth and the capacity of the laboratory, it was possible to conduct 8 periods of measurement for each animal at constant intervals during the experimental time from 20 to 90 kg of liveweight. Each period consisted of 14 days, divided into a preliminary period of 7 days without any measurements, followed by 7 days of collecting faeces and urine.

According to the feeding plan the different feedstuffs were weighed out individually in paper bags for each period of 14 days, and aliquot samples were taken for chemical analysis. At feeding time, which was always at 7 a.m. and 3 p.m., the feed was mixed with the vitamin oil and the prescribed amount of water.

In the preliminary periods the pigs were kept individually in pens with wood bedding and without straw. In the afternoon of the last preliminary day the pigs were weighed and carefully taken into their respective crates, where they were fed. As discussed earlier (p. 22) the crates in use now have a size of 140 × 70 cm, being about 1 m^2, which allows the animal to move around fairly freely. In experiments with males the collecting plate has a fall from all points to a small hole in the middle of the plate from where the urine is collected, thus giving the shortest distance of flow. Next morning after feeding and cleaning, the collecting period started at 8 a.m. The faeces and urine were collected at 4 hourly intervals in the daytime, stored in closed boxes in the cooling room (5–7°C) until next morning at 8 a.m. when the total amount of faeces and urine for each pig were weighed out for the 24 hours period.

In the first periods, 20% of the daily amount of urine was collected for analytical purposes, while in the later periods only 10% was taken for sampling. The samples were kept in the cooling room in plastic-bottles, with a teaspoonful of mercury iodide added in order to avoid bacterial growth. All faeces from the 7 days collecting period was stored in closed boxes in the cooling room and no preservative was added. After the collecting period was completed the animals were brought back to their pens at 8 p.m., and any small remains of faeces in the cages were carefully removed and added to the main part of faeces.

The total samples of faeces were mixed carefully after being passed twice through a mincer. A part of the sample, about 500 g, was spread in a thin layer in a galvanized box and dried at 60°C for 24 hours. After milling and airing for two days the samples were used for all chemical analyses except for the determination of nitrogen, which was carried out on fresh material. For the purpose of calculation the dry matter content was determined both in the fresh and in the dried material. The bottles containing urine were shaken vigorously before the samples for chemical analysis were taken.

The figures obtained for the average excretion of faeces and urine and for chemical composition of feed, faeces and urine were used for calculating the values for digestibility and for the nitrogen-balances. In combination with the figures for CO_2-production obtained from respiration measurements the carbon-and energy balances were calculated. The methods of calculation will be discussed at the end of this chapter.

3.5. Measurement of gas exchange

In order to measure the CO_2-production and O_2-consumption of the animals a respiration plant constructed and described by *Thorbek* (1969 a) was used. The respiration plant, consisting of two independent climatically controlled chambers is built according to the indirect calorimetric principle with open air ventilation.

The outgoing airflow was recorded by measuring the differential pressure over an orifice with a mercury meter body (*Honeywell*). By means of recipients, aliquot samples were taken from the outgoing air and the composition was determined according to physical principles. For oxygen a Magnos 2 (Paramagnetic principle) with a range from 19.0–21.0%, and for carbon dioxide an Uras 1 (Infra-red principle) with a range from 0–1.5% CO_2 was used. Both instruments were supplied by *Hartmann & Braun*, Frankfurt, and adjusted according to their instructions.

The temperature in the respiration chambers was maintained in accordance with the temperature in the stable, starting at 20°C in the first periods and gradually decreasing to 18°C in the last periods. The relative humidity in the chamber was kept at about 65%.

The respiration chambers are equipped with an automatic safety device and there was no supervision from 4 p.m. to 7 a.m. and no accidents occurred during the whole experimental time from 1964 to 1966.

After concluding a respiration experiment the Uras- and Magnos instruments were adjusted by means of test-gas and a very accurate scale-galvanometer before the samples of the outgoing air collected in the recipients were analyzed for their contents of carbon dioxide and oxygen.

Control experiments with carbon dioxide were carried out frequently as described by *Thorbek* (1969 a). The results obtained from 34 calibration experiments from 1964–66 with the two chambers are shown in Figure 7, indicating that the deviation between registered outgoing and ingoing CO_2 was independent of the volume of CO_2 introduced into the chambers. The deviation was found to be – 0.13 litres for chamber A and – 0.27 litres for chamber B, the standard errors of mean being 0.36 and 0.44, respectively. No significant

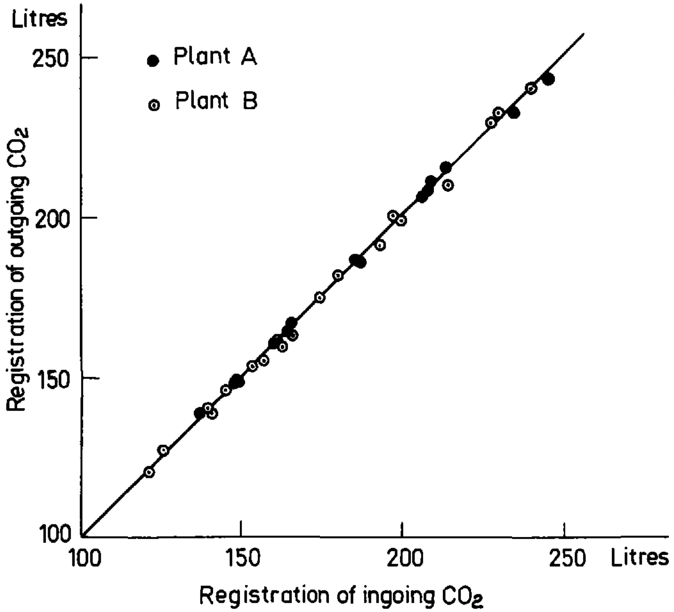

Figure 7.
CO_2-calibration of respiration plants A and B used in the experiments with pigs. Series C-D-E-F. 1964–1966.
CO_2-kalibrering af respirationsanlæg A og B anvendt til forsøg med svin i serie C-D-E-F. 1964–1966.

difference was found between the two chambers in the experimental period from 1964–66 (d.f. = 32, D = 0.14, t = 0.24 < $t_{.05}$ = 2.04).

When using the respiration plant in 1966–69, *Nielsen* (1970) found differences between results obtained from the two chambers and made corrections for these differences. A part of the deviation could possibly be explained by the circumstance, indicated by *Nielsen,* that the Honeywell instruments for measuring airflow were not adequately adjusted by that time.

Capacity and planning

As the maximum capacity is six 24 hours respiration experiments per week, and as it takes about 16 weeks for a pig to reach 90 kg of liveweight starting at 20 kg, 96 measurements could be conducted during that period. With 12 pigs in a series it would be possible to measure for each pig the gas exchange 8 times over a 24 hour-period, i.e. every fortnight in the growth period from 20 to 90 kg.

Whether a higher accuracy could be obtained by placing 2 respiration experiments in each collecting period is open to discussion. Such a procedure would reduce the numbers of animals to 6 in each series, thereby decreasing the information from the experiment. In an earlier investigation, concerning energy metabolism in growing pigs treated with aureomycin, *Ludvigsen & Thorbek* (1955) the pigs were kept on a constant ration for 16 days, with a collecting period of 7 days, and with a 24 hours respiration experiment placed on the second and the last day of the collecting periods. Using the results thus obtained, it has been found, that the CO_2-production was on average 11.1 litres higher on the last day of measurements, the standards errors of mean being 5.0, while the corresponding figures for O_2-consumption was 5.7 litres, with a standard error of 5.7. The difference was just significant for CO_2, but not for O_2. (CO_2: d.f. = 34, D = 11.1, t = 2.2 > $t_{.05}$ = 2.03; O_2: d.f. = 33, D = 5.7, t .= 1.1 < $t_{.05}$ = 2.03). Higher values for the first day of measurements could be expected if the animals were untrained, but this was not the case. The somewhat higher gas exchange in the second measurement can be explained by increased heat production in relation to the increased liveweight. In wiew of the results obtained in this earlier investigation, and to our preference for measuring 12 pigs in 8 balance-and respiration experiments for each series, it was decided when planning the trials from 1964–66 to place one 24-hour respiration experiment in the middle of each 7 days of collection.

To avoid exciting the pigs they were brought from the metabolic crates into the respiration chamber by means of a car on rubber wheels. In all experiments the pigs were transferred at 7 a.m. and fed in the chamber, the animals thus being eager to go into the chamber. Recording of CO_2- and O_2-concentration in the outgoing air started immediately, and it was accordingly possible from the curves to follow the state of the animals. No particular excitement was observed in the pigs during the whole experimental time.

The size of the respiration chamber being 3.1 m^3 and with a flow rate from 3-8 m^3 per hour in order to keep the CO_2-concentration in the outgoing air about 0.7%, it takes about one hour to obtain a steady state in the composition of the outgoing air. However, to be on the safe side, each measurement of the gas exchange started 2 hours after the animal was brought into the chamber by opening the recipients for aliquot sampling of the outgoing air and by reading the counter on the *Honeywell* flowmeter. At noon the faeces were collected, using the inside rubber gloves, and placed in the container fixed airtight to the floor, while the urine flowed unimpeded into a bottle during the experimental time. At 3 p.m. the animals were fed and faeces were collected in the container. At 7 a.m. next morning the animals received their feed and precisely at 9 a.m. the measuring ended by closing the recipients and taking the reading on the airflow counter. Then the animals were transported back to their metabolic crates for the last 3 days of collection. The respiration chambers were cleaned and the small amount of faeces remaining on the standing grate was collected and added to the total amount of faeces.

3.6. Chemical composition of feedstuffs

The total amount of the different feedstuffs required for each series was bought in one lot and ordered to be as uniform as possible. On delivery, the different types of grain were mixed individually and stored openly in the loft of the laboratory, while the skim-milk powder and protein mixture were stored in sacks. The skim-milk powder used was of Danish origin, dried according to the spray-method. The protein mixture, consisting of 67% soyabean meal + 33% meat-bone meal, was of the same origin as that delivered to the Danish Progeny Test Station in Roskilde.

In series E a small part of the skim-milk powder bought for this series was mistakenly used in an other experiment for which reason it was necessary to order from the same firm a supplementary supply of skim-milk powder for the last periods.

As mentioned earlier the different feedstuffs were weighed out individually in paper bags for each period of 14 days and aliquot samples were taken for chemical analysis 8 times in the respective series. The average values obtained for barley, maize and sorghum and the standard deviation calculated are given in Table 7.

When comparing the different lots of grains used from 1964 to 1966 it is remarkable that the lot of barley delivered for series E had a very low content of crude protein, being 7.6% against an average of 9.8% for the other series. With a corresponding higher value for nitrogen-free extracts the energy content was of the same magnitude in series E as in the 3 lots of barley used in series C, D and F, being 3.78 Mcal per kg against 3.82. For maize the differences in chemical

Table 7. Chemical composition of barley, maize and sorghum applied in the different series. Mean of 8 samples from each series

Tabel 7. Kemisk sammensætning af byg, majs og milo anvendt i de forskellige forsøgsserier. Middel af 8 prøver fra hver serie

Series no.	Dry matter %	Crude protein %	Crude fat %	N-free extract %	Crude fibre %	Ash %	Gross energy Mcal/kg
Barley. Series C-D-E-F.							
Series C	86.4	9.8	1.8	68.8	4.1	2.0	3.82
S.D.	0.4	0.3	0.1	0.4	0.3	0.2	0.03
Series D	85.0	10.1	1.9	67.1	3.9	2.0	3.82
S.D.	0.9	0.1	0.2	0.9	0.3	0.1	0.04
Series E	85.8	7.6	1.7	70.2	4.3	2.0	3.78
S.D.	0.5	0.1	0.1	0.6	0.2	0.1	0.04
Series F	85.9	9.6	1.9	67.8	4.5	2.2	3.82
S.D.	0.9	0.2	0.1	1.0	0.2	0.1	0.04
Maize. Series C-E.							
Series C	87.3	8.7	4.2	71.0	2.1	1.3	3.95
S.D.	0.2	0.1	0.1	0.1	0.1	0.1	0.02
Series E	87.6	9.3	4.4	70.7	1.9	1.5	4.00
S.D.	0.4	0.1	0.2	0.4	0.1	0.1	0.02
Sorghum. Series D-F.							
Series D	87.4	11.1	3.2	69.6	2.0	1.6	3.97
S.D.	0.8	0.2	0.2	0.9	0.2	0.1	0.04
Series F	87.6	9.4	3.0	71.4	2.3	1.5	3.92
S.D.	0.4	0.1	0.1	0.6	0.2	0.1	0.02

composition for the two lots used in series C and E were rather small, while greater differences occured in the two lots of sorghum applied in series D and F.

The chemical composition of skim-milk powder and protein mixture used in all four series is shown in Table 8. The average crude protein content in skim-milk powder varied from 36.8 to 38.5%, while the gross energy varied from 4.18 to 4.21 Mcal per kg. The protein mixtures were of a fairly constant composition during the two years of experiment, even if there was a slight tendency to an increased content of fat causing an increase in the gross energy from 3.98 to 4.10 Mcal per kg. At the same time the protein content decreased slightly from 48.7 to 47.1% crude protein.

The standard deviations indicate that the uniformity of the feedstuffs in question for each series and the sampling for chemical analysis were satisfactory. The somewhat higher S.D. for the skim-milk powder used in series E can be explained by the fact that it was necessary to use two lots in this series, as explained above.

Table 8. Chemical composition of skim-milk powder and protein mixture applied in the different series. Mean of 8 samples from each series

Tabel 8. Kemisk sammensætning af skummetmælkspulver og proteinblanding anvendt i de forskellige forsøgsserier. Middel af 8 prøver fra hver serie

Series no.	Dry matter %	Crude protein %	Crude fat %	N-free extract %	Crude fibre %	Ash %	Gross energy Mcal/kg
Skim-milk powder. Series C-D-E-F.							
(Danish origin. Spray dried)							
Series C	96.3	36.8	0.4	51.2	–	8.0	4.18
S.D.	0.3	0.4	0.1	0.3	–	0.1	0.02
Series D	96.1	37.0	0.2	51.0	–	7.9	4.20
S.D.	0.2	0.3	0.1	0.5	–	0.1	0.01
Series E	95.7	37.7	0.2	49.9	–	7.9	4.19
S.D.	0.3	1.2	0.1	1.2	–	0.1	0.04
Series F	95.8	38.5	0.1	49.2	–	8.1	4.21
S.D.	0.2	0.4	0.1	0.3	–	0.1	0.01
Protein mixture. Series C-D-E-F.							
(67% soyabean meal + 33% meat-bone meal)							
Series C	90.2	48.7	1.9	20.6	5.4	13.6	3.98
S.D.	0.2	0.6	0.1	0.9	0.7	0.3	0.03
Series D	90.9	47.2	2.4	21.3	5.0	15.1	3.99
S.D	1.4	0.9	0.1	0.8	0.3	0.5	0.05
Series E	91.2	47.7	3.7	20.4	4.6	14.9	4.05
S.D.	0.3	0.5	0.1	0.4	0.3	0.2	0.02
Series F	90.4	47.1	4.6	19.8	5.0	14.0	4.10
S.D.	0.8	0.7	0.2	0.7	0.3	0.3	0.03

3.7. Analytical methods and evaluation of their accuracy

Chemical analyses in feed, faeces and urine

In the previous section 3.4 (p. 27) the sampling and preparation of feed, faeces and urine have been described. In a part of the original feed sample the content of dry matter was determined, while the rest of the sample was milled and used for the determination of the percentage of dry matter, nitrogen, crude fat (ether extract), crude fibre and ash together with carbon and energy. By means of the values for dry matter content in the original and in the milled sample, the chemical composition determined in the milled sample was, recalculated in order to express the content in the original sample.

Immediately after concluding a balance period the content of dry matter and nitrogen in the collected sample of fresh faeces were determined. Then a part was dried, milled and aired as described, and this sample was used for chemical determinations and calculations according to the methods described above for feedstuffs.

The sample of urine was filtered and then the nitrogen content was determined. The carbon content was determined in freeze-dried samples of urine, while for determination of energy content the urine was dried on cellulose blocks over sulphuric acid in a vacuum desiccator. All chemical analyses, except for the carbon determination, were carried out as described by *Weidner & Jakobsen* (1962).

The carbon content was determined by means of a *Wösthoff* instrument measuring the difference of potential gradient caused by the decrease of electric conductivety in a measuring cell containing NaOH-solution, after absorption of CO_2 from a complete combustion of the sample in question. The instrument and the procedure as well as a comparison with the gravimetric method were described by *Neergaard, Petersen & Thorbek* (1969).

Gas analyses

For determining the concentration of carbon dioxide and oxygen in the aliquot samples of outgoing air an Uras 1 and a Magnos 2 together with a scale galvanometer were used as previously described. Details of the function and calibration of the instruments are given by *Thorbek* (1969 a).

Evaluation of accuracy in determination of nitrogen, carbon, energy and gas analyses

It is a common practice to conduct a special series of analyses in order to determine the accuracy of a method. Such a procedure may result in errors that are much less than they would be in the daily routine. This fact was pointed out by *Rasch, Ludvigsen & Thorbek* (1958) at the First Symposium on Energy Metabolism, and it was demonstrated that it is possible by means of a fairly simple cumulative statistical device to use the daily routine work with duplicate analyses to estimate the standard deviation of the method. This method of calculation has been used to evaluate the accuracy in the determination of nitrogen, carbon and energy and the composition of the outgoing air being the principal analyses, when measuring energy metabolism.

The accuracies obtained in the nitrogen determination in feed, faeces and urine in the four experimental series are shown in Table 9. For reasons of comparison the average nitrogen content in the different feedstuffs, samples of faeces and urine is stated together with the S.D., the relative standard deviation being below 1%. As the nitrogen excreted in faeces constituted 12–22% of the intake of nitrogen, while the nitrogen in urine varied from 35–50% of the nitrogen intake, the accuracy obtained for the determinations of nitrogen in the different samples of feed, faeces and urine are considered to be satisfactory.

The accuracies obtained in the determinations of carbon and energy are shown in Table 10 and 11. The accuracy obtained in the determination of carbon and energy in feed and faeces was even higher than that obtained in case

Table 9. Accuracy in determination of nitrogen in feed, faeces and urine. Series C-D-E-F
Tabel 9. Analytisk nøjagtighed ved bestemmelse af kvælstof i foder, gødning og urin. Serie C-D-E-F

Materials	Series no.	d.f.	Mean %	S.D.	C.V. %
Barley	C-D-E-F	33	1.50	0.011	0.73
Maize	C-E	17	1.43	0.009	0.63
Sorghum	D-F	16	1.64	0.010	0.61
Sk.milk powder	C-D-E-F	32	6.00	0.035	0.58
Protein mixture	C-D-E-F	33	7.63	0.035	0.46
Faeces, fresh	C	108	1.27	0.012	0.94
» »	D	92	1.50	0.012	0.80
» »	E	91	1.30	0.011	0.85
» »	F	88	1.53	0.014	0.92
Urine	C	108	0.491	0.0034	0.69
»	D	95	0.538	0.0048	0.89
»	E	94	0.450	0.0040	0.89
»	F	96	0.498	0.0039	0.78

of nitrogen. The relative standard deviation being fairly constant around 0.30%. The accuracy in determining carbon and energy in urine was lower than in the case of feed and faeces, the relative standard deviation being about ten times as high, partly caused by inaccuracy in the technical process of drying the

Table 10. Accuracy in determination of carbon in feed, faeces and urine. Series C-D-E-F
Tabel 10. Analytisk nøjagtighed ved bestemmelse af kulstof i foder, gødning og urin. Serie C-D-E-F

Materials	Series no.	d.f.	Mean %	S.D.	C.V. %
Barley	C-D-E-F	32	39.84	0.116	0.29
Maize	C-E	17	40.78	0.110	0.27
Sorghum	D-F	13	40.64	0.141	0.35
Sk.milk powder	C-D-E-F	29	41.47	0.101	0.24
Protein mixture	C-D-E-F	28	39.11	0.146	0.38
Faeces, dried	C	105	39.99	0.146	0.37
» »	D	95	40.02	0.149	0.37
» »	E	91	41.82	0.141	0.34
» »	F	96	42.07	0.118	0.28
Urine	C	97	0.381	0.0125	3.28
»	D	82	0.458	0.0099	2.16
»	E	86	0.390	0.0088	2.26
»	F	93	0.437	0.0097	2.22

Table 11. Accuracy in determination of energy in feed, faeces and urine. Series C-D-E-F
Tabel 11. Analytisk nøjagtighed ved bestemmelse af energi i foder, gødning og urin. Serie C-D-E-F

Materials	Series no.	d.f.	Mean kcal/kg	S.D.	C.V. %
Barley	C-D-E-F	31	3857	10.6	0.27
Maize	C-E	15	3974	10.1	0.25
Sorghum	D-F	16	3949	8.9	0.23
Sk.milk powder	C-D-E-F	33	4193	10.0	0.24
Protein mixture	C-D-E-F	33	4032	12.6	0.31
Faeces, dried	C	105	4119	10.2	0.25
» »	D	92	4124	11.1	0.27
» »	E	92	4352	11.0	0.25
» »	F	91	4411	14.9	0.34
Urine	C	101	45.6	1.06	2.32
»	D	87	48.5	1.02	2.10
»	E	88	46.3	1.33	2.87
»	F	88	48.3	1.38	2.86

urine before the determination. However, with the very low content of carbon and energy in urine influencing the carbon-and energy balances by only 2–3%, the validity of the balances is not influenced by the lower accuracy obtained in the determination of carbon and energy in the urine.

For the gas analyses two independent working recipients are used for collecting aliquot samples of the outgoing air. The evaluation of accuracy in the determinations of CO_2 and O_2 are made by comparing the results obtained from the two recipients and the figures are shown in Table 12.

The Uras instrument is designed to measure from zero to 1.5% CO_2, while the Magnos instrument measures in the range from 19.0 to 21.0%, or at a maximum difference of 2.0% O_2. The results obtained indicate that the stan-

Table 12. Accuracy in determination of CO_2 and O_2-concentration in outgoing air by means of URAS and MAGNOS instruments. Series C-D-E-F
Tabel 12. Analytisk nøjagtighed ved bestemmelse af CO_2 og O_2-koncentration i udgående luft ved hjælp af URAS og MAGNOS instrumenter. Serie C-D-E-F

	Determination of CO_2 (URAS)			Determination of O_2 (MAGNOS)		
Series no.	d.f.	Mean %	S.D.	d.f.	Mean %	S.D.
C	107	0.696	0.0052	107	20.313	0.0033
D	96	0.794	0.0040	96	20.232	0.0031
E	96	0.755	0.0030	96	20.264	0.0026
F	96	0.715	0.0028	96	20.259	0.0019

dard deviation was of the same magnitude for both instruments, the values for CO_2-determination ranging from 0.003 to 0.005% (abs.) and for O_2-determination from 0.002 to 0.003%. (abs.). As the carbon loss in CO_2 is about 50% of the carbon intake, the accuracy obtained in the determination of CO_2 in the outgoing air is considered to be high and in correspondance with the accuracy obtained in the determination of carbon in feed.

3.8. Methods of calculation

At the First Symposium of Energy Metabolism (Copenhagen, 1958) a small committee was appointed to consider and to recommend constants and factors to be used in calculation of the energy metabolism in animals. A provisory set of constants and factors was discussed at the Second Symposium and the final set was presented and accepted at the Third Symposium. (*Brouwer,* 1965).

In accordance with this set of constants and factors the protein and fat gain as well as the heat production according to the RQ-method have been calculated in the following way:

Protein gain

g N intake – (g N in faeces + g N in urine) = g N retained
g N retained × 6.25 = g protein retained
g protein retained × 5.7 = kcal in protein gain

Fat gain

Litre CO_2-production × 0.5360 = g C in CO_2-production
g N retained × 3.25 = g C retained in protein
g C intake – (g C in faeces + g C in urine + g C in CO_2-production)
= g total C retained

g total C retained – g C retained in protein = g C retained in fat
g C retained in fat × 1.304 = g fat retained
g fat retained × 9.5 = kcal in fat gain

Heat production (RQ-method)*)

(1.200 × litre CO_2-production) + (3.866 × litre O_2-consumption)
– (1.431 × g N in urine) = Heat production, HP (RQ), kcal

*) In these trials no measurements of CH_4 were made.

CHAPTER 4.

Intake of energy and protein, live weight gain and feed conversion

In all trials the pigs were weighed in the afternoon before and after each 7 days period of collection. From these data mean values, indicating the live weight for each individual in the middle of the collection period, have been calculated and tabulated in the main tables, (p. 159). As all the 24 hour respiration experiments are placed on the 4th day af each balance period, the live weight indicated corresponds to the weight on the day when the gas exchange was measured.

The intake of feed compounds for each period and ration consisting of grain with skim-milk powder or protein mixture are shown in Tables 5 and 6. The contents of digestible and metabolizable energy, as well as the digestible nitrogen in the rations were determined for each pig in each period, and the individual figures are collected in the main tables, (p. 159). These figures being accessible some problems connected with intake of energy and protein, live weight gain and feed conversion should be discussed.

4.1. Age and live weight of experimental animals

The mean values of age and live weight in the experiments with barley and skim-milk powder or protein mixture, including in all 24 pigs in 8 balance periods, are indicated in Table 13 and shown graphically in Figure 8. The

Table 13. Age and live weight of animals in the experiments with barley. Series C-D-E-F. Mean of 12 pigs in each group

Tabel 13. Dyrenes alder og legemsvægt i forsøgene med byg. Serie C-D-E-F. Middel af 12 svin i hver gruppe

Period	Barley and skim-milk powder			Barley and protein mixture		
	Age	Live weight		Age	Live weight	
no.	days	kg	S.D.	days	kg	S.D.
I	85	23.7	2.7	91	23.4	2.1
II	99	29.3	2.6	105	28.7	2.2
III	113	35.7	2.8	119	34.7	2.2
IV	128	43.3	3.2	134	42.8	2.3
V	142	52.3	3.2	148	50.9	2.7
VI	156	61.4	3.8	162	59.6	3.8
VII	170	72.6	4.1	176	69.6	4.1
VIII	184	83.1	4.5	190	80.2	5.1

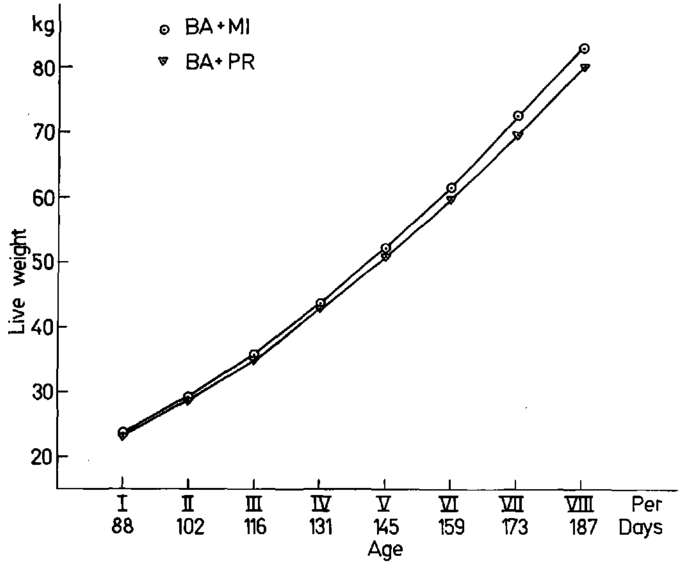

Figure 8.
Mean values of live weight in relation to mean values of age in period I to VIII. Exp. with barley (BA) and skim-milk powder (MI) or protein mixture (PR). Series C-D-E-F. 1964–1966.
Middelværdier for legemsvægt i relation til middelværdier for alder i periode I til VIII. Forsøg med byg (BA) og skummetmælkspulver (MI) eller proteinblanding (PR). Serie C-D-E-F. 1964–1966.

corresponding values for age and live weight in the experiments with maize and skim-milk powder or protein mixture, including in all 12 pigs, will be found in Table 14 and Figure 9. The mean values for age and live weight in the experiments with 12 pigs recieving sorghum and skim-milk powder or protein mixture are shown in Table 15 and Figure 10.

In the first period the mean age of the pigs in the barley group was 85 and 91 days, with an average live weight of 23.7 and 23.4 kg, respectively. In the maize group the pigs were 87 and 91 days in the first period and their live weights were 21.7 and 22.0 kg, respectively, while the corresponding values for the sorghum group were 92 and 99 days with a live weight of 24.0 and 23.9. No significant difference in live weight was found between the different groups when the trials started.

The total experimental time was 112 days, divided into 8 balance periods with a 7 days preliminary and a 7 days collection period. The growth curves during the experimental time indicate that the group receiving barley and protein mixture had a somewhat slower growth than the group on barley and skim-milk powder. The daily live weight gain from period I to VIII for the (BA+MI)-group

Table 14. Age and live weight of animals in the experiments with maize. Series C-E. Mean of 6 pigs in each group

Tabel 14. Dyrenes alder og legemsvægt i forsøgene med majs. Serie C-E. Middel af 6 svin i hver gruppe

Period	Maize and skim-milk powder			Maize and protein mixture		
	Age	Live weight		Age	Live weight	
no.	days	kg	S.D.	days	kg	S.D.
I	87	21.7	3.1	91	22.0	3.1
II	101	27.3	2.9	105	27.2	3.0
III	115	33.5	3.4	119	33.1	3.8
IV	131	41.9	4.4	136	41.3	3.2
V	145	49.7	5.3	150	49.0	3.4
VI	159	57.8	6.2	164	57.4	3.9
VII	173	67.6	6.6	178	66.7	4.0
VIII	187	77.4	6.4	192	77.2	4.1

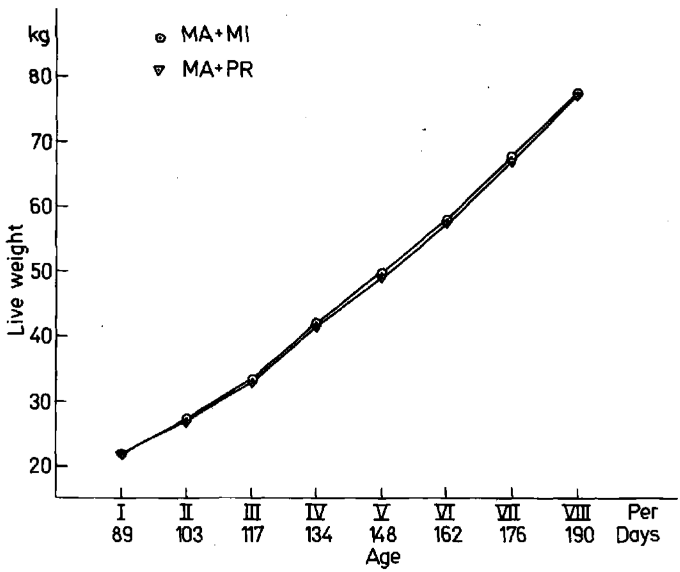

Figure 9.

Mean values of live weight in relation to mean values of age in period I to VIII. Exp. with maize (MA) and skim-milk powder (MI) or protein mixture (PR). Series C-E. 1964–1965.

Middelværdier for legemsvægt i relation til middelværdier for alder i periode I til VIII. Forsøg med majs (MA) og skummetmælkspulver (MI) eller proteinblanding (PR). Serie C-E. 1964–1965.

Table 15. Age and live weight of animals in the experiments with sorghum. Series D-F. Mean of 6 pigs in each group

Tabel 15. Dyrenes alder og legemsvægt i forsøgene med milo. Serie D-F. Middel af 6 svin i hver gruppe

Period	Sorghum and skim-milk powder			Sorghum and protein mixture		
	Age	Live weight		Age	Live weight	
no.	days	kg	S.D.	days	kg	S.D.
I	92	24.0	1.5	99	23.9	1.9
II	106	29.0	1.6	113	29.1	1.8
III	120	35.3	2.2	127	35.4	1.7
IV	134	43.0	3.5	141	42.7	2.2
V	148	50.6	4.2	155	51.2	2.7
VI	162	60.1	4.9	169	60.1	3.3
VII	176	70.6	6.2	183	70.8	4.0
VIII	190	80.4	6.9	197	81.2	5.0

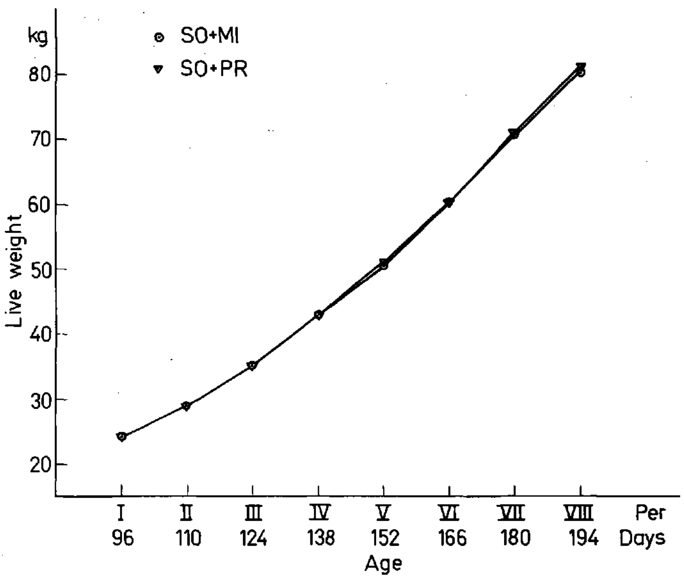

Figure 10.

Mean values of live weight in relation to mean values of age in period I to VIII. Exp. with sorghum (SO) and skim-milk powder (MI) or protein mixture (PR). Series D-F. 1965–1966.

Middelværdier for legemsvægt i relation til middelværdier for alder i periode I til VIII. Forsøg med milo (SO) og skummetmælkspulver (MI) eller proteinblanding (PR). Serie D-F. 1965–1966.

was on average 606 g, and for the (BA+PR)-group 580 g. For the (MA+MI) and the (MA+PR)-group, the weight gain was 568 and 563 g daily, while the average daily live weight gain for the pigs in the (SO+MI) or (SO+PR)-groups was 576 g and 585 g.

After 112 days of investigation the mean live weight for the barley groups was 83.1 and 80.2 and for the sorghum groups 80.4 and 81.2 kg, while the mean live weight for the maize groups was 77.4 and 77.2 kg. The difference in live weight between the (BA+MI) and the (MA+MI) being 5.7 kg was just significant ($t = 2.20 > t_{.05} = 2.12$), while the difference of 3.0 kg between the (BA+PR) and (MA+PR) group was not significant.

4.2. Intake of energy

From the feeding plans (Tables 5 and 6) the average daily intake of feed for each ration and each period is calculated and indicated in Tables 16, 17 and 18 together with the mean values for live weight in the different periods. The intake of metabolizable energy has been determined for each pig in each balance period, and from these individual values (Main tables p. 159) the mean values are calculated and shown in the same tables.

Table 16. Daily intake of feed and energy in the experiments with barley. Series C-D-E-F. Mean of 12 pigs in each group

Tabel 16. Daglig optagelse af foder og energi i forsøgene med byg. Serie C-D-E-F. Middel af 12 svin i hver gruppe

Period	Barley and skim-milk powder				Barley and protein mixture			
	Live weight	Daily intake of			Live weight	Daily intake of		
no.	kg	Feed kg	ME Mcal	NEF*) Mcal	kg	Feed kg	ME Mcal	NEF*) Mcal
I	23.7	0.81	2.66	1.84	23.4	0.81	2.49	1.69
II	29.3	1.02	3.38	2.32	28.7	1.02	3.15	2.13
III	35.7	1.21	4.02	2.76	34.7	1.21	3.75	2.54
IV	43.3	1.48	4.88	3.32	42.8	1.48	4.60	3.11
V	52.3	1.78	5.87	3.95	50.9	1.78	5.64	3.74
VI	61.4	2.08	6.80	4.58	59.6	2.08	6.51	4.37
VII	72.6	2.36	7.74	5.16	69.6	2.36	7.42	4.95
VIII	83.1	2.66	8.66	5.79	80.2	2.66	8.35	5.58

*) Calculated from *Nehring et al.* Futtermitteltabellenwerk. (1970)

The intake of net energy expressed in terms of NEF (Nettoenergie-Fett, Schwein) has been calculated according to the Rostock-System, (*Nehring, Beyer & Hoffmann* (1970), Futtermittel-Tabellenwerk). From these tables (p. 318-332) the following values for NEF kcal per kg dry matter have been taken:

Barley	2448
Maize	2757
Sorghum	2585
Skim-milk powder	2829
Soyabean meal	2397
Meatbone meal	2140
Protein mixture, calculated	2311

Table 17. Daily intake of feed and energy in the experiments with maize. Series C-F. Mean of 6 pigs in each group

Tabel 17. Daglig optagelse af foder og energi i forsøgene med majs. Serie C-F. Middel af 6 svin i hver gruppe

Period	Maize and skim-milk powder				Maize and protein mixture			
	Live weight	Daily intake of			Live weight	Daily intake of		
no.	kg	Feed kg	ME Mcal	NEF*) Mcal	kg	Feed kg	ME Mcal	NEF*) Mcal
I	21.7	0.74	2.63	1.85	22.0	0.74	2.44	1.69
II	27.3	0.94	3.34	2.35	27.2	0.94	3.10	2.16
III	33.5	1.11	4.00	2.78	33.1	1.11	3.73	2.56
IV	41.9	1.35	4.83	3.35	41.	1.35	4.51	3.14
V	49.7	1.61	5.79	3.99	49.0	1.61	5.40	3.78
VI	57.8	1.89	6.79	4.65	57.4	1.89	6.50	4.44
VII	67.6	2.13	7.63	5.23	66.7	2.13	7.27	5.02
VIII	77.4	2.39	8.49	5.85	77.2	2.39	8.23	5.64

*) Calculated from *Nehring et al.* Futtermitteltabellenwerk. (1970)

Table 18. Daily intake of feed and energy in the experiments with sorghum. Series D-F. Mean of 6 pigs in each group

Tabel 18. Daglig optagelse af foder og energi i forsøgene med milo. Serie D-F. Middel af 6 svin i hver gruppe

Period	Sorghum and skim-milk powder				Sorghum and protein mixture			
	Live weight	Daily intake of			Live weight	Daily intake of		
no.	kg	Feed kg	ME Mcal	NEF*) Mcal	kg	Feed kg	ME Mcal	NEF*) Mcal
I	24.0	0.80	2.81	1.92	23.9	0.80	2.60	1.77
II	29.0	1.00	3.54	2.38	29.1	1.00	3.29	2.20
III	35.3	1.19	4.21	2.84	35.4	1.19	3.92	2.62
IV	43.0	1.47	5.16	3.48	42.7	1.47	4.95	3.27
V	50.6	1.75	6.14	4.10	51.2	1.75	5.86	3.89
VI	60.1	2.03	7.15	4.75	60.1	2.03	6.83	4.54
VII	70.6	2.31	8.09	5.38	70.8	2.31	7.80	5.17
VIII	80.4	2.60	9.05	6.02	81.2	2.60	8.86	5.81

*) Calculated from *Nehring et al.* Futtermitteltabellenwerk. (1970)

The average daily intake of feed in relation to liveweight is demonstrated graphically in Figure 11. Calculated according to the Scandinavian Feed Unit System, the pigs in Series C-D-E-F with a mean live weight of 23 kg in period I received on average 0.90 Sc.f.u., ending with 2.85 Sc.f.u. at a live weight of about 80 kg.

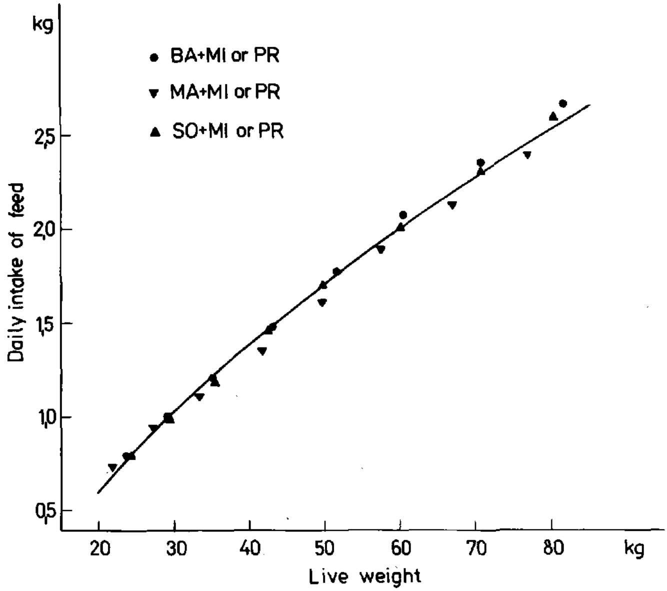

Figure 11.
Daily intake of feed in relation to live weight.
Daglig optagelse af forsøgsfoder i relation til legemsvægt.

In the studies of *Oslage, Fliegel, Farries & Richter* (1966) concerning protein-and fat gain in growing pigs it was stated, that the animals were fed to a maximum level which would ensure no feed residue. In the live weight group from 20–30 kg the pigs were able to eat 1.1 kg of a diet consisting of 70% barley and 30% protein mixture, being about 30% above the norm used in our investigation. At 80–90 kg the norm was of the same magnitude 2.70 kg in both investigations.

In the present investigation, the mean values for daily intake of metabolizable energy for the six rations in question (Tables 16, 17, 18) are plotted against the corresponding live weight, and the mean curve is demonstrated in Figure 12. For comparison, curves indicating the intake of metabolizable energy used by other authers in their trials concerning energy metabolism in growing pigs, are shown.

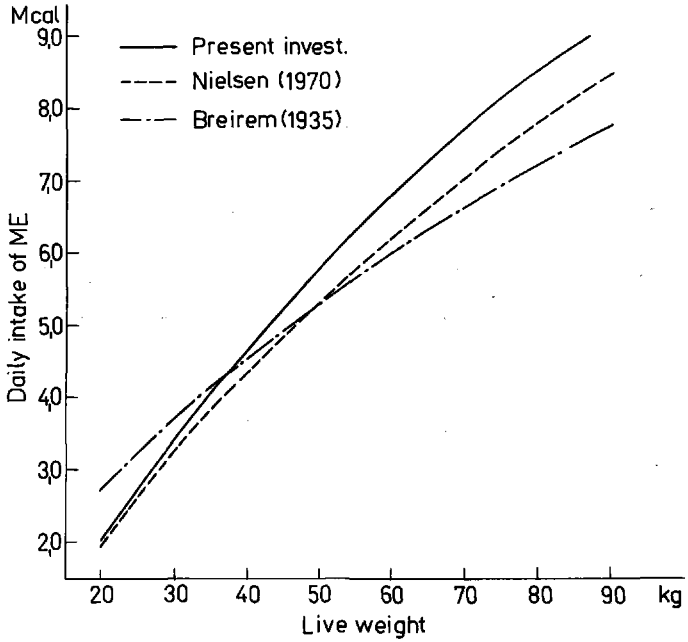

Figure 12.
Daily intake of metabolizable energy (ME) in relation to live weight.
Daglig optagelse af omsættelig energi (ME) i relation til legemsvægt.

The curve from the trials of *Nielsen* (1970), including 56 pigs receiving no screenings from U.S.5 barley in their rations, indicates at 20 kg live weight the same norm of about 2.0 Mcal ME as in our investigation. The feed curve used by *Nielsen* increases less rapidly than the curve used by us, thereby the pigs at 85 kg live weight in the experiments of *Nielsen* received 8.2 Mcal ME, being 0.7 Mcal ME less than in our experiments.

From the trial of *Breirem* (1935), 5 pigs on low protein diet and 3 pigs on high protein diet were used for the calculation of intake of metabolizable energy at different live weights. At 20 kg the intake was 2.7 Mcal ME being about 0.7 Mcal above our norm, while at 85 kg the norm used by *Breirem,* increasing rather slowly, was only 7.5 Mcal ME or 1.4 Mcal below the norm used in our experiments.

The norm used by *Verstegen* (1971) in his experiments with 8 »single pigs in pair«, started with 2.3 Mcal ME at 20 kg and from 30 kg of live weight it was closely related to that of *Breirem* (1935). While all the curves discussed are of the same types, the curve from the trial of *Oslage* et al. (1966) is quite otherwise, being more S-shaped. No explanation can be found, but perhaps it is related to the fact that the respiration trial started with 4 pigs, but one pig became ill and died during the experimental time.

The use of digestible energy (DE) instead of metabolizable energy (ME) to express the energy values of rations for pigs is frequently discussed. In *A.R.C.* (1967) it is stated »that pigs are usually given well balanced diets in which urinary losses are reasonably constant, then variations in the ratio ME:DE should be small, and hence it could be equally satisfactory to use the more easily determined DE values«.

In the present investigation, where we have tried to keep the intake of protein close to the requirement, a problem which will be discussed in the next section, the energy loss in urine has been constant and rather low. The constancy of the ratio ME:DE during the experimental time, independent of the 6 ration in question, is demonstrated in Figure 13.

A regression of ME on DE is calculated from the individual figures in the main tables and the results are shown in Table 19. For all rations in question the metabolizable energy was found to be 97.2% of the digestible energy, or an

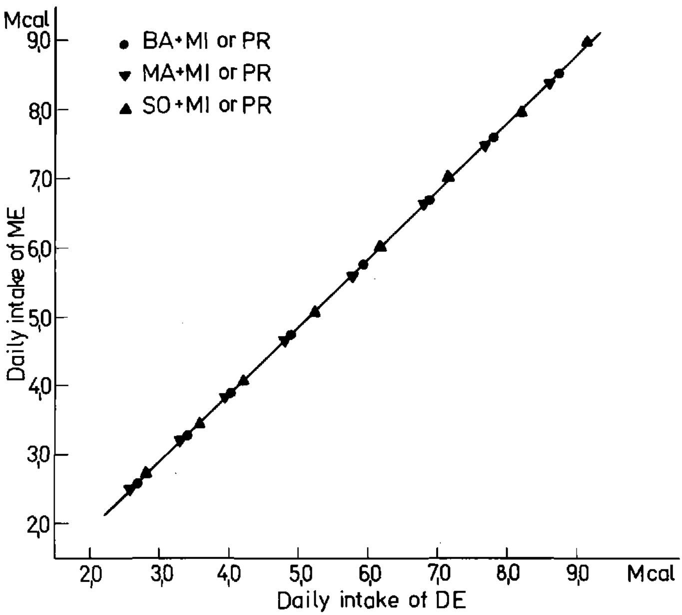

Figure 13.

Metabolizable energy (ME) in relation to digestible energy (DE). Mean of 6 different rations measured in 8 balance periods.

Omsættelig energi (ME) i relation til fordøjelig energi (DE). Middelværdier for 6 fodertyper målt i 8 balance-perioder.

Table 19. Regression of metabolizable energy on digestible energy. Series C-D-E-F
Tabel 19. Regression af omsættelig energi på fordøjelig energi. Serie C-D-E-F

				n	Regression-coefficients	s_b
Barley	+	Skim-milk powder,	BA + MI	94	0.974	0.00037
»	+	Protein mixture,	BA + PR	96	0.970	0.00044
Maize	+	Skim-milk powder,	MA + MI	48	0.973	0.00057
»	+	Protein mixture,	MA + PR	48	0.968	0.00057
Sorghum	+	Skim-milk powder,	SO + MI	47	0.975	0.00074
»	+	Protein mixture,	SO + PR	48	0.972	0.00068
Total				381	0.972	0.00024

urinary loss of energy of 2.8% which is considered to be low. The slightly higher energy loss i urine, found by feeding compounds containing protein mixture as compared with milk compounds, could be explained by the somewhat higher intake of protein. (cf. section 4.3.).

In the experiments with low and high protein level *Breirem* (1935) found an energy loss in urine from 2.2% to 4.0% of the gross energy, the same values as found by *Verstegen* (1971). In the trials of *Nielsen* (1970) with 6 different types of grain combined with different amounts of protein mixture the loss of energy in the urine varied from 2.6–4.1% in the first balance period and from 3.6–4.6% in the last period. In the experiments with adult pigs fed different rations performed at the *Oskar Kellner Institute*, the energy loss in urine was found to be on average 4.9% of the DE, with a range of variations from 3.5–6.4%, *Schiemann, Nehring, Hoffmann, Jentsch & Chudy* (1971). In their difference experiments with concentrates, the energy loss in urine was on average 8.3% of DE, ranging from 2.6–15.9% caused by the rather high intake of protein from the concentrates.

The intake of net energy (NEF) has been calculated as described earlier and the figures are shown in Tables 16, 17, 18. The relation between the calculated intake of net energy and the determined intake of metabolizable energy in the different rations used in the present investigation is shown graphically in Figure 14. The graph indicates that in the present investigation there was a close proportionality between the calculated net energy and the metabolizable energy determined for the 6 different rations consisting of barley, maize or sorghum in combination with skim-milk powder or protein mixture, irrespective of the increasing amount of grain in the feed compounds during the experimental time.

From the individual figures a regression of NEF on ME is calculated and the results are shown in Table 20. For all rations in question the ratio of NEF to ME

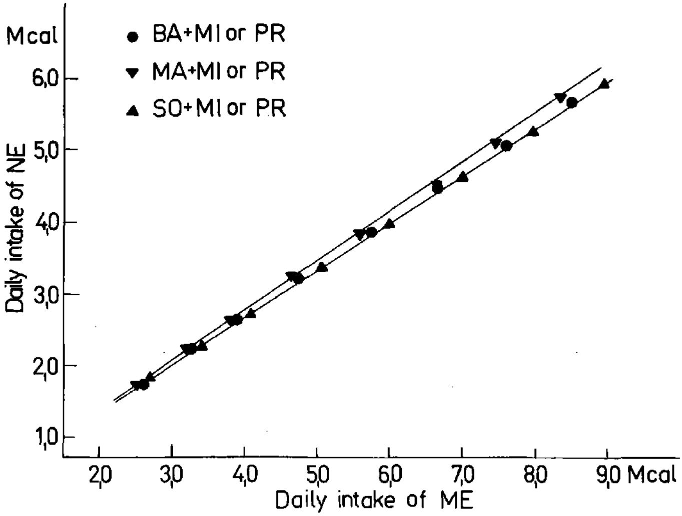

Figure 14.
Net energy (NE, calculated) in relation to metabolizable energy (ME, determined). Mean of 6 different rations measured in 8 balance periods.
Netto energi (NE, beregnet) i relation til omsættelig energi (ME, bestemt). Middelværdier for 6 fodertyper målt i 8 balance-perioder.

was 67.3% differing from 66.0% for the compound of sorghum + protein mixture to 68.8% for the maize + skim-milk or protein mixture compounds.

The commonly used feed compounds for growing-fattening pigs consist mostly of 70–80% grain products, with 15–25% protein supply of different origin. In well balanced diets for pigs it can be expected that for practical feeding the feed value can be expressed with the same validity in terms

Table 20. Regression of net energy (calculated) on metabolizable energy (determined). Series C-D-E-F

Tabel 20. Regression af netto energi (beregnet) på omsættelig energi (målt). Serie C-D-E-F

				n	Regression-coefficients	s_b
Barley	+	Skim-milk powder,	BA + MI	94	0.672	0.0031
»	+	Protein mixture,	BA + PR	96	0.668	0.0031
Maize	+	Skim-milk powder,	MA + MI	48	0.688	0.0043
»	+	Protein mixture,	MA + PR	48	0.688	0.0041
Sorghum	+	Skim-milk powder,	SO + MI	47	0.666	0.0047
»	+	Protein mixture,	SO + PR	48	0.660	0.0052
Total				381	0.673	0.0017

of digestible energy (DE), metabolizable energy (ME) or net energy (NEF). The multilateral problem concerning preference for one term or another will not be discussed here, as it has not been the aim of the present investigation.

4.3. Intake of protein

The intake of nitrogen (NI) and digested nitrogen (ND) was determined for each pig in each balance period and the individual figures will be found in the main tables (p. 159). From these figures the mean values for intake of digestible protein in the 6 different rations have been calculated (ND × 6.25) and will be found in Tables 21, 22, and 23 together with the intake of lysine and methionine + cystine. The concentrations of the amino acids in the different feedstuffs in question are determined by the courtesy of *Bjørn O. Eggum* of this institute, according to the method of *Moore, Spackman & Stein* (1958).

From the tables it will be found that in the first period the intake of digestible protein started at 120 g for the compounds with skim-milk powder, and about 130 g for the protein mixture compounds, ending in period VIII with 280 g and 300 g respectively. The protein norm has been established according to previous investigations (*Møllgaard* (1955), *Ludvigsen & Thorbek* (1955)) to ensure a maximal protein retention. From the investigations mentioned it was found that the curve for nitrogen retention was fairly constant in the live weight group from 40 to 90 kg. For barrows the nitrogen retention was about 18–20 g daily, on the assumption that no lack of protein intake had occured in the previous periods. According to these findings the norm used in series C-D-E-F is characterized by a rather high and increasing intake of digestible protein in the live

Table 21. Daily intake of digestible protein, lysine and methionine + cystine in the experiments with barley. Series C-D-E-F, Mean of 12 pigs in each group

Tabel 21. Daglig optagelse af fordøjeligt protein, lysin og methionin + cystin i forsøgene med byg. Serie C-D-E-F. Middel af 12 svin i hver gruppe

Period	Barley and skim-milk powder				Barley and protein mixture			
no.	Live weight kg	Dig. protein g	Lysine g	Methionine + cystine g	Live weight kg	Dig. protein g	Lysine g	Methionine + cystine g
I	23.7	119	9.5	4.9	23.4	133	9.7	5.2
II	29.3	149	12.0	6.2	28.7	168	12.2	6.5
III	35.7	176	14.3	7.3	34.7	198	14.4	7.7
IV	43.6	198	15.1	8.4	42.8	218	15.5	8.8
V	52.3	223	16.4	9.7	50.9	243	16.7	10.0
VI	61.4	246	17.6	10.9	59.6	263	17.9	11.3
VII	71.9	266	18.7	12.1	69.6	283	18.9	12.4
VIII	83.1	283	19.6	13.0	80.2	299	19.9	13.3

Table 22. Daily intake of digestible protein, lysine and methionine + cystine in the experiments with maize. Series C-E. Mean of 6 pigs in each group

Tabel 22. Daglig optagelse af fordøjeligt protein, lysin og methionin + cystin i forsøgene med majs. Serie C-E. Middel af 6 svin i hver gruppe

Period	Maize and skim-milk powder				Maize and protein mixture			
no.	Live weight kg	Dig. protein g	Lysine g	Methionine + cystine g	Live weight kg	Dig. protein g	Lysine g	Methionine + cystine g
I	21.7	116	8.6	4.5	22.0	133	9.0	5.0
II	27.3	149	10.9	5.8	27.2	171	11.5	6.4
III	33.5	173	12.5	6.7	33.1	196	13.2	7.4
IV	41.9	191	13.3	7.7	41.3	216	13.9	8.4
V	49.7	219	14.5	8.9	49.0	238	14.8	9.5
VI	57.8	238	15.6	9.9	57.4	261	15.5	10.5
VII	67.6	257	15.8	10.9	66.7	279	16.2	11.5
VIII	77.4	269	16.4	11.8	77.2	295	16.8	12.4

weight group from 20–50 kg, while in the last period from 50–90 kg the rate of increase is slowed down.

Using feed compounds with a constant composition during the whole period of growth very often implies that the nitrogen intake in the lower weight classes is below the requirement for maximal protein gain, and above the requirement in the later periods of growth, causing an excessive loss of nitrogen through the urine.

In the trials described here, the amount of skim-milk powder or protein mixture constituted about 30% of the total ration in period I, decreasing to

Table 23. Daily intake of digestible protein, lysine and methionine + cystine in the experiments with sorghum. Series D-F. Mean of 6 pigs in each group

Tabel 23. Daglig optagelse af fordøjeligt protein, lysin og methionin + cystin i forsøgene med milo. Serie D-F. Middel af 6 svin i hver gruppe

Period	Sorghum and skim-milk powder				Sorghum and protein mixture			
no.	Live weight kg	Dig. protein g	Lysine g	Methionine + cystine g	Live weight kg	Dig. protein g	Lysine g	Methionine + cystine g
I	24.0	124	9.0	4.6	23.9	131	8.7	4.7
II	29.0	156	11.0	5.7	29.1	169	10.8	5.8
III	35.3	184	13.1	6.8	35.4	201	12.9	6.9
IV	43.0	206	13.9	7.8	42.7	225	13.7	7.9
V	50.6	224	14.5	8.6	51.2	237	14.2	8.7
VI	60.1	250	15.3	9.8	60.1	265	15.0	9.8
VII	70.6	271	16.0	10.6	70.8	282	15.6	10.7
VIII	80.4	281	16.5	11.5	81.2	301	16.1	11.5

about 13% in period VIII. Expressed in terms of digestible protein, the feed compounds contained 15–17% in the first period and 11–12% in the last period.

Comparing the intake of digestible protein (Tables 21, 22 and 23) with the intake of metabolizable energy (Tables 16, 17 and 18) for the respective rations, it will be found, that the ratio g digestible protein: Mcal metabolizable energy for the rations containing skim-milk powder decreased from 44 to 32, while the ratio decreased from 53 to 35 for the rations with protein mixture, according to the somewhat higher intake of protein and lower intake of energy in these rations.

As discussed in section 4.2 the energy loss in urine, closely related to the excretion of nitrogen, has been rather low in the present investigation, indicated by the regression coefficient of ME on DE being 0.972 (Tables 19) for all rations in question. This indicates, that the norm used for intake of digestible protein in relation to intake of metabolizable energy, is not above the requirement, as an excess of nitrogen intake would have caused a higher excretion of nitrogen in the urine, thereby lowering the ratio ME:DE. The question remains whether the protein norm and the intake of amino acids combined with the energy norm used is sufficient to secure a maximum protein gain during the growth period, a problem which will be discussed later in relation to protein- and fat gain.

The daily intake of digestible protein in relation to daily intake of metabolizable energy is demonstrated graphically in Figure 15, indicating the mean

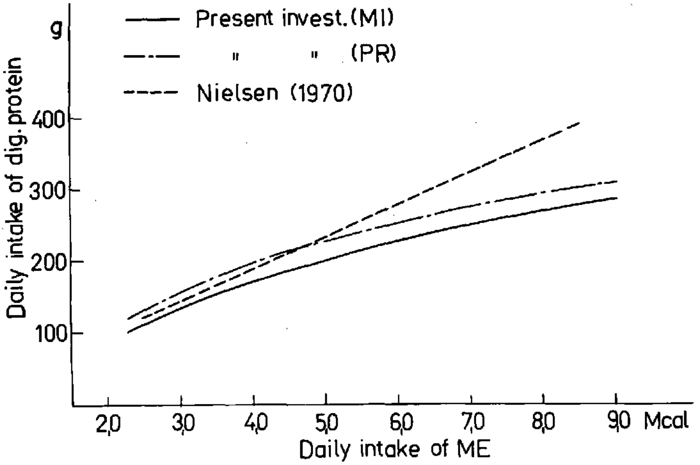

Figure 15.

Daily intake of digestible protein in relation to daily intake of metabolizable energy (ME).

Daglig optagelse af fordøjeligt protein i relation til daglig optagelse af omsættelig energi (ME).

curves for the rations containing skim-milk powder or protein mixture, respectively, compared with the rations used by *Nielsen* (1970). The intake of digestible protein in relation to metabolizable energy has been calculated from the trials of *Nielsen* for the 56 pigs not receiving screenings from U.S. 5 barley in their rations. As commonly used in practical feeding, different kind of pellets, each with a constant composition were used in the experiments of *Nielsen,* and for the six different feed compounds investigated the protein mixture varied from 14 to 24% of the total compound. Expressed in relation to intake of metabolizable energy only small variations existed between the different feed compounds. The mean curve, being linear, is demonstrated in Figure 15, and the ratio of digestible protein to metabolizable energy was found to be fairly constant, around 47, which probably caused the somewhat greater energy loss in urine, found by *Nielsen* in the last balance periods, as discussed in section 4.2.

4.4. Feed conversion to live weight gain

From the individual observations concerning live weight and age during the experimental time (Main Tables p. 159), the means of live weight and daily gain of weight have been calculated for the six rations in question. The corresponding values are plotted in Figure 16, and the mean curve is drawn. The values of daily gain for different live weight classes taken from the curve are tabulated in Table 24, together with the daily intake of feed, metabolizable energy (ME) and net energy (NEF). These values are obtained by plotting the figures from Table 16, 17 and 18 against the corresponding live weight, and reading the curves obtained. From these figures the conversion of feed or energy to live weight gain is calculated, as shown in the three last columns in Table 24.

It is obvious that the live weight gain of 250 g in the class from 20 to 30 kg live weight is low, a fact which can be explained by the rather low intake of energy in the first balance period. In the following periods the daily gain of live weight increased, ending at 775 g in the live weight class of 80 kg. In average for all compounds the mean gain was 571 g during the experimental time, with a feed conversion ratio increasing from about 2,6 kg feed per kg live weight gain until 3.4.kg, the average being 2.9 kg. Expressed in terms of metabolizable energy 8 Mcal was needed for 1 kg of live weight gain from 20 to 30 kg live weight, increasing to 11 Mcal ME at 80 kg of live weight, caused by the higher maintenance requirement, and the changes in the body composition, consisting of more fat and less protein and water with increasing age. Using the calculated values for net energy in the rations according to the Rostock-equations (*Nehring* et al. (1970)), it was found, that the requirement per kg live weight in the present investigations was about 6 Mcal NEF from 20 to 40 kg live weight, increasing to 7.4 Mcal with a daily gain of 775 g at 80 kg live weight.

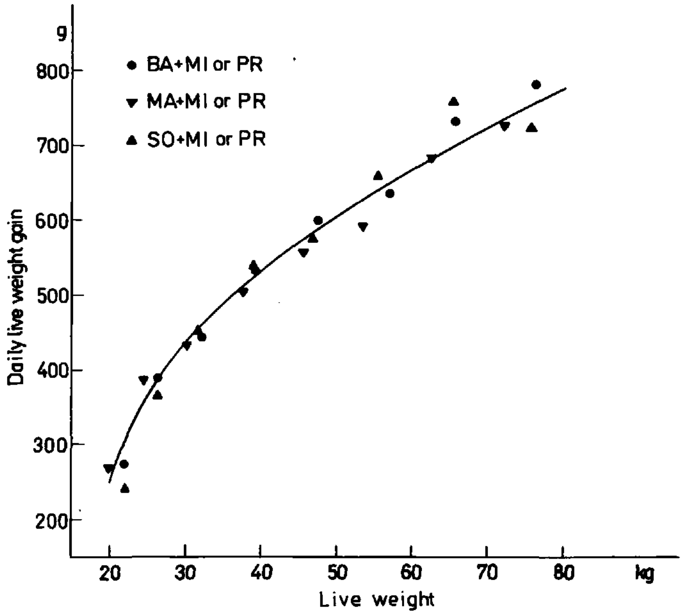

Figure 16.
Daily live weight gain in relation to live weight. Mean of 6 different rations in series C-D-E-F. 1964–1966.
Daglig tilvækst i relation til legemsvægten. Middelværdier for 6 fodertyper i serie C-D-E-F. 1964–1966.

Table 24. Estimation of feed- and energy conversion to kg live weight gain in different live weight classes. Series C-D-E-F. Mean of all compounds

Tabel 24. Beregnet foder- og energiudnytning pr. kg tilvækst indenfor forskellige vægtklasser. Serie C-D-E-F. Middel for alle undersøgte foderblandinger

Live weight class	Daily live weight gain	Daily intake of			Conversion of feed to kg live weight gain		
kg	g	Feed kg	ME Mcal	NEF*) Mcal	Feed kg	ME Mcal	NEF*) Mcal
20	250	0.65	2.00	1.50	2.6	8.0	6.0
30	435	1.05	3.45	2.40	2.4	7.9	5.5
40	535	1.40	4.70	3.20	2.6	8.8	6.0
50	610	1.70	5.80	3.90	2.8	9.5	6.4
60	670	2.00	6.80	4.60	3.0	10.2	6.9
70	725	2.30	7.75	5.20	3.2	10.7	7.2
80	775	2.60	8.55	5.75	3.4	11.0	7.4

*) Net energy for fattening swine, *Nehring et al.* (1970)

In the experiment of *Verstegen* (1971) a daily live weight gain of 550-600 g was found in pigs from 20 to 100 kg and the feed conversion for the 3 groups of pair was 3.4, 2.9 and 3.2 kg feed pr. kg growth.

The daily live weight gain (corrected) for all pigs, in the trials of *Nielsen* (1970) was in average 629 g with a feed conversion of 2.77 Sc.f.u. per kg growth. The somewhat higher live weight gain found, in spite of the lower intake of metabolizable energy than in our experiments (cf. Figure 12), can be explained by the fact, that the trials of *Nielsen* were carried out with sows as well as with barrows, and the growth of sows is faster than of barrows.

In the experiments of *Breirem* (1935) with 5 pigs on low protein and 3 pigs on high protein diet but all on a low intake of metabolizable energy (cf. Figure 12) the mean daily gain in live weight from 20 to 90 kg was only 483 g for the low protein group. For the high protein group on the same intake of ME the daily gain in live weight was in average 567 g. Compared with the results obtained by *Nielsen* (1970) and by us in the present investigation, the rather low growth in the experiment of *Breirem* can be partly explained by the genetic progress in the Danish Landrace with its greater ability to utilize the feed, and partly to the norm used.

A.R.C. (1967) recommends 18.5–20% crude protein up to 45–50 live weight and then 15–16.5% until 90 kg, combined with an increasing intake of energy, starting at 3.0 Mcal digestible energy at 20 kg live weight, ending with 9.6 Mcal at 90 kg. In the present investigations the norm for intake of protein is close to the A.R.C.-norm, while the intake of energy has been more restricted, especially from 20 to 50 kg, caused by the fear of any feed residue in the balance experiments.

In the publication of *Schiemann* et al. (1971) an attempt has been made, on the basis of their extensive investigations, to calculate the requirement of net energy (NEF) per. kg growth at different live weight classes and with different daily gain in weight. Comparing the results we have obtained (Table 24) with the values by *Schiemann* et al. for the same live weight and daily gain af weight, it will be found that our results, starting between 5.5–6.0 and ending with 7.4 Mcal NEF per kg growth, are about 12% lower than the figures from Rostock. The difference was greatest for the lower weight classes, about 18% decreasing to 5% at 80 kg live weight. As the same method of calculation the NEF content in the feed intake has been used, the discrepancy may be explained by genetic differences in the races with a somewhat higher efficiency of the Danish Landrace in utilising the feed, especially as regards protein gain.

CHAPTER 5

Digestibility and metabolizable energy in barley, maize, sorghum, skim-milk powder and protein mixture

As described earlier (Chapter 3.4.) the daily intake of nutrients from the six rations in question were determined for each pig in eight collection periods of 7 days during the experiment, together with the corresponding values for the digested nutrients. At the same time the individual intake of metabolizable energy was determined, and all the figures will be found in the main tables, (p. 159).

From these figures the average digestibility of the nutrients in the six different feed compounds during the experiment have been calculated, and the results obtained are discussed. Subsequently an attempt has been made, by means of a regression model, to determine the digestibility of the feed components used in the different compounds.

The intake of digestible nutrients in the different periods has been used together with the corresponding determined figures for intake of metabolizable energy to discuss the possibility of calculating the metabolizable energy in feed compounds used for growing pigs, based on the knowledge of the amount of digestible nutrients in the compounds, and finally the metabolizable energy in the feed components applied has been evaluated.

5.1. Digestibility of the feed compounds during the experiment

Barley combined with skim-milk powder or protein mixture

For each compound, 12 pigs from different litters were used (cf. Table 4) in order to facilitate the general application of the results obtained, as discussed earlier (Chapter 3.1.). The average values for intake and digestibility of the different nutrients and the gross energy from period I to period VIII are compiled in Table 25 and 26 and graphically demonstrated in Figure 17.

As discussed in Chapter 4.3. all the experiments have been conducted with a protein norm closely related to the requirement for maximal protein gain. This has been obtained by a steadily increasing intake of grain through all periods combined with a constant intake of skim-milk powder or protein mixture from period III (cf. Table 5).

From Table 25 and Figure 17 it will be found that the digestibility of nitrogen-free extract (NFED), organic matter (OMD) and gross energy (GED) in the compound of barley and skim-milk powder is comparatively constant during all

Table 25. Intake and digestibility of the different nutrients in the compounds of barley and skim-milk powder. Series C-D-E-F. Mean of 12 pigs in 8 balance periods

Tabel 25. Optagelse og fordøjelighed af de forskellige næringsstoffer i forsøgsfoderet bestående af byg og skummetmælkspulver. Serie C-D-E-F. Middel af 12 svin i 8 balanceperioder

Period no.		I	II	III	IV	V	VI	VII	VIII
					Crude protein				
Intake,	g	142	178	209	236	267	294	320	341
Digested,	%	84	84	84	85	84	84	83	83
	S.D.	2.5	2.7	2.3	2.2	2.7	1.9	3.1	3.2
					Crude fat				
Intake,	g	19	22	25	29	35	40	45	50
Digested,	%	75	73	74	80	73	79	80	81
	S.D.	12.5	14.7	18.1	6.1	12.5	9.9	7.5	12.3
					Crude fibre				
Intake,	g	24	32	35	47	58	75	83	96
Digested,	%	23	25	20	24	24	29	23	26
	S.D.	8.9	9.9	8.1	9.3	10.3	8.8	7.0	8.2
					Nitrogen-free extraxt				
Intake,	g	503	640	768	944	1164	1356	1557	1764
Digested,	%	93	93	93	92	93	92	92	93
	S.D.	1.0	1.0	0.7	0.6	0.8	0.8	0.8	0.6
					Organic matter				
Intake,	g	694	876	1040	1260	1529	1769	2028	2256
Digested,	%	88	88	88	88	88	88	88	88
	S.D.	1.4	1.6	1.1	1.1	0.9	1.0	0.9	1.0
					Gross energy				
Intake,	Mcal	3.20	4.06	4.81	5.83	7.04	8.15	9.24	10.35
Digested,	%	86	86	86	86	86	86	85	86
	S.D.	1.6	2.0	1.5	1.3	1.9	1.0	1.7	1.3

the periods, being about 93, 88 and 86% respectively, while the digestibility of nitrogen (ND) has a slight tendency to decline, from 84 to 83%.

In the compound of barley and protein mixture (Table 26), the digestibility of nitrogen is comparatively constant, about 80%, while the digestibility of nitrogen-free extract, organic matter and gross energy increase slightly from period IV, apparently due to the increasing percentage of grain in the compound.

A higher digestibility of organic matter, nitrogen-free extract and nitrogen as well as gross energy was found in the compound of barley and skim-milk than in the compound of barley and protein mixture. With the same intake of barley from the two compounds for each period, the difference in digestibility may be

Table 26. Intake and digestibility of the different nutrients in the compounds of barley and protein mixture. Series C-D-E-F. Mean of 12 pigs in 8 balance periods

Tabel 26. Optagelse og fordøjelighed af de forskellige næringsstoffer i forsøgsfoderet bestående af byg og proteinblanding. Serie C-D-E-F. Middel af 12 svin i 8 balanceperioder

Period no.		I	II	III	IV	V	VI	VII	VIII
				Crude protein					
Intake,	g	166	210	246	272	301	329	354	376
Digested,	%	80	80	81	80	81	80	80	80
	S.D.	1.4	2.5	2.0	2.9	2.5	3.5	3.9	3.1
				Crude fat					
Intake,	g	26	31	34	39	45	50	56	61
Digested,	%	79	77	79	77	81	80	80	80
	S.D.	10.1	12.9	10.9	8.2	6.7	11.3	10.7	11.1
				Crude fibre					
Intake,	g	36	48	52	65	74	92	100	113
Digested,	%	37	38	34	33	35	35	34	33
	S.D.	6.8	7.4	8.5	7.7	6.7	6.1	5.8	10.2
				Nitrogen-free extract					
Intake,	g	431	547	663	845	1060	1255	1454	1660
Digested,	%	90	90	90	90	91	91	91	91
	S.D.	0.9	0.6	0.9	0.8	0.5	0.6	0.7	0.6
				Organic matter					
Intake,	g	659	836	995	1220	1481	1726	1966	2210
Digested,	%	84	84	84	85	86	85	86	86
	S.D.	0.9	1.2	1.0	1.6	0.9	1.1	1.2	0.9
				Gross energy					
Intake,	Mcal	3.16	4.01	4.75	5.80	6.98	8.09	9.19	10.29
Digested,	%	82	82	82	82	84	83	83	84
	S.D.	1.0	1.8	1.4	2.1	1.3	1.5	1.5	1.2

caused by a higher digestibility of these nutrients in skim-milk powder than in protein mixture. The problem will be discussed in details in the following section.

Maize combined with skim-milk powder or protein mixture

The digestibility of the nutrients and energy in the compounds containing maize were determined by means of 6 pigs for each compound, and the average values are shown in Tables 27 and 28 and demonstrated in Figure 18.

The results obtained show the same characteristics as for the compounds with barley. The values for OMD, NFED, ND and GED being in all periods

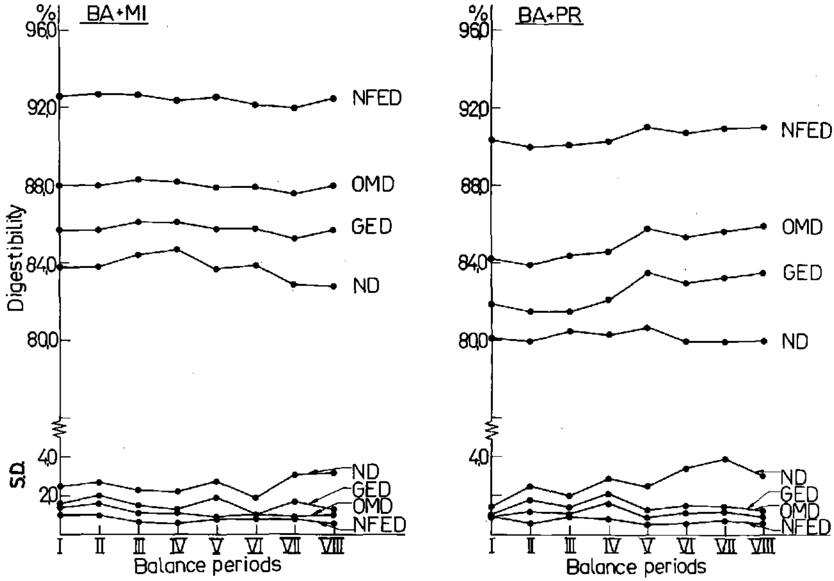

Figure 17.

Digestibility of nitrogen-free extract (NFED), organic matter (OMD), nitrogen (ND) and gross energy (GED) in compounds of barley and skim-milk powder (BA + MI) or barley and protein mixture (BA + PR).
Fordøjelighedskvotienter for kvælstof-fri ekstraktstoffer (NFED), organisk stof (OMD), kvælstof (ND) og brutto-energi (GED) i forsøg med byg og skummetmælkspulver (BA+MI) eller byg og proteinblanding (BA+PR).

higher for the compound of maize and skim-milk powder, than for the compounds of maize and protein mixture.

With the same intake of skim-milk powder and protein mixture respectively in the different compounds with barley or maize, the higher level of digestibility for maize compared with barley is clearly demonstrated in Figures 17 and 18. A method of calculating the digestibility of the single components in the compounds will be discussed in the next section.

Table 27. Intake and digestibility of the different nutrients in the compounds of maize and skim-milk powder. Series C-E. Mean of 6 pigs in 8 balance periods

Tabel 27. Optagelse og fordøjelighed af de forskellige næringsstoffer i forsøgsfoderet bestående af majs og skummetmælkspulver. Serie C-E. Middel af 6 svin i 8 balanceperioder

Period no.		I	II	III	IV	V	VI	VII	VIII
				Crude protein					
Intake,	g	133	169	196	218	248	271	293	314
Digested,	%	87	88	88	88	88	88	88	86
	S.D.	2.7	2.2	1.9	1.7	1.5	1.8	1.7	2.8
				Crude fat					
Intake,	g	29	35	42	52	64	73	87	94
Digested,	%	82	78	82	84	83	83	84	84
	S.D.	8.3	11.5	8.9	7.2	7.3	6.0	6.1	3.7
				Crude fibre					
Intake,	g	10	14	16	20	24	30	35	40
Digested,	%	39	44	46	45	50	56	59	58
	S.D.	4.3	5.0	5.7	9.4	7.9	7.9	13.0	12.5
				Nitrogen-free extract					
Intake,	g	471	602	722	881	1065	1266	1429	1617
Digested,	%	94	94	94	95	95	95	95	95
	S.D.	0.4	0.4	0.8	0.8	0.8	1.0	1.1	1.5
				Organic matter					
Intake,	g	652	825	982	1177	1410	1648	1852	2075
Digested,	%	92	92	92	92	92	93	93	93
	S.D.	1.0	0.8	0.9	1.2	1.1	1.0	1.3	2.0
				Gross energy					
Intake,	Mcal	3.02	3.84	4.58	5.49	6.57	7.67	8.61	9.63
Digested,	%	90	90	90	91	91	91	91	91
	S.D.	1.4	1.3	1.1	1.4	1.3	1.3	1.3	2.1

Table 28. Intake and digestibility of the different nutrients in the compounds of maize and protein mixture. Series C-E. Mean of 6 pigs in 8 balance periods

Tabel 28. Optagelse og fordøjelighed af de forskellige næringsstoffer i forsøgsfoderet bestående af majs og proteinblanding. Serie C-E. Middel af 6 svin i 8 balanceperioder

Period no.		I	II	III	IV	V	VI	VII	VIII
				Crude protein					
Intake,	g	159	204	235	257	285	308	330	350
Digested,	%	83	84	84	84	83	85	85	84
	S.D.	1.3	2.2	2.6	2.1	1.0	2.1	3.2	3.1
				Crude fat					
Intake,	g	35	43	51	61	73	81	96	103
Digested,	%	84	82	86	85	82	85	84	86
	S.D.	9.1	9.9	10.4	6.0	7.1	7.1	4.9	5.5
				Crude fibre					
Intake,	g	22	32	34	37	40	47	52	57
Digested,	%	55	61	59	60	53	64	63	62
	S.D.	8.1	8.4	7.7	7.6	9.8	4.5	3.2	5.4
				Nitrogen-free extract					
Intake,	g	398	505	615	773	962	1166	1325	1513
Digested,	%	91	91	91	92	92	93	93	94
	S.D.	0.8	1.1	0.8	0.9	1.1	0.9	0.4	0.8
				Organic matter					
Intake,	g	616	785	937	1131	1364	1606	1809	2031
Digested,	%	87	88	88	89	89	90	90	91
	S.D.	1.0	1.8	1.3	1.3	1.1	0.7	1.0	1.1
				Gross energy					
Intake,	Mcal	2.97	3.78	4.52	5.43	6.51	7.61	8.56	9.57
Digested,	%	85	85	86	86	86	88	88	89
	S.D.	1.0	2.2	1.8	1.6	1.1	1.0	1.4	1.4

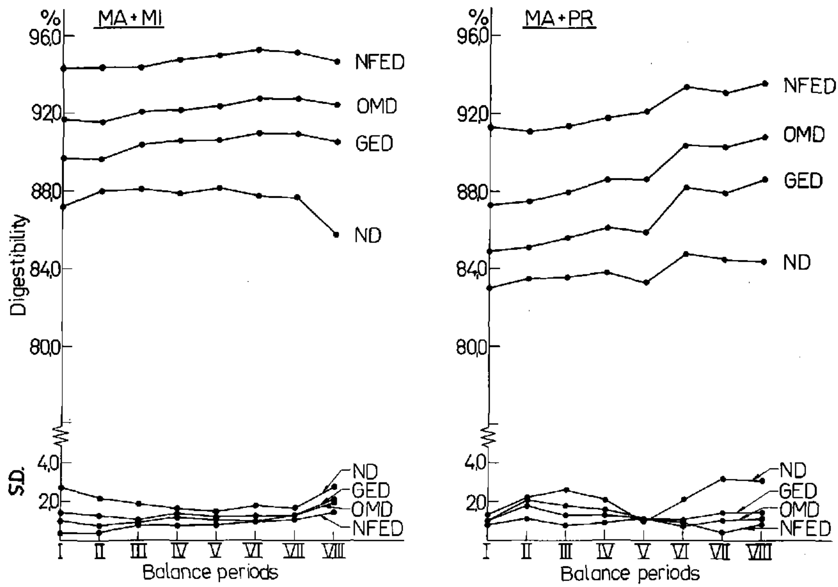

Figure 18.
Digestibility of nitrogen-free extract (NFED), organic matter (OMD), nitrogen (ND) and gross energy (GED) in compounds of maize and skim-milk powder (MA + MI) or maize and protein mixture (MA + PR).
Fordøjelighedskvotienter for kvælstof-fri ekstraktstoffer (NFED), organisk stof (OMD), kvælstof (ND) og brutto-energi (GED) i forsøg med majs og skummetmælkspulver (MA + MI) eller majs og proteinblanding (MA + PR).

Sorghum combined with skim-milk powder or protein mixture

The digestibility was determined by means of 6 pigs for each compound, and the average values are compiled in Tables 29 and 30, and demonstrated in Figure 19. As for the other compounds investigated, a higher digestibility was found for the compound containing skim-milk powder. Compared with the barley compounds the values for OMD, NFED and GED are higher in the sorghum compounds while the ND-values are lower.

Accuracy obtained in the determinations of OMD, NFED, ND and GED

From the Tables (25–30) and the Figures (17–19) it will be found that for all compounds in question the accuracy in determining the digestibility of nitrogen-free extract is rather high, the standard deviation (S.D.) being below 1.0% in nearly all cases. The digestibility of organic matter and gross energy was determined with a somewhat lower degree of accuracy, the standard deviations being 0.5 to 2.4%.

Table 29. Intake and digestibility of the different nutrients in the compounds of sorghum and skim-milk powder. Series D-F. Mean of 6 pigs in 8 balance periods

Tabel 29. Optagelse og fordøjelighed af de forskellige næringsstoffer i forsøgsfoderet bestående af milo og skummetmælkspulver. Serie D-F. Middel af 6 svin i 8 balanceperioder

Period no.		I	II	III	IV	V	VI	VII	VIII
					Crude protein				
Intake,	g	149	183	218	248	274	308	334	354
Digested,	%	84	85	85	83	82	81	81	79
	S.D.	1.9	2.5	2.6	5.0	3.7	2.6	3.0	2.8
					Crude fat				
Intake,	g	26	30	35	42	52	60	70	80
Digested,	%	73	77	75	71	70	73	74	71
	S.D.	7.8	7.8	11.4	14.0	9.9	7.9	10.3	10.6
					Crude fibre				
Intake,	g	14	15	16	22	27	36	41	46
Digested,	%	60	57	66	61	68	73	69	71
	S.D.	8.2	15.6	4.6	9.7	9.6	6.6	4.0	2.2
					Nitrogen-free extract				
Intake,	g	507	638	765	967	1165	1353	1559	1766
Digested,	%	95	96	96	95	96	96	96	96
	S.D.	0.6	0.7	0.6	1.2	0.8	0.6	0.4	0.4
					Organic matter				
Intake,	g	700	870	1041	1285	1526	1766	2016	2257
Digested,	%	91	93	92	92	92	92	92	92
	S.D.	0.7	0.7	1.0	2.0	1.5	0.5	0.7	0.6
					Gross energy				
Intake,	Mcal	3.27	4.06	4.84	5.98	7.05	8.16	9.28	10.39
Digested,	%	89	90	90	89	90	90	89	89
	S.D.	0.8	0.9	1.3	2.4	1.9	0.8	1.1	1.2

In the determination of digestible nitrogen a lower degree of accuracy was obtained. In most cases a standard deviation of 2–3% was found, except for the experiments with sorghum where the standard deviation increased in some periods to approximately 5%.

The overall lower accuracy in the determination of ND may be caused, partly by the lower intake of nitrogen compared with the intake of organic matter and nitrogen-free extract and partly by the risk of contamination with nitrogen from the urine. As discussed earlier in Chapter 2 we have preferred to keep the

Table 30. Intake and digestibility of the different nutrients in the compounds of sorghum and protein mixture. Series D-F. Mean of 6 pigs in 8 balance periods

Tabel 30. Optagelse og fordøjelighed af de forskellige næringsstoffer i forsøgsfoderet bestående af milo og proteinblanding. Serie D-F. Middel af 6 svin i 8 balanceperioder

Period no.		I	II	III	IV	V	VI	VII	VIII
					Crude protein				
Intake,	g	169	211	251	283	306	341	366	391
Digested,	%	78	80	80	79	77	78	77	77
	S.D.	3.3	3.2	2.9	3.3	2.1	4.6	4.8	4.6
					Crude fat				
Intake,	g	33	40	42	53	63	72	82	94
Digested,	%	73	74	66	70	66	69	68	71
	S.D.	8.4	8.2	15.2	12.2	10.1	10.4	12.2	7.8
					Crude fibre				
Intake,	g	26	29	33	41	44	54	58	63
Digested,	%	60	66	66	70	67	74	70	68
	S.D.	7.5	8.8	5.5	5.0	7.2	2.9	2.0	8.8
					Nitrogen-free extract				
Intake,	g	436	549	664	865	1060	1250	1456	1675
Digested,	%	93	94	94	94	95	95	95	95
	S.D.	0.5	0.7	1.2	0.3	0.6	0.6	0.4	0.4
					Organic matter				
Intake,	g	664	832	996	1245	1476	1721	1968	2227
Digested,	%	87	88	88	89	89	90	90	90
	S.D.	1.7	1.5	1.2	1.4	0.8	1.4	1.2	1.3
					Gross energy				
Intake,	Mcal	3.22	4.01	4.79	5.94	6.99	8.11	9.23	10.43
Digested,	%	84	85	85	86	86	87	87	87
	S.D.	2.2	1.8	1.5	2.0	1.3	2.1	1.9	1.9

animals in crates, in which they could move around, to make the results obtained more applicable to normal conditions. As a result the accuracy in the determination of digestible nitrogen is lowered, but the validity of the results obtained concerning nitrogen balances is not influenced. The accuracy in the determinations of digestible organic matter, nitrogen-free extract and gross energy is comparable to results obtained in experiments with pigs in confined crates.

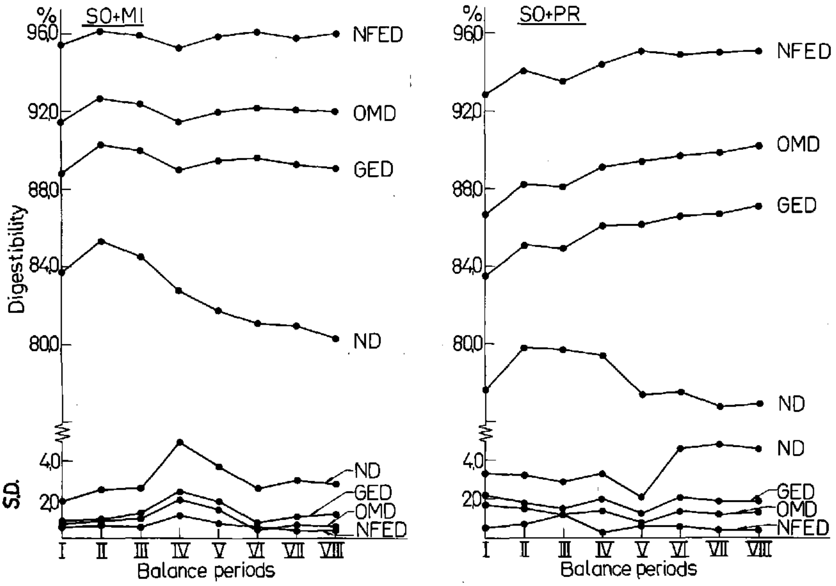

Figure 19.
Digestibility of nitrogen-free extract (NFED), organic matter (OMD), nitrogen (ND) and gross energy (GED) in compounds of sorghum and skim-milk powder (SO + MI) or sorghum and protein mixture (SO + PR).
Fordøjelighedskvotienter for kvælstof-fri ekstraktstoffer (NFED), organisk stof (OMD), kvælstof (ND) og brutto-energi (GED) i forsøg med milo og skummetmælkspulver (SO + MI) eller milo og proteinblanding (SO + PR).

Accuracy obtained in the determinations of EED and CFD

The accuracy in determining the digestibility of crude fat is low (S.D. ranging from 3.7–18.1%), a part of which could be explained by the rather low fat content in the compounds in question. Undoubtedly the major cause of the low accuracy must be ascribed to the fact that the ether-extract method, as used in the present investigations, is a very poor method of determining the fat content, especially in faeces from pigs, as pointed out by *Nehring et al.* (1963) and discussed in detail by *Nielsen* (1970). The results obtained by *Thomsen* (1971) indicate that HCl-hydrolysis of the faeces before ether-extraction may be preferred, giving more acceptable proportion between gross energy and fat in the faeces than is obtained without hydrolysis.

The daily intake of crude fibre was rather low, influencing the accuracy obtained in the determination of the digestibility of crude fibre, (S.D. ranging from 2.0 to 15.6%) but the difference between pigs in their microflora in the lower gut and their ability to break down crude fibre may the major cause of the low degree of accuracy obtained in the determination of digestible crude fibre.

5.2. Digestibility of the feed components used in the different feed compounds

In the previous section the digestibility of the compounds used in the different series and through the eight balance-period have been discussed. It is obvious that in experiments concerning protein-and fat gain, a knowledge of the digestibility of the compounds in question is valuable, but if it were possible from the digestibility experiments to determine the digestibility of the single feed components used in the different compounds more general informations could be obtained.

Model used for calculating the digestibility of the feed components

In the present investigation such an attempt has been made by using the regression equation:

(1) $$y = \alpha x_1 + \beta x_2$$

where y = total digested amount of nutrients
x_1 = intake of component 1
x_2 = intake of component 2

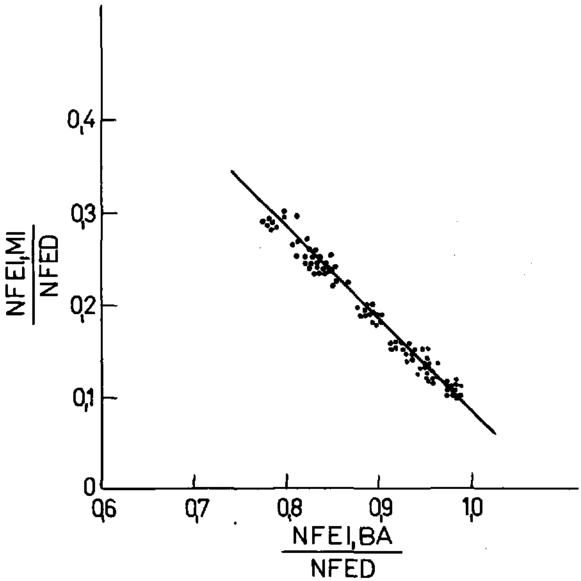

Figure 20.
Intake of nitrogen-free extract in skim-milk powder divided with the total amount of nitrogen-free extract digested in relation to the corresponding values for barley.
Tilført kvælstof-fri ekstraktstoffer i skummetmælkspulver divideret med totalt fordøjet NFE i relation til de tilsvarende værdier for byg.

It is a condition that the proportion x_1 / x_2 is not a constant, because otherwise it is impossible to separate the contributions from the two components. In the present investigation, with an increasing intake of grain during the periods and a constant intake of skim-milk powder or protein mixture from period III, the proportion x_1 / x_2 is not constant.

Before any calculations were carried out graphical examinations of the observations were made in accordance with the following transformation of equation (1):

$$1 = \alpha \frac{x_1}{y} + \beta \frac{x_2}{y} \qquad (2)$$

The graph obtained by plotting the intake of nitrogen-free extract from barley divided by the total digested amount of NFE [(NFEI, BA) / NFED] against the corresponding values for skim-milk powder [(NFEI, MI) / NFED] is demonstrated in Figure 20. A similar graph for intake of nitrogen in barley or skim-milk powder divided by total digested nitrogen [(NI, BA) / ND] against [(NI, MI) / ND] is shown in Figure 21.

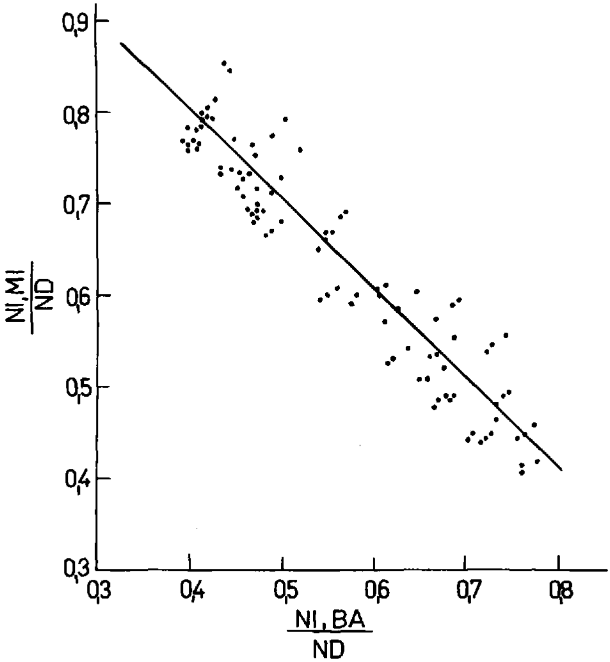

Figure 21.
Intake of nitrogen in skim-milk powder divided with the total amount of nitrogen digested in relation to the corresponding values for barley.
Tilført kvælstof i skummetmælkspulver divideret med totalt fordøjet kvælstof i relation til de tilsvarende værdier for byg.

The graphs indicate linearity in the range of the measurements. The same picture is obtained for all compounds in respect of organic matter, nitrogen, nitrogen-free extract and gross energy. The graphs also show that the random variation around the line is constant, which means that the random variation of Y in the expression (1) is proportional to the expected value of Y, or that the relative standard deviation is constant. The regression coefficients and standard deviations have therefore been calculated according to model 3 (cf. *Rasch* p. 15).

$$Y = \alpha x_1 + \beta x_2 + w \tag{3}$$

where w is normally distributed around zero with variance:

$$V\{w\} = k\,(E(Y))^2$$

Results and discussion

The values obtained for digestibility of organic matter, nitrogen, nitrogen-free extract and gross energy in the different feed components are compiled in Table 31. With the great inaccuracy in the determinations of digestible fat and digestible crude fibre in the compounds discussed in the previous section, no

Table 31. Digestibility of nutrients and gross energy in the individual feed components: Barley (BA), maize (MA), sorghum (SO), skim-milk powder (MI) and protein mixture (PR). Series C-D-E-F

Tabel 31. Fordøjelighed af næringsstoffer og brutto energi i de enkelte foderkomponenter: Byg (BA), majs (MA), milo (SO), skummetmælkspulver (MI), og proteinblanding (PR). Serie C-D-E-F

Compo-nents	Combined with	n	OM-digested		N-digested		NFE-digested		GE-digested	
			%	s_b	%	s_b	%	s_b	%	s_b
BA	MI	96	87.1	0.5	83.8	1.5	91.9	0.3	84.9	0.6
BA	PR	96	86.9	0.4	80.2	1.7	91.6	0.2	84.5	0.6
MA	MI	48	93.3	0.6	85.4	1.8	95.6	0.4	91.5	0.7
MA	PR	48	93.3	0.6	85.4	2.2	94.9	0.4	90.6	0.8
SO	MI	47	92.2	0.6	76.5	2.5	96.1	0.4	88.8	0.8
SO	PR	48	92.5	0.6	77.1	3.1	96.7	0.3	89.4	0.9
MI	BA	96	95.2	1.7	83.7	1.3	95.2	1.2	93.4	1.7
MI	MA	48	94.2	1.9	89.2	1.4	91.4	1.7	92.5	2.0
MI	SO	47	96.3	2.0	88.3	2.5	94.3	1.7	96.6	2.4
PR	BA	96	80.6	1.5	80.0	1.2	78.7	2.5	80.8	1.8
PR	MA	48	77.2	2.1	82.9	1.4	63.8	3.5	79.2	2.3
PR	SO	48	78.5	2.4	78.9	2.4	67.1	3.7	78.4	2.9

attempt was made to calculate the digestibility of these nutrients in the single components.

In the different compounds barley, maize and sorghum were combined with skim-milk powder or protein mixture, and from the results obtained(Table 31) an examination has been made by means of t-test's, as to whether the digestibility found for each of the 5 components in question was influenced by the mixture in which it occurred.

For barley, maize and sorghum no significant differences were found. The digestibility coefficients for the different nutrients were independent of whether the other components were skim-milkpowder or protein mixture.

In the combination of skim-milk powder with grains, the value of 83.7% for nitrogen digestibility in the combination with barley was significant lower than the value of 89.2% estimated in the combination with maize. ($t = 2.87 > t_{.01} = 2.63$). For the other nutrients no significant differences were found in the different combinations of skim-milk powder with grains.

For the protein mixture in combination with barley, the value of 78.7% for digestible NFE was significant different from the value of 63.8% in the combination with maize and the value of 67.1 in combination with sorghum. ($t = 3.63 > t_{.001} = 3.39$, respectively $t = 2.77 > t_{.01} = 2.63$). No other significant differences were found.

For the grain products in question a rather high degree of accuracy has been obtained in the estimation of the digestibility of organic matter, nitrogen-free extract and gross energy, the standard deviation being below 1.0%. The estimate of nitrogen digestibility is less accurate (s_b between 1.5–3.1%) due to a possible contamination of nitrogen from the urine as discussed in the previous section.

The intake of organic matter, nitrogen-free extract and gross energy is lower from the skim-milk powder or protein mixture than from the grain products. This may have caused the somewhat lower accuracy obtained in the estimation of the digestibility coefficients for these two components compared with the grain components. The s_b in most cases are found between 1.2–2.5%.

The digestibility coefficients estimated for barley, maize, sorghum and skim-milk powder are, in Table 32, compared with those found in different collection of tables and with the results obtained by *Madsen* (1963).

In *DLG-Futterwerttabelle für Schweine* (1970) acceptable figures from the world literature have been collected and are indicated by their arithmetic mean values and the standard deviation, thereby offering much more information, than by giving mean figures only. The values from digestibility trials with pigs in Scandinavia from 1925 to 1967 are collected in *Fodermiddeltabel, NJF* (1969). The numbers of experiments and the mean values are indicated, but the standard deviation or the total range for the individual experiments are not given.

Table 32. Coefficients of digestibility of barley, maize, sorghum and skim-milk powder estimated from series C-D-E-F compared with values obtained by other authors

Tabel 32. Fordøjelighedskvotienter for byg, majs, milo og skummetmælkspulver fundet i serie C-D-E-F sammenlignet med værdier fra litteraturen

Feedstuff	Ref. no.	Nos. of exp.	Organic matter %	Crude protein %	N-free extract %	Gross energy %
Barley	1	279	83 ± 3	76 ± 7	89 ± 3	
	2		84	81	90	81
	3	48	85	73	91	
	4		80 ± 2	62 ± 4	90 ± 1	78 ± 2
	4		88 ± 2	76 ± 4	94 ± 1	87 ± 3
	5		87 ± 1	82 ± 2	92 ± 0.3	85 ± 1
Maize	1	116	90 ± 3	80 ± 10	93 ± 2	
	2		89	79	93	86
	3	48	84	59	91	
	4		69 ± 7	38 ± 12	83 ± 5	65 ± 8
	4		86 ± 2	57 ± 10	95 ± 2	85 ± 5
	5		93 ± 1	85 ± 2	95 ± 0.4	91 ± 1
Sorghum	1	11	90 ± 1	72 ± 5	95 ± 2	
	2		86	71	90	82
	3	6	92	75	96	
	5		92 ± 1	77 ± 3	96 ± 0.4	89 ± 1
Skim-milk powder	1	4	93 ± 1	94 ± 2	94 ± 0	
	2		93	90	95	92
	3	34	96	96	95	
	4		90 ± 4	91 ± 2	93 ± 3	91 ± 4
	4		101 ± 2	98 ± 1	102 ± 2	101 ± 3
	5		94 ± 2	84 ± 1	91 ± 2	93 ± 2
	5		96 ± 2	89 ± 1	95 ± 1	97 ± 2

Ref. no. 1: DLG-Futterwerttabelle für Schweine (1970)
» » 2: Futtermitteltabellenwerk, Rostock (1970)
» » 3: Fodermiddeltabel, N.J.F. (1969)
» » 4: Madsen, A. Thesis (1963)
» » 5: Present investigation.

The figures indicated in *Futtermitteltabellenwerk, Rostock* (1970) are regression coefficients calculated by means of a regression equation based on the chemical composition of the feedstuff in question, and established by the extensive digestibility trials with different feedstuff at the *Oskar Kellner Institute*. The mean values are given in the tables mentioned, but no figures for the standard deviation (s_b) are stated.

In the comprehensive work by *Madsen* (1963) 3 different techniques, (direct, difference and regression methods) have been used to determine the digestibility of single feed components used in feeding growing pigs. The figures given in Table 32 are the lowest and highest values and their respective s_b obtained by the regression method. The figures from the present investigation are the figures from Table 31, where they are presented in detail.

Looking at the numbers of experiments presented, it is staggering that so many experiments all over the world have been made with barley, and so comparatively few with maize, sorghum and skim-milk powder, in spite of the fact that they are commonly used feed components in feed compounds for pigs.

The digestibility values obtained for barley and maize in the present investigation are between the ranges indicated in *DLG-Futterwerttabelle für Schweine* (1970), but somewhat above the values given by *Fodermiddeltabel, NJF* (1969) and the values in *Futtermitteltabellenwerk, Rostock* (1970). In the digestibility experiments of *Madsen* (1963) using the regression method, lower values have been found than in our investigation. The cause may be that *Madsen* has used quite other combinations of feed components and has covered a much greater range of combinations than in our investigation, where the main purpose has been to use the components in such a combination, that they are able to cover the requirement for a high protein-and fat gain during the growth period. It should be noticed, that *Madsen* quotes »that the mean digestibility coefficient of 50% for crude protein in maize is presumably too low«.

For sorghum very few digestibility experiments have been carried out, no ranges are indicated in the table works, but the values found by us are slightly higher than the mean values given by other authors.

For skim-milk powder the results obtained in the present investigation are between the ranges given by *DLG-Futterwerttabelle für Schweine* (1970) except for crude protein, where we have found values between 84–89%, compared with 94 ± 2. In *Futtermitteltabellenwerk, Rostock* (1970) a mean value of 90% digestibility of crude protein is given. Even if our values are rather low, it is questionable if values higher than about 95% should be accepted, keeping in mind that the figures indicate the apparent digestibility. With correction for endogenous nitrogen excreted in faeces, values higher than 100% for true digestibility of protein could be expected, but not accepted.

5.3. Metabolizable energy in the feed compounds measured directly in balance experiments or calculated by means of the values for digested nutrients

From their difference experiments with »adult« barrows (Deutsche Edelschwein) fed concentrates as well as roughages *Schiemann et al.* (1971) have established a regression equation for calculating metabolizable energy in feed compounds based on the knowledge of the amount of digestible nutrients in the compounds in question. Each pig was measured several times in the basal and in the addition period, and the results gave the following equation:

$$ME,kcal = 4.98x_1 + 8.75x_2 + 3.41x_3 + 4.06x_4$$

where x_1 = g digested crude protein
x_2 = g digested crude fat
x_3 = g digested crude fibre
x_4 = g digested nitrogen-free extract (NFE).

In the present investigation the metabolizable energy as well as the amount of digested nutrients have been determined for each pig in all periods, and the individual figures are presented in the main tables. The figures are used to calculate regression equations for metabolizable energy in growing pigs (Dansk Landrace) in order to compare these equations with the Rostock-equation obtained with »adult« pigs of another race.

Before any calculations were made, some graphical tests were carried out to investigate if a marked correlation exists between digested crude protein (x_1) and digested NFE (x_4). These two variables have been chosen, because in feed compounds with a low fat content, as used in these trials, around 80% of the metabolizable energy is derived from the NFE digested, while 10–15% comes from digested protein. In Figure 22 and 23 the relation between protein digested

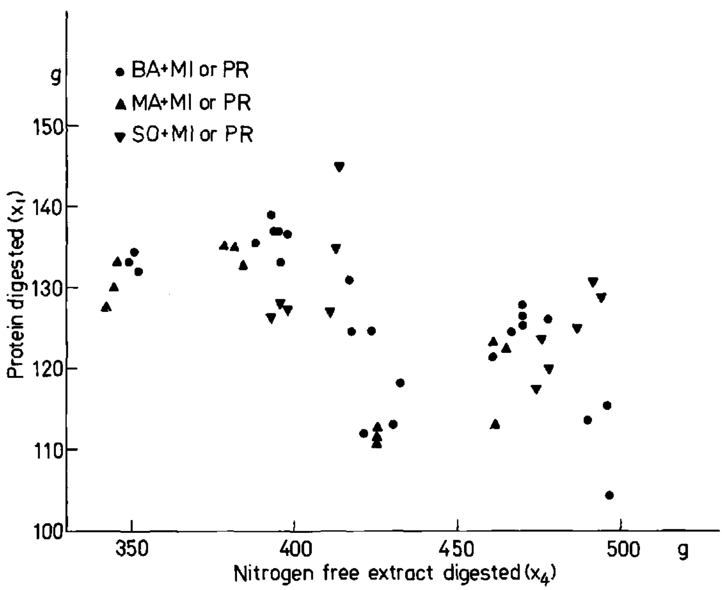

Figure 22.
Digested protein (x_1) in relation to digested NFE (x_4), in period I.
Fordøjet protein (x_1) i relation til fordøjet NFE (x_4), i periode I.

and NFE digested in period I and VIII is demonstrated, and it is found, that the observations are scattered over the area, from which we conclude that no marked correlation between the two variables (x_1 and x_4) exists.

The calculations were carried out for each period according to different regression models, and the values obtained are shown in Table 33. In model 1 the calculations are made with intercept, while in model 2 the regression plane is supposed to pass through the origin. (For statistical details see p.). From a biological point of view model 2 should be used because no intake of feed (no metabolizable energy) would cause no excretion of faeces, except from a very small excretion of nitrogenous compounds from the digestive tract. Nevertheless, from a statistical point of view it is possible that model 1 with intercept would give a better estimate of the linear relation. For reason of comparison both models have been used.

From Table 33 it is found that for all periods the intercept in model 1 is significant or highly significant and the standard deviation of residuals were below 1% of ME. However, the regression coefficients for digested protein (x_1) and digested NFE (x_4) are biological unacceptable, being above the theoretical values for total combustion. Calculation according to model 2 gave biological acceptable values for the regression coefficients and the estimates of the

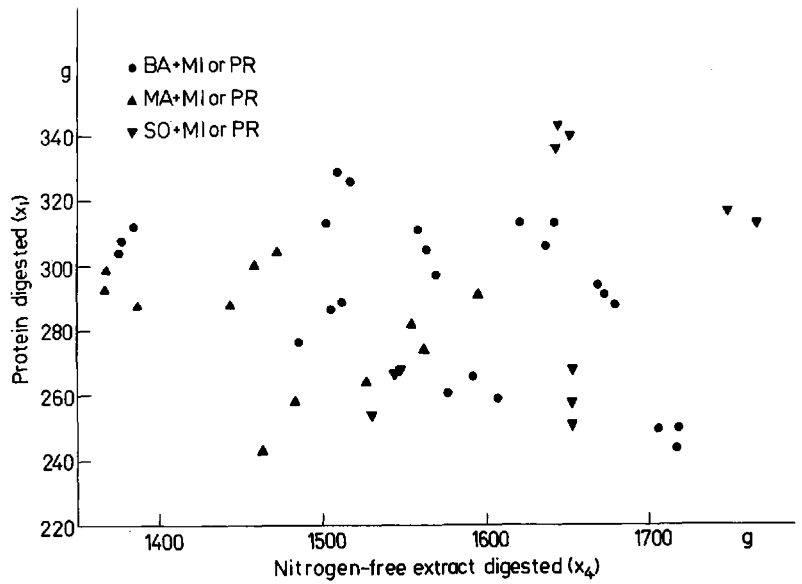

Figure 23.

Digested protein (x_1) i relation to digested NFE (x_4), in period VIII.

Fordøjet protein (x_1) i relation til fordøjet NFE (x_4), i periode VIII.

Table 33. Values of regressionscoefficients for calculating metabolizable energy based on digested nutrients according to model 1 or 2. (see statistical appendix, p. 150). Series C-D-E-F, 6 feed compounds

Tabel 33. Værdier af regressionskoefficienter til beregning af omsættelig energi baseret på fordøjede næringsstoffer i henhold til model 1 eller 2. (se statistisk appendix, s. 150). Serie C-D-E-F, 6 foderblandinger

	Crude protein dig. (x_1)		Crude fat dig. (x_2)		Crude fibre dig. (x_3)		N-free extract dig. (x_4)				S.D. of reciduals	
	Regress. coeff.	s_b	Regress. coeff.	s_b	Regress. coeff.	s_b	Regress. coeff.	s_b	Inter-cept	s_I	kcal	% of ME
Per. I n=48												
Model 1	6.93	0.48	8.70	0.61	3.03	0.87	4.50	0.08	-401	69	18	0.7
» 2	4.67	0.38	8.49	0.81	4.37	1.11	4.21	0.07			24	0.9
Per. II n=48												
Model 1	7.55	0.51	6.30	0.76	1.72	1.17	4.27	0.13	-401	119	29	0.9
» 2	6.37	0.42	6.10	0.84	0.64	1.26	3.91	0.08			32	1.0
Per. III n=48												
Model 1	6.11	0.33	7.03	0.52	3.11	0.92	4.22	0.10	-214	103	26	0.7
» 2	5.68	0.27	6.76	0.53	2.45	0.90	4.05	0.05			27	0.7
Per. IV n=47												
Model 1	6.12	0.27	8.23	0.34	2.82	0.67	4.40	0.05	-402	68	24	0.5
» 2	4.94	0.25	7.76	0.45	3.99	0.86	4.20	0.05			32	0.7
Per. V n=48												
Model 1	5.85	0.32	7.48	0.42	4.28	0.61	4.35	0.06	-363	105	32	0.6
» 2	5.10	0.26	7.06	0.46	4.31	0.68	4.18	0.05			36	0.6
Per. VI n=48												
Model 1	5.60	0.25	7.95	0.41	2.36	0.62	4.30	0.07	-252	110	35	0.5
» 2	5.31	0.22	7.68	0.41	2.00	0.62	4.17	0.04			36	0.5
Per. VII n=47												
Model 1	6.31	0.30	8.24	0.49	2.79	0.89	4.32	0.08	-538	140	50	0.7
» 2	5.73	0.30	7.61	0.53	2.49	1.01	4.07	0.05			57	0.7
Per. VIII n=47												
Model 1	6.75	0.36	8.89	0.53	2.08	0.85	4.47	0.09	-949	184	60	0.7
» 2	5.68	0.38	7.96	0.63	3.34	1.03	4.07	0.06			76	0.9
Total n=381												
Model 1	5.59	0.10	7.68	0.18	2.97	0.29	4.15	0.01	- 73	11	42	0.8
» 2	5.00	0.06	7.87	0.19	3.59	0.29	4.19	0.01			45	0.8

equations were nearly as good as in model 1, the S.D. of residuals being 1% of ME or below and therefore model 2 has been preferred.

In previous publications, *Thorbek* (1969b, 1970a and 1970b), the calculation of the ME-equation was made only by model 2 using all the values from the 8 periods in a total calculation (n = 381), as indicated at the bottom of Table 33.

This way of calculation can be critized, because the measurements for each individual pig are repeated 8 times during the growth period, possibly including »a sleeping partner« in the form of some correlation between the observations, thereby causing a greater accuracy in the determinations of the regression coefficients, than is really true. To avoid such an influence, it has in the present study been preferred to calculate the regression equations for each of the 8 periods at different live weight, including the 6 different feed compounds in question.

In period II the regression coefficients are suspicious and no explanation can be given, otherwise no systematical variations have been found from period I to VIII in the regression coefficients for the different digested nutrients (x_1 –x_4). The regression coefficients for digested NFE (x_4), contributing 80% of the metabolizable energy, varied from 4.05 to 4.21, and were estimated with a high accuracy, s_b between 0.04 and 0.08. For digested protein (x_1) the regression coefficients varied much more through the periods from 4.7 to 5.7 and were estimated with a lower accuracy, s_b between 0.22 and 0.38.

For digested crude fat even a greater variation from 6.8 to 8.5 was found and for digested crude fibre there was a variation from 2.0 to 4.4. and these regression coefficients were estimated with a low accuracy in accordance with the low accuracy obtained in the determinations of the digestibility of the two nutrients, as discussed in chapter 5.1.

In the present investigation only 5 to 10% of the metabolizable energy derives from digested crude fat and crude fibre and therefore the regression coefficients for these two nutrients are of minor interest with little influence on the accuracy obtained for the regression equation, as indicated by the high accuracy obtained in all periods with a standard deviation of residuals being 1% of ME or below.

The observations of digested nutrients and metabolizable energy from the work of *Nielsen* (1970), including 80 pigs on 20 groups on different rations have been examined in the same way. The general picture was identical, no marked correlations were found between digested protein (x_1) and digested NFE (x_4). The results for period I and VI, are shown in Table 34, together with the equation given by *Schiemann et al.* (1971), and the results from the first and the last period in the present investigation.

In the difference experiments of *Schiemann et al.* with »adult« barrows the standard deviation between measured and calculated metabolizable energy was ±91 kcal or ±1.3% of the mean metabolizable energy, but no figures of the accuracy in the determinations of the four regression coefficients are given. From Table 34 it will be found that in the experiments of *Nielsen,* as in our trials the highest accuracy is obtained in the determination of the regression coefficients for digested NFE, the s_b between 0.13 and 0.19. For digested protein the accuracy is lower, with s_b'around 0.7, but considering that only 10–15% of the

Table 34. Equations for calculating metabolizable energy based on digested nutrients
Tabel 34. Ligninger til beregning af omsættelig energi baseret på fordøjede næringsstoffer

Schiemann et al. (1971)	
»Adult« pigs	ME, kcal = $(4.98\ x_1 + 8.75\ x_2 + 3.41\ x_3 + 4.06\ x_4) \pm 91$ kcal
Nielsen (1970)	
20–25 kg. Per. I	ME, kcal = $(5.3\ x_1 + 9.9\ x_2 + 5.2\ x_3 + 3.99\ x_4) \pm 31$ kcal
	s_b 0.7 1.7 3.9 0.19
80–85 kg. Per. VI	ME, kcal = $(4.6\ x_1 + 8.7\ x_2 + 5.1\ x_3 + 4.16\ x_4) \pm 70$ kcal
	s_b 0.7 1.0 2.6 0.13
Present investigation. Ser. C-D-E-F. 1964–66.	
20–30 kg. Per. I	ME, kcal = $(4.7\ x_1 + 8.5\ x_2 + 4.4\ x_3 + 4.21\ x_4) \pm 24$ kcal
	s_b 0.4 0.8 1.1 0.07
70–90 kg. Per. VIII	ME, kcal = $(5.7\ x_1 + 8.0\ x_2 + 3.3\ x_3 + 4.07\ x_4) \pm 76$ kcal
	s_b 0.4 0.6 1.0 0.06

metabolizable energy is derived from digested protein, compared with about 80% from the digested NFE, the regression coefficients are estimated with the same accuracy for the two nutrients. For digested fat the s_b varies between 1.0 and 1.7 in the trials of *Nielsen* and between 0.6 and 0.8 in our investigations for the periods in question. For digested crude fibre the accuracy is even lower from 1.0 to 1.1 in the present investigation and from 2.6 to 3.9 in the experiments of *Nielsen*. But keeping in mind that only 5–10% of the metabolizable energy in these trials have derived from digested fat and crude fibre, the equations are acceptable, though it seems reasonable to indicate x_1, x_2 and x_3 to one decimal place only.

In the trials of *Schiemann et al.* (1971) with »adult« pigs from 75 to 175 kg the regression coefficient for digested nitrogen-free extract is estimated at 4.06. In the present investigation a value of 4.07 $\mp$0.06 was found in period VIII, with a live weight between 70 to 90 kg. It is remarkable, that the regression coefficients are so near each other, when we consider the differences in experimental method, feeding stuffs and races.

With regard to the regression coefficients for digested protein we have in our investigation found 5.7 ± 0.4 in period VIII, compared with 4.6 ± 0.7 in the trials of *Nielsen* (1970) and 5.0 in the experiments from Rostock, *Schiemann et al.* (1971). The higher coefficient found in the present investigation may partly be explained by the fact that we have tried to keep the protein supply near the pig's requirement for maximum protein retention, while in the experiment of *Nielsen*, with a constant composition of the feed compounds, the protein supply was above the requirement in the last period, resulting in an increasing nitrogen excretion in the urine, as discussed earlier. In the difference experiments of *Schiemann et al.*, with a large supply of nitrogen in the addition periods, the techniques may be responsible for an extensive deamination resulting in an lower coefficient for digested protein.

While the coefficients for NFE seems to be rather constant, with a high degree of accuracy, independent of the feed compounds in question, it may be expected that the factor for digested protein is more variable, depending, inter alia, on the intake of protein in relation to requirement and of the biological value of the protein in question.

5.4. Metabolizable energy in the feed components used in the different feed compounds

In the present investigation the feeding plan consisted of a steady increasing intake of barley, maize or sorghum and a constant intake of skim-milk powder or protein mixture from period III (cf. Tables 5 and 6). The contrast between the intake of the two components should therefore be sufficient to apply a regression analysis for estimation of the metabolizable energy in the single feed components.

The individual measurements of the total metabolizable energy in the feed compounds for all periods (Main tables II) have been used together with the informations concerning feed intake (Tables 5 and 6) to estimate the regression coefficients in the following equation:

$$\text{ME,kcal} = \alpha x_1 + \beta x_2$$

where x_1 = intake (kg) of barley, maize or sorghum

x_2 = intake (kg) of skim-milk powder or protein mixture

The results obtained are compiled in Table 35 together with the values of chemical composition (mean figures from Tables 7 and 8) and the estimated digestibility of the feed components in question (Table 31). The metabolizable energy is estimated with a rather high accuracy for the grains, the S.D. of residuals varying form 16 to 29 kcal pr. kg corresponding to 0.5–0.8%, while the S.D. of the residuals was 72–76 kcal or 2.0–2.6% for the skim-milk powder and protein mixture.

In the present investigation the metabolizable energy in barley was estimated to be about 3200 kcal/kg, while the values for maize and sorghum were estimated to be about 3500 kcal/kg or 11% higher than the value for barley. For skim-milk powder the value was estimated to 3600–3700 kcal pr. kg or about 15% above the value for barley. On dry matter basis the values for barley, maize and sorghum were 3700, 4050 and 4000 kcal/kg dry matter respectively and about 3800 kcal for skim-milk powder, proportional to 100, 109, 108 and 103 respectively.

Table 35. Chemical composition, digestibility and metabolizable energy in barley, maize, sorghum, skim-milk powder and protein mixture

Tabel 35. Kemisk sammensætning, fordøjelighed og omsættelig energi i byg, majs, milo, skummetmælkspulver og proteinblanding

	Chemical composition				Digestibility			Metabolizable energy		
	Dry matter %	Organ. matter %	Crude protein %	N-free extract %	Organ. matter %	Crude protein %	N-free extract %	n	kcal per kg	S.D.
Barley	85.8	83.5	9.3	68.5	87.0	82.0	91.8	190	3185	16
Maize	87.5	86.0	9.0	70.9	93.3	85.4	95.2	96	3542	22
Sorghum	87.5	86.0	10.3	70.5	92.4	76.8	96.4	95	3503	29
Skim-milk powder	96.0	88.0	37.5	50.3	95.2	87.1	93.6	191	3668	72
Protein mixture*) ...	90.7	76.5	47.7	20.5	78.8	80.6	69.9	190	2908	76

*) 67% soyabean meal + 33% meat-bone meal.

Compared with values from the literature it will be found that in *Fodermiddeltabel NJF* (1969) the values are given as 3490, 3570 and 3820 kcal/kg dry matter of barley, maize and sorghum respectively and 3830 kcal/kg dry matter of skim-milk powder, while in *Futtermitteltabellenwerk, Rostock* (1970) the corresponding values are given as 3470, 3820 and 3610 kcal/kg dry matter for the grains and 3920 kcal/kg dry matter for skim-milk powder.

In the present investigation we have found about 6–12% higher metabolizable energy in barley, maize and sorghum than indicated in the literature mentioned which may be caused by the higher digestibility estimated in our experiments, as discussed in chapter 5.2. The figure for skim-milk powder is in correspondence with the references.

5.5. Conclusions

1. Digestibility of feed compounds

In the compounds consisting of barley, maize or sorghum combined with skim-milk powder the digestibility of organic matter, NFE, nitrogen and gross energy was higher than in the compounds of grain and protein mixture ($^2/_3$ soyabean-meal + $^1/_3$ meat-bone meal). (Tables 25-30).

The accuracy obtained in the determination of the digestibility coefficients was highest for NFE, the standard deviation (S.D.) in nearly all cases being below 1%. For organic matter and gross energy the range of S.D. was 0.5–2.4%, while the digestibility of nitrogen was determined with a somewhat lower degree of accuracy, in most cases the S.D. was between 2–3%. This may be caused by contamination with nitrogen from the urine, as the animals are allowed some freedom for their movements in the metabolic crates. The validity of the determinations of the nitrogen balances is not influenced by the lower accuracy obtained in determination of the nitrogen digestibility.

The low accuracy obtained in the determination of digestibility coefficients for crude fat is discussed and ascribed to the ether-extract method applied. It seems to be a very poor way of determining fat in faeces from pigs, and an analytical method including HCL-hydrolysis before ether-extraction must be preferred.

2. Digestibility of feed components

As we still have many gaps in our knowledge concerning the digestibility of the different feedstuffs used for different species, and as our ability to evaluate their feed values mainly are based on the digestibility, independent of the system preferred, it would be advantageous if results from digestibility trials with different compounds could be used to calculate the digestibility of the components used in the compounds.

A regression analysis based on the condition that the proportion between the components used in the compounds is not kept constant is demonstrated in Table 31. The results obtained by using such a model to estimate the digestibility of the components in question are discussed. A fairly high degree of accuracy is obtained for the determination of digestible organic matter, nitrogen, NFE and gross energy in barley, maize, sorghum and skim-milk powder and the results are compared with those given by other authors (Table 32).

3. Regression equations for calculating metabolizable energy in feed compounds

The individual observations for digested crude protein, crude fat, crude fibre and NFE have been used together with the observed metabolizable energy to establish regression equations for growing pigs in order to calculate metabolizable energy based on digested nutrient.

The regression coefficients obtained for each period (Table 33) by using regression models with or without intercept are discussed. Calculating with intercept gave biological unacceptable values for digested protein (x_1) and digested NFE (x_4), being above the theoretical values for total combustion. Calculating without intercept gave biological acceptable values for the regression coefficients and the estimates of the equations were nearly as good as in model with intercept, the S.D. of residuals being 1% of ME or below.

The regression equations obtained in period I (20–30 kg live weight) and period VIII (70–90 kg live weight) are compared with the equation given by *Schiemann et al.* (1971) for »adult« pigs (Table 34). The regression coefficient for digested NFE in period VIII is very close to the results obtained by »adult« pigs, while the factor for digested protein is more variable, depending on the intake of protein in relation to the requirement of the animals and of the biological value of the protein in question.

4. Estimates of metabolizable energy in feed components

In the present investigation with a steady increasing intake of grains and a constant intake of protein supply from period III it has been possible by means of a regression equation to estimate the content of metabolizable energy in the feed components applied. Values of 3700, 4050 and 4000 kcal/kg dry matter were found for barley, maize and sorghum respectively being 6–12% higher than values from the literature, caused by the higher digestibility found in the present investigation, as discussed in 5.2. For skim-milk powder a value of 3800 kcal/kg dry matter was found being in the range cited in the literature.

CHAPTER 6

Gas exchange and heat production in growing pigs fed different feed compounds

In the present investigation 381 respiration experiments with determination of the CO_2-production were carried out in all but for technical reasons only 367 measurements of the O_2-consumption were accomplished, and in this chapter only the figures from the complete respiration trials have been used to evaluate the gas exchange and heat production.

The values for heat production (RQ-method), protein gain and fat gain are calculated in accordance with the set of constants and factors accepted at the Third Energy Symposium, *Brouwer* (1965). (For details of calculation cf. chapter 3 p. 37). The values for heat production (CN-method) are determined by deducting the total energy gain (protein + fat gain) from the metabolizable energy.

The results have been used to evaluate the gas exchange and heat production (RQ) in growing pigs in relation to their live weight and intake of metabolizable energy. An attempt has then been made to formulate equations for gas exchange and heat production in relation to metabolic live weight; and finally the figures for heat production calculated according to the RQ or CN-methods have been compared and discussed.

6.1 Gas exchange and heat production in relation to live weight and intake of metabolizable energy

The individual measurements of live weight, intake of ME, gas exchange and heat production, (RQ), will be found in the main tables. From these figures mean values and standard deviation for each period including all 6 feed compounds, have been calculated and the figures are shown in Table 36.

It will be found that most of the values for the relative standard deviation for the mean values of live weight and intake of metabolizable energy are between 5 and 8%. The gas exchange and heat production are strongly influenced by the live weight of the animals and their intake of energy. As demonstrated in Table 36 the relative standard variations of the mean values for gas exchange and heat production are of the same magnitude as for the mean values of live weight and intake of ME.

The values for CO_2-production, O_2-consumption and heat production (RQ) in relation to live weight taken frem Table 36 have been graphically demonstrated in Fig. 24, 25, 26 and compared with the corresponding values obtained by *Breirem* (1935) and *Nielsen* (1970).

Table 36. Gas exchange and heat production (RQ). Series C-D-E-F. Mean of individual measurements of pigs on 6 different feed compounds

Tabel 36. Respiratorisk stofskifte og varmeproduktion (RQ). Serie C-D-E-F. Middel af individuelle målinger af svin på 6 forskellige foderblandinger

Period		Live weight		Intake of ME		CO_2-product.		O_2-product.		HP (RQ)	
no.	n	kg	S.D.	Mcal	S.D.	litres	S.D.	litres	S.D.	kcal	S.D.
I	36	23.0	2.7	2.56	0.16	430	28	432	37	2172	169
II	46	28.5	2.4	3.28	0.18	499	31	494	34	2494	165
III	48	34.7	2.7	3.92	0.20	564	28	545	37	2767	170
IV	47	42.6	2.9	4.80	0.32	648	45	613	45	3127	219
V	48	50.8	3.5	5.78	0.33	721	51	667	50	3408	252
VI	48	59.7	4.3	6.74	0.35	813	50	716	50	3714	248
VII	47	69.9	4.8	7.64	0.44	905	62	789	58	4102	290
VIII	47	80.3	5.4	8.57	0.50	991	76	858	71	4470	352

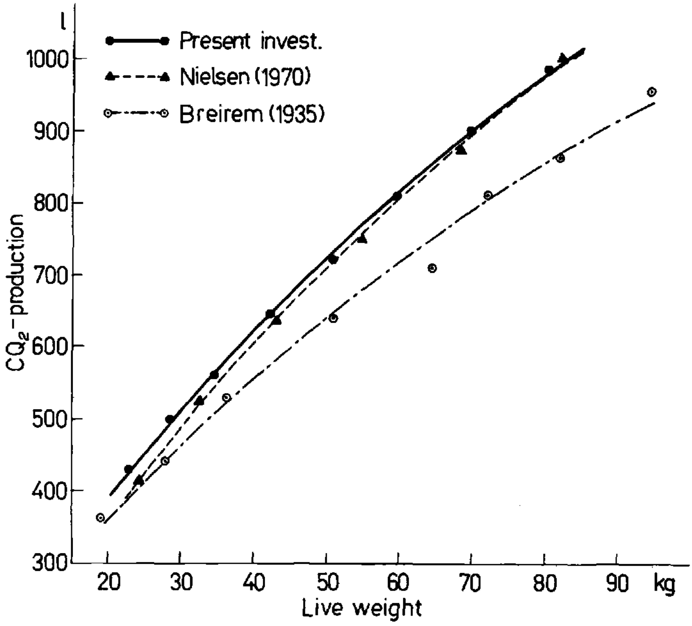

Figure 24.

CO_2-production in relation to live weight.

CO_2-produktion i relation til legemsvægt.

From the work of *Breirem* (1935), including 5 pigs on low protein intake, measured in 26 individual respiration experiments, the mean values for gas exchange and heat production at comparable live weights have been used for comparison. From the work of *Nielsen* (1970) with 80 pigs measured in 6 periods the data consisting of mean values for each of 4 pigs have been used, independently of the type of feeding.

It is clearly demonstrated that the curves for gas exchange and heat production in relation to live weight observed in the trials of *Breirem* are on a lower level than found in our investigation. In the live weight group from 20–30 kg the 24 hour CO_2-production was 35 l below and the O_2-consumption 80 l below our results, the difference increased to 125 l CO_2 and 155 l O_2 in the weight group from 80–90 kg. The difference in heat production (RQ) was 0.30 Mcal in the lower weight group increasing to 0.55 Mcal in the higher weight group.

The differences might be caused by the protein and energy norm used by *Breirem* (cf. chap. 4). The protein norm used for the pigs on »Low protein« was about 35% below our norm during the experimental time, so in spite of the ME-intake being 0.5 Mcal higher in the liveweight group from 20–30 kg in the

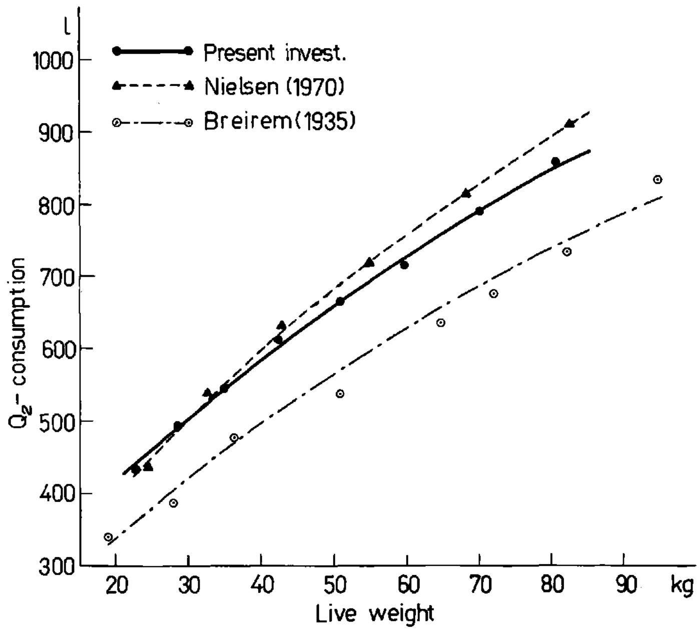

Figure 25.
O_2-consumption in relation to live weight.
O_2-forbrug i relation til legemsvægt.

experiments of *Breirem* (cf. Fig. 12) the lower protein intake may be responsible for the lower heat production of 0.30 Mcal. The reduced ME-intake of 1.4 Mcal in the live weight group from 80–90 kg together with the lower protein intake gave a heat production 0.55 Mcal below our results.

Comparing the present investigation with the results obtained by *Nielsen* (1970) it is striking how closely the curves for CO_2-production (Fig. 24) follow each other during the growth period from 20–90 kg, considering the many different types of feed compounds in question. The curves for O_2-consumption are identical too, in the lower weight classes, but with a greater slope of the curve from the observations of *Nielsen* a difference of about 50 l O_2 daily was found in the weight group from 80–90 kg, thereby causing a difference in the heat production of about 0.2 Mcal daily above the results obtained in the present investigation (Fig. 26).

As discussed in chapter 4 and demonstrated in Figure 12 the energy norm used by *Nielsen* was about 0.7 Mcal ME lower in the weight group from 80–90 kg than in the present investigation. With a lower ME-intake one would have expected a correspondingly lower heat production, but instead a somewhat higher heat production was found. This may be caused by the higher protein intake for the heavier pigs in the experiments of *Nielsen*. With the ratio of g digestible protein to Mcal metabolizable energy being fairly constant around

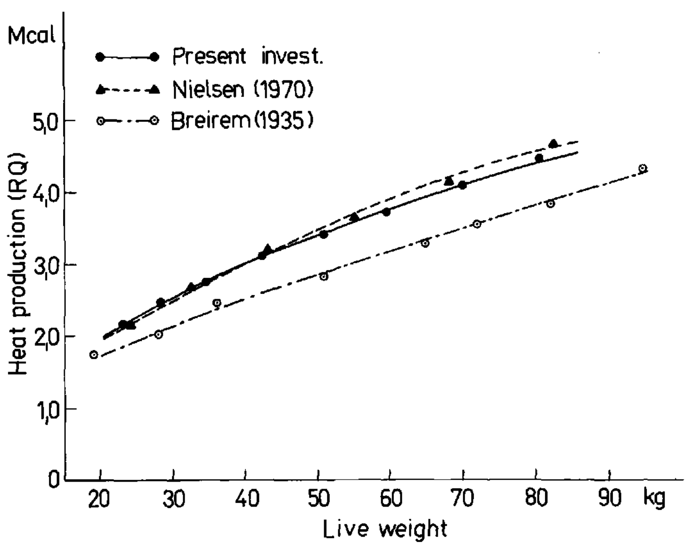

Figure 26.
Heat production (RQ) in relation to live weight.
Varmeproduktion (RQ) i relation til legemsvægt.

47, the norm apparently was above the requirement for maximum protein gain in the later weight classes, thereby causing a somewhat greater energy loss in urine. An excess of nitrogen intake above the requirement for maximum nitrogen retention will result in an excretion of the superfluous nitrogen as urea and this, being an oxygen consuming process, will increase the O_2-consumption and thereby increase the heat loss, as found from the trials of *Nielsen*.

In order to discuss the heat production found in the present investigation with figures commonly used for planning the ventilation in pigsties values for ME-intake, gas exchange and heat production have been estimated from Fig. 12, 24, 25 and 26 and compiled in Table 37.

Table 37. CO_2-production, O_2-consumption and heat production (RQ) in different live weight classes, estimated frem Fig. 12, 24, 25 and 26

Tabel 37. CO_2-produktion, O_2-forbrug og varmeproduktion i forskellige vægtklasser, aflæst fra Fig. 12, 24, 25 og 26

Live weight kg	Intake of ME Mcal	CO_2-product. litres	O_2-consumption litres	RQ	Heat product. (RQ) Mcal
20–30	2.75	450	460	0.98	2.25
30–40	4.05	570	545	1.05	2.80
40–50	5.25	675	620	1.09	3.20
50–60	6.30	770	695	1.11	3.60
60–70	7.30	860	790	1.13	3.95
70–80	8.15	940	820	1.15	4.25
80–90	8.90	1015	870	1.17	4.55

On the basis of the work of *Cords-Parchim* (1947), indicating a unit for heat production in milking cows of 775 kcal per hour for a body weight of 500 kg (GVE = Grossvieheinheit), *Korsgaard* (1951) proposed a unit for heat production (Vpe = Varmeproduktionsenhed) of 800 kcal per hour. Based on the existing measurements of heat production in pigs *Korsgaard* calculated for an »average« pig at 45 kg a heat production of 0.15 Vpe corresponding to 120 kcal per hour or 2.88 Mcal per 24 hour. Since that time it has been a commonly used procedure to calculate the heat production which could be expected in pigsty proportionally with the live weight of the pigs, based on 0.15 Vpe for a pig at 45 kg.

In an earlier investigation (*Ludvigsen & Thorbek,* 1955) a heat production of about 2.76 Mcal per 24 hour was found at an average live weight of 45 kg, being quite near the value of 2.88 Mcal. In the present investigation as well as in the trials of *Nielsen* (1970) the heat production is now found to be about 3.20 Mcal daily for pigs at 45 kg live weight (Table 37). The increment of about 10% above the former »norm« may be explained by the genetic development of the Danish Landrace and by a greater intake of energy and protein causing a higher heat production.

As clearly demonstrated in Fig. 26 and Table 37 the heat production at different live weight classes is not proportional to the live weight and the relation between heat production and live weight is not even a straight line. Therefore calculations of expected heat production based on proportional values will lead to erroneous results. In sties housing younger pigs the heat production would be underestimated, while it would be overestimated in sties with heavier pigs, as discussed by *Ludvigsen & Thorbek* (1955) and *Mathes & Bergner* (1963).

In conventional »mixed« sties with pigs in all weight classes the figures from the under- and overestimation of the expected heat production from the different weight group of pigs would balance each other, and no great error would occur by calculating the heat production proportional to live weight as has been done hitherto.

In »all in - all out« sties the estimated heat production would be too high when all the pigs are in the heavier weight group. At 40 kg the heat production would be around 3.0 Mcal daily, but doubling the live weight to 80 kg would not double the heat production to 6.0 Mcal daily, but only 4.4 Mcal could be expected. Calculating with proportional values for heat production in that type of pigsty would therefore give rather erroneous results. A better way of calculating the expected heat production in that type of sty would be to use values proportional to metabolic live weight as discussed in the next section.

6.2 Gas exchange and heat production in relation to metabolic live weight

The figures for mean live weight in the 8 experimental periods given in Table 36 have been transformed to metabolic live weight ($kg^{0.75}$) and plotted against the mean values for gas exchange and heat production in Figures 27 and 28.

This transformation of live weight clearly indicates a pronounced linear relation between gas exchange and heat production respectively to the metabolic live weight. By means of the 367 individual measurements indicated in the main tables, regressions of gas exchange and heat production (RQ) on metabolic live weight ($kg^{0.75}$) according to model 1, with intercept have been calculated and the regression equations for CO_2-production, O_2-consumption and heat production (RQ) are given in the first part of Table 38.

For reasons of comparison similar equations based on the work of *Nielsen* (1970) have been computed and added to the table. The data consists, as mentioned in the foregoing section, of the measurements of gas exchange in 80 pigs in 6 periods of different type of feeding ($n = 480$). The data has been grouped by *Nielsen* and is given as the mean of 4 pigs, thereby reducing the number of observations for this calculation to 120. From the work of *Verstegen* (1971) 109 observations concerning heat production in pair of pigs kept above the critical temperature have been used to compute the regression on metabolic live weight and the equation is also shown in Table 38.

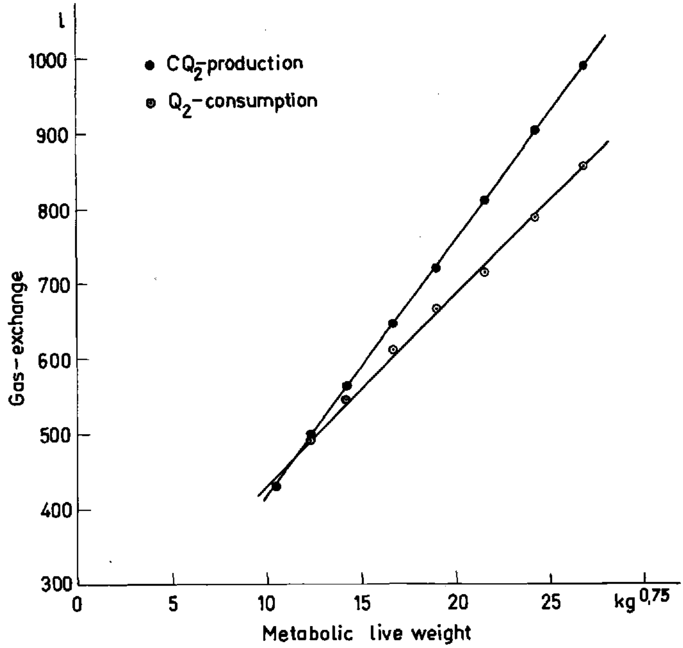

Figure 27.
Gas exchange in relation to metabolic live weight (kg$^{0.75}$).
Respiratorisk stofskifte i relation til metabolisk legemsvægt (kg$^{0.75}$).

Comparing the equations estimated from the results of *Nielsen* with the present investigation it is found that the standard deviations of the regression coefficient are of the same magnitude in the two investigations. A somewhat higher S.D. of the residuals are found in the present investigation compared with the trials of *Nielsen*, which may by explained by the fact that it was sought to have a rather large genetic variation between the animals in our experiments in order to facilitate a general application, as discussed in chapter 3. Furthermore the data of *Nielsen* consist, as mentioned, of mean values.

The curves obtained for heat production from the two trials are demonstrated in Figure 28. As discussed in the previous section the heat production in the trials of *Nielsen*, was somewhat higher for the heavier pigs, caused by an intake of protein being above the requirement for maximum protein retention. Nevertheless the curves are very similar, and the difference in heat production at 25 kg live weight (11.2 kg met. live weight) was found to be 2% lower in the trials of *Nielsen* and 3% higher at 85 kg (28.0 kg met. live weight) than in the present investigation.

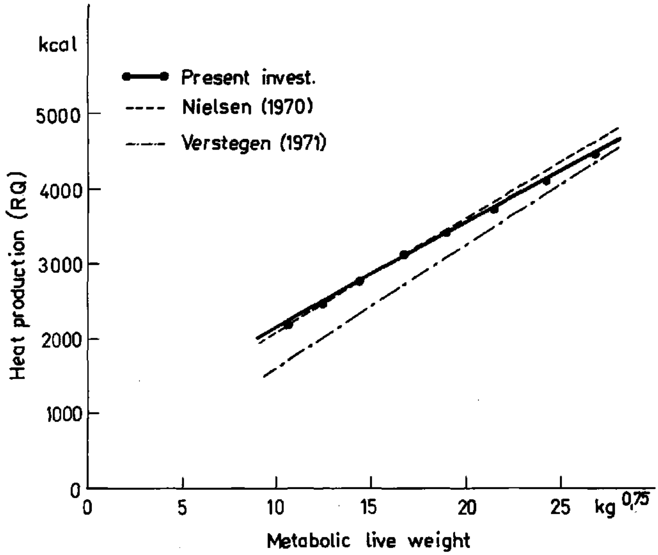

Figure 28.
Heat production (RQ) in relation to metabolic live weight ($kg^{0.75}$).
Varmeproduktion (RQ) i relation til metabolisk legemsvægt ($kg^{0.75}$).

Considering the many different types of feed compounds in question in the two trials it may be concluded that the equations given in Table 38 based on metabolic live weight would give reliable results for calculating the expected

Table 38. CO_2-production, O_2-consumption and heat production (RQ) in relation to metabolic live weight ($kg^{0.75}$) in growing pigs from 20–90 kg
Tabel 38. CO_2-produktion, O_2-forbrug og varmeproduktion (RQ) i relation til metabolisk legemsvægt ($kg^{0.75}$) hos voksende svin fra 20–90 kg

Present investigation. Series C-D-E-F. (n = 367)			
CO_2-production, litres	= (76 + 34.2 $kg^{0.75}$) ± 36	s_I = 7,	s_b = 0.35
O_2-consumption, litres	= (180 + 25.3 $kg^{0.75}$) ± 41	s_I = 8,	s_b = 0.40
Heat production (RQ), kcal	= (786 + 138 $kg^{0.75}$) ± 194	s_I = 36,	s_b = 1.87
Nielsen (1970). (n = 120)			
CO_2-production, litres	= (40 + 35.3 $kg^{0.75}$) ± 25	s_I = 8,	s_b = 0.40
O_2-consumption, litres	= (140 + 28.5 $kg^{0.75}$) ± 24	s_I = 7,	s_b = 0.38
Heat production (RQ), kcal	= (607 + 150 $kg^{0.75}$) ± 114	s_I = 36,	s_b = 1.84
Verstegen (1971). (n = 109)			
Heat production (RQ), kcal	= (–6 + 162 $kg^{0.75}$) ± 351	s_I = 101,	s_b = 5.25

heat production in a pigsty where the pigs are fed according to a norm for protein, securing maximum protein gain. Thereby the errors which would occur by calculating heat production proportionally to live weight, as discussed in the previous section, could be avoided.

The regression equation (Table 38) and curve (Fig. 28) for heat production based on observations made by *Verstegen* (1971) with pair of pigs kept above the critical temperature differ rather much from the results obtained with the respiration plant in Copenhagen. The intercept is not significant, the slope of the curve is much steeper and the standard deviation of the residuals is greater than in the trials from Copenhagen. At 25 kg live weight the heat production calculated according to the equation based on measurements of *Verstegen* was about 22% below the values obtained from the present investigation, while at 85 kg the difference was only about 2%. The rather low heat production in the first period of growth is probably connected with the protein norm applied, as the intake of ME is of the same magnitude as in the Danish investigations. Some nitrogen balances were determined by *Verstegen* indicating that the nitrogen intake for the lighter pigs was too low to secure maximum protein gain. In the weight group from 25–30 kg, seven pairs of pigs, had a mean nitrogen retention of 11.3 g daily, corresponding to 70 g protein. Based on the same live weight and intake of energy, a low protein norm will reduce the heat production, as demonstrated from the results of *Verstegen*.

In a recent paper, *Fuller & Boyne* (1972) have presented their results concerning the heat production in 18 pigs divided into 9 groups at different temperatures and levels of feeding, determined by means of a closed-circuit chamber. The mean values for the heat production of two pigs kept at 23°C and with a daily intake of 116 g food/$kg^{0.73}$, corresponding to the conditions in the present investigation, have been used for comparison. The figures for heat production given for live weight groups from 25–85 kg have been plotted against metabolic live weight. A linear function could be demonstrated, and a graphical estimate of the regression gave HP (RQ) = 500 + 140 $kg^{0.75}$, corresponding rather well with the equation derived from the trials of *Nielsen* and from the present investigation.

Close, Mount & Start (1971) have measured by direct calorimetry the heat losses in pigs from 30–40 kg live weight, housed in groups of 5 animals kept at different temperatures and levels of feed. Comparing their results from pigs kept at 20°C with the present investigation it was found that the heat loss was somewhat lower in groups of pigs, than in pigs kept singly. With approximately the same intake of energy and protein the difference was about 300 kcal at a live weight of 30 kg decreasing to 200 kcal at 40 kg. The heat loss was thereby 10 to 6% lower for group of pigs compared with our results with singly kept pigs.

6.3 Heat production calculated according to the RQ- or CN-method

In order to compare the values for heat production calculated according to the RQ or CN-method the mean values from each type of feeding and for each period are taken from the main tables and plotted against each other in Fig. 29.

It is obvious that the values from the experiments with barley and sorghum combined with skim-milk powder or protein mixture are close to each other and to the line of identity, while the figures for the maize compounds deviate rather much from the line of identity in the later part of the experiments.

For a closer inspection of the results obtained, regressions of heat production (RQ) on heat production (CN) have been computed according to model 2 without intercept and are shown in Table 39.

In the first part of the table the regressioncoefficients for each period, including all 6 feed compounds, are shown. The regression coefficients increase slowly through the periods from 0.98 to 1.04, the accuracy of the estimate is rather high with s_b varying from 0.004 to 0.009.

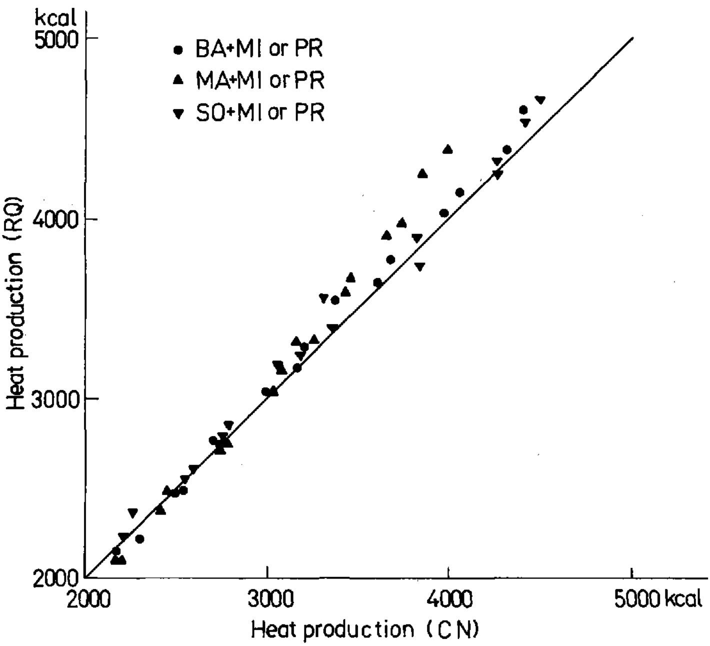

Figure 29.

Heat production calculated according to the RQ-method in relation to the values obtained by the CN-method.

Varmeproduktion beregnet efter RQ-metoden i relation til værdierne beregnet efter CN-metoden.

Table 39. Regression of heat production HP (RQ) on heat production HP (CN). Series C-D-E-F

Tabel 39. Regression af varmeproduktion HP (RQ) på varmeproduktion HP (CN). Serie C-D-E-F

Feed Compounds	Period no.	n	HP (RQ) kcal	HP (CN) kcal	Regr. coeff.	s_b
All compounds	I	36	2172	2209	0.983	0.0085
»	II	46	2494	2496	0.998	0.0044
»	III	48	2767	2734	1.012	0.0038
»	IV	47	3127	3074	1.015	0.0063
»	V	48	3408	3277	1.038	0.0068
»	VI	48	3714	3637	1.020	0.0054
»	VII	47	4102	3995	1.024	0.0054
»	VIII	47	4470	4268	1.044	0.0079
All compounds	Total	367			1.024	0.0024
BA+MI or PR	I–VIII	182	3321	3263	1.018	0.0031
SO+MI or PR	»	89	3442	3376	1.018	0.0042
MA+MI or PR	»	96	3194	3081	1.042	0.0054
BA+SO+MI or PR	I–VIII	271	3361	3300	1.018	0.0025
MA+MI or PR	I–V	60	2734	2719	1.007	0.0053
MA+ MI or PR	VI–VIII	36	3962	3686	1.075	0.0066

f-test for differences between regression coefficients

	n_1/n_2	f	
BA+XX/SO+XX	182/89	0.002	Not significant
BA+SO+XX/MA+XX	271/96	20.1	Significant > $f_{.001}$ = 11.1
MA+XX (I-V)/ MA+XX (VI-VIII)	60/36	69.4	Significant > $f_{.001}$ = 11.6

For all periods (n = 367) the regression coefficient was 1.024, s_b = 0.0024 indicating that the heat production calculated according to the RQ-method gave results about 2% higher than the values found by the CN-method. Thereby the energy gain calculated by means of the gas exchange (RQ) will be about 2% lower than the values obtained by determination of the nitrogen and carbon-balances (CN).

In the trials of *Nielsen* (1970) the energy gain calculated by the RQ-method was about 5% lower than by the CN-method. Compared with the slaughter technique *Nielsen* found that this method gave results 2.2% lower than the CN-method. It must be kept in mind that in slaughter technique some systematic errors exist, which will give values for the energy gain which are lower than the »true« values, while the systematic errors attached to the balance technique will accumulate to give figures for the energy gain higher than the true values, as found in the trials of *Nielsen*.

In the present investigation with feed compounds based on barley, maize or sorghum it was investigated whether any difference could be found between values for heat production obtained by the RQ or CN-method for the different grains.As graphically demonstrated in Fig. 29 the maize compounds deviate from the compounds of barley or sorghum and in the later part of Table 39 the regression coefficients for HP (RQ) on HP (CN) calculated for the different compounds through all periods (I–VIII) are shown.

For the compounds of barley combined with skim-milk powder or protein mixture a regression coefficient of 1.018, s_b = 0.0031 was found, for the sorghum compounds the regression coefficient was 1.018, s_b = 0.0042, while the value for the maize compounds was 1.042, s_b = 0.0054. A f-test showed that no significant difference between the regression coefficients for the compounds af barley (BA + XX) or sorghum (SO + XX) exists, but the difference between the regression coefficients for the maize compounds (MA + XX) and the barley and sorghum compounds together (BA + SO + XX) was highly significant ($f = 20.1 > f_{.001} = 11.1$).

The graph in Fig. 29 indicates for the compounds with maize an increasing deviation from the line of identity. In period I–V the mean heat production was 2734 kcal according to the RQ-method and 2719 kcal after the CN-method or a difference of o.7% while in period VI–VIII the mean values were 3962 kcal (RQ) and 3686 kcal (CN) respectively, and the difference between the regression coefficients of 1.007 and 1.075 was highly significant ($f = 69.4 > f_{.001} = 11.6$), indicating that an increasing intake of maize will influence the difference between the two ways of calculating the heat production.

The difference found between maize and the two other grains, barley and sorghum, as well as the difference found by increasing intake of maize may be explained by the fat content and the composition of fat in maize. As discussed by *Blaxter* (1962) the factors involved in calculation of heat production according to the RQ – method are based on the combustion heat from palmitic acid. For fatty acid with chain lengths less than that of palmitic acid, heat of combustion is overestimated, as is the case for unsaturated fatty acids. No determination of the fat composition from the different grains has been made, but usually the maize fat has a higher content of unsaturated fatty acids, which may explain the greater difference between the two methods of calculating the heat production.

Both ways of calculation include a set of factors, and as *Blaxter* (1962) writes: »even the best set of factors can provide no more than a statistical estimate of the heat produced, and no preference for one of the two methods could be given«. The difference of 2.4% found in the present investigation is rather low compared with the variation which could be expected in biological experiments, so both methods could be applied. In the present investigation 381 determinations of the CO_2-production were carried out, while for technical reasons only 367 determinations of the O_2-consumption were accomplished; therefore, in the following chapter, the use of the CN-method for calculation of the energy gain has been preferred.

6.4 Conclusions

1. In the present investigation above the critical temperature, gas exchange and thereby heat production (RQ-method) was found to be a curvilinear function of the animals body weight. In planning the ventilation in pigsties it is common to calculate with values proportional to live weight which will lead to rather erroneous figures for the expected heat production in »al in – all out« sties.
2. In transforming the observations of live weight to metabolic live weight ($kg^{0.75}$) a pronounced linear relation between gas exchange and heat production respectively to metabolic live weight was demonstrated. Regression equations for gas exchange and heat production were calculated and compared with equations obtained from observations made by other authers. The equations will give more reliable figures for expected gas exchange and heat production in pigsties than by calculating with values proportional to live weight.
3. The gas exchange and heat production is strongly influenced by the live weight of the animals, their intake of energy and environmental temperature, but from the present investigation compared with results obtained by other authors it was demonstrated that different levels of protein intake influence the heat production rather much, and should not be omitted in this context. An intake of protein above the requirement for maximal protein gain, will cause a higher O_2-consumption and a higher heat production.
4. A comparison has been made between values for heat production obtained by calculating according to the RQ or CN-method. A regression of HP (RQ) on HP (CN) for all the individual measurements ($n = 367$) gave a regression coefficient of 1.024, $s_b = 0.0024$. Compared with variations in biological experiments a difference of 2.4% between the two methods of calculations is reasonable. In the present investigation with more determinations of CO_2-production than of O_2-consumption the use of the CN-method in the further calculations has been preferred.
5. By using maize compounds a greater difference between the two ways of calculating heat production was found in the later periods with an increasing intake of maize, which may be explained by the fat content and the composition of fat in maize.

CHAPTER 7

Nitrogen metabolism in growing pigs fed different feed compounds

7.1. Own investigations

The nitrogen metabolism has been measured in balance experiments at regular time intervals in 48 growing pigs from 20 to 85 kg live weight, fed 6 different feed compounds. The nitrogen retention in relation to live weight, intake of digestible nitrogen and metabolizable energy will be discussed, as well as the efficiency of nitrogen utilization.

The nitrogen intake (NI) and the nitrogen losses in faeces (NF) and urine (NU) have been determined for each pig in 8 balance periods during the experimental time. On the basis of these figures the nitrogen balances (NBAL) have been calculated and all the individual figures are given in the main tables.

For the 6 different feed compounds in question the mean value of nitrogen retained and the calculated standard deviation (S.D.) have been compiled in Tables 40–45. The tables include mean values of live weight, intake of metabolizable energy, intake of nitrogen and digested nitrogen, all being factors affecting the nitrogen retention. (The intake of lysine and methionine + cystine is shown in Tables 21–23). The efficiency of nitrogen utilization is expressed as nitrogen retained as a percentage of nitrogen digested.

Summarizing the figures for energy intake for the feed compounds of grains and skim-milk powder (Tables 40, 42, 44), the intake of ME was 2.69 Mcal or

Table 40. Nitrogen metabolism in growing pigs in experiments with barley and skim-milk powder. Series C-D-E-F. Mean of 12 pigs

Tabel 40. Kvælstofomsætning hos voksende svin i forsøg med byg og skummetmælkspulver. Serie C-D-E-F. Middel af 12 svin

Period no.	Live weight kg	Metab. energy Mcal	Nitrogen intake g	Nitrogen digested g	Nitrogen retained g	Nitrogen retained S.D.	N-retained in relation to N-digested %
I	24	2.66	22.7	19.0	11.5	1.3	61
II	29	3.38	28.5	23.9	14.3	1.8	60
III	36	4.02	33.4	28.2	16.2	1.7	57
IV	43	4.88	37.5	32.1	17.2	2.5	54
V	52	5.87	42.7	35.8	19.2	2.2	54
VI	61	6.80	47.0	39.4	20.0	2.3	51
VII	73	7.74	51.2	42.7	20.3	2.7	48
VIII	83	8.66	54.6	45.2	20.3	2.3	45

Table 41. Nitrogen metabolism in growing pigs in experiments with barley and protein mixture. Series C-D-E-F. Mean of 12 pigs

Tabel 41. Kvælstofomsætning hos voksende svin i forsøg med byg og proteinblanding. Serie C-D-E-F. Middel af 12 svin

Period no.	Live weight kg	Metab. energy Mcal	Nitrogen intake g	Nitrogen digested g	Nitrogen retained g	Nitrogen retained S.D.	N-retained in relation to N-digested %
I	23	2.49	26.6	21.3	11.7	1.0	55
II	29	3.15	33.6	26.9	14.8	1.6	55
III	35	3.75	39.3	31.7	16.5	2.0	52
IV	43	4.60	43.5	34.9	17.7	2.2	51
V	51	5.64	48.2	38.9	19.6	2.9	50
VI	60	6.51	52.6	42.1	19.9	3.0	47
VII	70	7.42	56.7	45.2	20.9	2.5	46
VIII	80	8.35	60.1	47.8	20.4	1.9	43

251 kcal ME/kg$^{0.75}$ in period I, increasing to 8.72 Mcal or 324 kcal ME/kg$^{0.75}$ in period VIII. The corresponding values for the compounds of grains and protein mixture (Tables 41, 43, 45) were slightly lower, being 2.51 Mcal or 239 kcal ME/kg$^{0.75}$ in period I and 8.45 Mcal or 318 kcal ME/kg$^{0.75}$ in period VIII.

The amount of digested nitrogen was 19.1g in period I for the skim-milk compounds, increasing to 44.6 g in period VIII. In the compounds with protein mixture somewhat higher values were found, 21.2 g digested N in period I and 47.6 g in period VIII. The differences between the compounds are caused by the higher content of digestible nitrogen in the protein mixture, being 6.1% against 5.2% in the skim-milk powder (cf. Tables 8 and 31).

The relation between protein and energy intake expressed as the ratio of g digestible protein/Mcal ME was 44 in period I for the skim-milk compounds, decreasing to 32 in period VIII and for the compounds containing protein mixture the corresponding values were 53 decreasing to 35. The reduction of the ratio from period I to period VIII was caused by the norm used consisting of a steady increasing intake of grains but with a constant intake of skim-milk powder or protein mixture from period III (cf. Tables 5 and 6).

The content of lysine was determined for each feed component for each period. In the experiments with barley and skim-milk powder or barley and protein mixture the intake of total lysine was rather identical, being 9.6 g in period I increasing to 19.8 g in period VIII (Table 21). In the experiments with maize or sorghum combined with skim-milk powder or protein mixture (Tables 22, 23) the mean intake of lysine was 8.8 g in period I increasing to 16.5 g in period VIII, thereby being 9 to 20% lower than in the experiments with barley. In the present investigation no determination of the availability of the lysine was carried out.

Table 42. Nitrogen metabolism in growing pigs in experiments with maize and skim-milk powder. Series C-E. Mean of 6 pigs

Tabel 42. Kvælstofomsætning hos voksende svin i forsøg med majs og skummetmælkspulver. Serie C-E. Middel af 6 svin

Period no.	Live weight kg	Metab. energy Mcal	Nitrogen intake g	Nitrogen digested g	Nitrogen retained g	Nitrogen retained S.D.	N-retained in relation to N-digested %
I	22	2.63	21.2	18.5	10.9	0.4	59
II	27	3.34	27.1	23.8	14.3	0.6	60
III	34	4.00	31.3	27.6	14.9	1.3	54
IV	42	4.83	34.9	30.6	15.7	1.3	51
V	50	5.79	39.7	34.9	17.1	1.1	49
VI	58	6.79	43.3	38.0	18.5	1.7	49
VII	68	7.63	46.9	41.0	19.1	1.7	47
VIII	77	8.49	50.2	42.9	19.0	1.5	44

The nitrogen retention measured at regular time intervals from 20 to 85 kg live weight for all feed compounds in question was of the same magnitude for each period, and no significant differences between the 6 compounds could be found. In the first period with a live weight about 23 kg the mean nitrogen retention for all compounds was 11 g increasing to about 20 g in period VI, where the mean live weight was 60 kg. Then the nitrogen retention was fairly constant, around 20 g in the two following periods at 70 and 80 kg live weight, even if some pigs showed a declining nitrogen retention in the last period.

The mean nitrogen retention for each period and for each compound are determined with standard deviation ranging from 0.4 to 3.0 g, as demonstrated

Table 43. Nitrogen metabolism in growing pigs in experiments with maize and protein mixture. Series C-E. Mean of 6 pigs

Tabel 43. Kvælstofomsætning hos voksende svin i forsøg med majs og proteinblanding. Serie C-E. Middel af 6 svin

Period no.	Live weight kg	Metab. energy Mcal	Nitrogen intake g	Nitrogen digested g	Nitrogen retained g	Nitrogen retained S.D.	N-retained in relation to N-digested %
I	22	2.44	25.5	21.1	11.6	0.6	55
II	27	3.10	32.7	27.3	15.3	0.9	56
III	33	3.73	37.6	31.4	16.3	1.1	52
IV	41	4.51	41.2	34.5	16.8	1.3	49
V	49	5.40	45.6	37.9	18.2	0.8	48
VI	57	6.50	49.3	41.8	19.9	1.5	48
VII	67	7.27	52.8	44.5	19.5	2.2	44
VIII	77	8.23	56.1	47.2	19.6	1.4	42

Table 44. Nitrogen metabolism in growing pigs in experiments with sorghum and skim-milk powder. Series D-F. Mean of 6 pigs

Tabel 44. Kvælstofomsætning hos voksende svin i forsøg med milo og skummetmælkspulver. Serie D-F. Middel af 6 svin

Period no.	Live weight kg	Metab. energy Mcal	Nitrogen intake g	Nitrogen digested g	Nitrogen retained g	Nitrogen retained S.D.	N-retained in relation to N-digested %
I	24	2.81	23.8	19.9	10.8	1.1	54
II	29	3.54	29.2	25.0	13.7	2.1	55
III	35	4.21	34.8	29.4	16.3	1.8	55
IV	43	5.16	39.7	32.9	17.2	2.1	52
V	51	6.14	43.8	35.9	18.3	1.6	51
VI	60	7.15	49.3	40.1	20.0	2.6	50
VII	71	8.09	53.5	43.2	20.0	2.1	46
VIII	80	9.05	56.6	45.0	20.5	2.7	46

in Tables 40 to 45. Unexpectedly the greatest standard deviations are found in the experiments with barley compounds, in spite of the number of animals being twice the numbers as in the experiments with sorghum compounds. The accuracy of the determination of the nitrogen retention is influenced 1) by experimental errors, 2) by variation between animals and possibly 3) by variation in the chemical composition of the feed compounds applied. In order to evaluate the influence of the different sources of errors, a closer inspection of the values obtained has been carried out and the results are discussed in the following.

Table 45. Nitrogen metabolism in growing pigs in experiments with sorghum and protein-mixture. Series D-F. Mean of 6 pigs

Tabel 45. Kvælstofomsætning hos voksende svin i forsøg med milo og proteinblanding. Serie D-F. Middel af 6 svin

Period no.	Live weight kg	Metab. energy Mcal	Nitrogen intake g	Nitrogen digested g	Nitrogen retained g	Nitrogen retained S.D.	N-retained in relation to N-digested %
I	24	2.60	27.1	21.0	11.2	0.6	53
II	29	3.29	33.8	26.9	14.6	0.5	55
III	35	3.92	40.2	32.0	17.2	1.1	54
IV	43	4.95	45.3	35.9	18.5	1.5	51
V	51	5.86	49.0	37.9	19.4	2.0	51
VI	60	6.83	54.6	42.1	20.3	1.5	48
VII	71	7.80	58.6	44.7	20.2	2.0	45
VIII	81	8.86	62.5	47.5	20.3	1.7	43

The experimental errors including accurary in procedure of weighing, feeding, collecting faeces and urine and mixing the samples together with the accuracy of the chemical analysis have been discussed earlier (cf. chapter 3). The accuracy obtained in the determination of digestibility of organic matter, nitrogen free extracts, nitrogen and energy, which includes the errors mentioned, indicates that the experimental errors are rather low and acceptable (cf. chapter 5).

In order to facilitate the general application of the results obtained, it was purposely sought to have a rather large variation between animals, using 12 different litters in all as discussed in chapter 3 and shown in Table 4. A rather large variation in the animals capability for protein formation could therefore be expected, influencing the accuracy in the determination of the mean nitrogen retention. The question remains whether the nitrogen retention observed for the individuals is randomized in the whole range of variation or whether the animals keep their individual parameter with rather small variations around their nitrogen curve. In the last case it should be possible to verify different levels and rather constant differences between the individual observations.

In order to demonstrate the individual levels for nitrogen retention the highest and lowest values found for each series in the experiments with barley and skim-milk powder are shown in Table 46. It is characteristic that the animals keep their own level giving »high« or »low« nitrogen retention curves, the values for the individuals are not mixed and constant differences are maintained. In series C the mean difference between »high« and »low« nitrogen retention for the eight periods was 3.6 g being significant ($t = 4.7 > t_{.01} = 3.5$). Between D. 1. and D. 3. the mean difference of 2.5 g was highly significant ($t = 9.9 > t_{.001} = 5.4$) and for series E and F the differences were 3.0 and 1.3

Table 46. Highest and lowest individual values for nitrogen retention obtained in experiments with barley and skim-milk powder. Series C-D-E-F

Tabel 46. Højeste og laveste individuelle værdier for kvælstofaflejring målt i forsøg med byg og skummetmælkspulver. Serie C-D-E-F

Period No.	Series C No. 1 g	Series C No. 2 g	Series D No. 1 g	Series D No. 3 g	Series E No. 1 g	Series E No. 3 g	Series F No. 1 g	Series F No. 3 g
I	12.3	11.8	14.4	12.0	12.1	9.8	11.2	9.8
II	16.6	14.9	16.5	14.4	14.8	12.9	12.6	10.3
III	17.8	15.4	19.4	16.8	15.5	13.0	17.2	14.3
IV	19.7	15.7	21.2	17.9	15.1	12.4	17.2	17.2
V	21.8	17.8	22.1	18.6	18.9	14.3	19.8	17.8
VI	24.7	19.0	22.3	20.0	18.9	15.6	19.8	20.0
VII	22.8	19.4	22.4	19.7	18.6	14.5	23.2	21.5
VIII	24.4	17.1	21.5	20.3	18.5	16.3	22.3	22.0

respectively. With t-values of 8.6 and 3.4 the differences were highly significant in series E (P% < 0.1) and significant between the 5% and 1% level in series E. A similar investigation for the experiments with barley and protein mixture showed the same picture of pigs maintaining a »high« or a »low« nitrogen retention curve. The mean differences for each series were of the same magnitude as in the experiments with barley and skim-milk powder and were all significant.

Concerning the problem of variation in the nitrogen content in the barley applied it is obvious that different levels of nitrogen retention are found in the different series. The highest nitrogen retention was obtained in series C and D, while a lower level was maintained in series F and an even lower one was found in series E. The mean difference between series (C + D) and E for both compounds during 8 periods was 3.0 g nitrogen and the difference was highly significant ($t = 9.0 > t_{.001} = 4.07$, d.f. = 15). Between series (C + D) and F the difference for the barley and skim-milk compounds was 1.3 g nitrogen being significant (P% < 1) and for the barley and protein mixture compound the difference was 2.1 g nitrogen, being highly significant (P% < 0.1). The reason for the significant differences in nitrogen retention obtained in the different series may be explained by variation in the nitrogen content in the barley used in the different series. As discussed in chapter 3 the lot of barley used in series E had a rather low nitrogen content, being 1.22% compared with 1.57%, 1.62% and 1.54% nitrogen in the barley used for series C, D and F respectively (cf. Table 7).

It may be concluded that the variation between the animals in their capability to form protein, and the variation in the chemical composition of the grains used in the different series, are the main source of variations causing the rather low accuracy in the determination of the mean nitrogen retention for each period, demonstrated in Table 40–45. Nevertheless, for a broader application of the results obtained we have preferred to demonstrate the range of variations which could be expected between individual pigs, and between different lots of the same kind of grain instead of trying to keep the variations as small as possible.

The efficiency of nitrogen utilization expressed as nitrogen retained in percent of digested nitrogen was lowest in the compounds containing protein mixture caused by the somewhat higher amount of digestible nitrogen in these compounds, but no great differences were found. In period I the mean efficiency was 58% for the skim-milk compounds and 54% for the compounds with protein mixture decreasing to 45% and 43% respectively in period VIII. The rather high efficiency of nitrogen utilization maintained during the growth period is caused by the energy and protein norm applied. As discussed in chapter 4, we have tried, on the basis of our experience, to find a norm which could secure maximum nitrogen retention combined with a low nitrogen loss in urine.

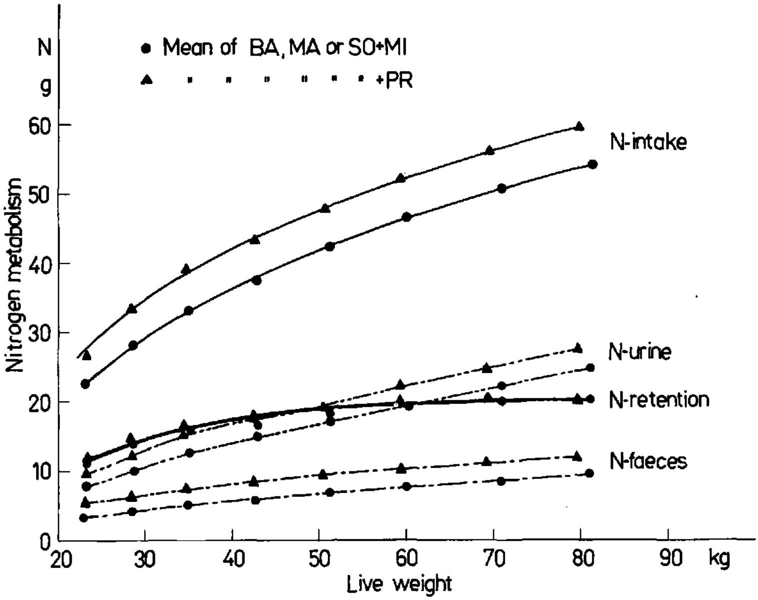

Figure 30.

Intake of nitrogen, excretion of nitrogen and nitrogen retention in relation to live weight. Compounds of grains combined with skim-milk powder or protein mixture.

Tilført kvælstof, udskillelse af kvælstof og aflejret kvælstof i relation til legemsvægten. Korn i blanding med skummetmælkspulver eller proteinblanding.

For a closer inspection of the nitrogen metabolism in relation to live weight a graph has been drawn (Fig. 30) demonstrating the mean values for nitrogen intake, nitrogen losses in faeces and urine together with the nitrogen retention for the two groups of compounds with skim-milk powder or protein mixture. The curves demonstrate clearly the higher nitrogen intake from the compounds with protein mixture, but with the higher excretion of nitrogen in faeces and urine for these compounds the curve for nitrogen retention was rather identical with the curve obtained by feeding with skim-milk compounds. The graph demonstrates that the nitrogen retention in the present investigation was curvilinear in relation to live weight from 20 to 60 kg and then nearly linear until 80 kg live weight. As some investigators express the nitrogen retention as a linear function of the live weight in the power of 0.67, the mean nitrogen retention observed in the present investigation has been plotted against $kg^{0.67}$, but no linear function could be found covering the range of live weight from 20 to 85 kg.

By transforming the live weight to metabolic live weight ($kg^{0.75}$) it was sought

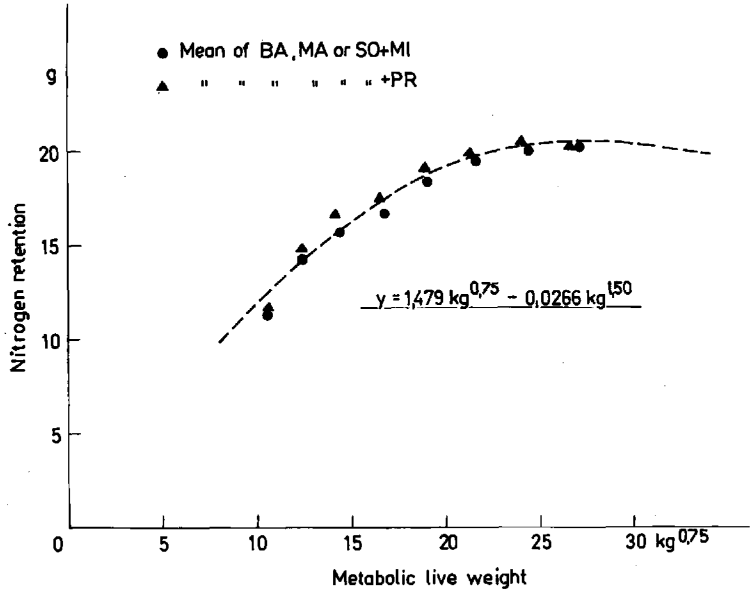

Figure 31.
Nitrogen retention in relation to metabolic live weight ($kg^{0.75}$).
Kvælstofaflejring i relation til metabolisk legemsvægt ($kg^{0.75}$).

to find a linear function between nitrogen retention and metabolic live weight. The graph obtained (Fig. 31) shows that it is not possible to fit a linear relationship between nitrogen retention and metabolic live weight ($kg^{0.75}$) covering the range in live weight from 20 to 85 kg. Inspecting the curve obtained, and assuming that the nitrogen retention would start at zero at the moment of conception, increasing to a maximum and then declining to zero values for the adults, it seems reasonable to apply a quadratic function: $y = Ax + Bx^2 + C$, with $x = kg^{0.75}$. By means of a regression analysis and using all the individual measurements of nitrogen retention and live weight (n = 381) the following function through the origin (C = O) was found:

Nitrogen retention, g	=	$1.479\ kg^{0.75}$ –	$0.0266\ kg^{1.50}$
s_b	:	0.023	0.0011
SD of residual	:	1.99	

From the equation the maximum retention was calculated as 20.6 g nitrogen at a metabolic live weight of 27.8 $kg^{0.75}$, corresponding to 84 kg live weight.

7.2. Discussion

For many years it has been discussed whether the nitrogen retention in growing animals should be considered as a function of external factors such as nitrogen and energy intake or as a function of internal factors i.e. the capacity of the cells to form protein, depending on the animals' body weight, age, genetic structures etc. *Miller & Payne* (1963) have in their publication »A Theory of Protein Metabolism« distinctly expressed the nitrogen retention in growing pigs as a function of protein intake, »chemical score« and energy intake, but they stressed that the theory has only been tested using data obtained from young growing animals. From his work concerning »The Theory of Growth-Measuring« *Møllgaard* (1955) concluded, using the data from measurements of nitrogen-calcium- and phophorus balances from 35 growing pigs in the age from 60 to 200 days, that »the quotient pro time differential within a certain time interval never will be constant, but always a function af age«. This indicates the existence of a maximum level for nitrogen retention related to age.

As discussed in detail by *Hock & Pürschner* (1966), *Gebhardt* (1966) and *Kielanowski* (1972) these two points of view are to some extent contradictory. In an attempt to combine the two theories *Kielanowski* assumes that pigs in their first period of growth have such a great capability of forming protein that the maximum level corresponding to their age could never be reached under practical feeding conditions. Thereby the nitrogen retention in the young animals would be a function of protein and energy intake, according to the theory of *Miller & Payne* (1963). Assuming that the capability for protein formation decreases with increasing age, the animals are then, at later ages, able to reach the maximum level for nitrogen retention on a certain level of protein – and energy intake. On reaching the maximum level a further increment of protein and/or energy will not influence the nitrogen retention but the retention will be a function of age, according to the theory of *Møllgaard* (1955).

Before discussing a function for nitrogen retention, based on the present observations the results obtained should be compared with values from the literature. As early as in 1935 *Lund* gave a curve for maximum nitrogen retention in female pigs of Danish Landrace from 20 to 100 kg live weight. His results showed a nitrogen retention of 14 g at 20 kg live weight increasing to 23 g at 60 kg and then declining to 19 g nitrogen daily at 100 kg live weight. Considering that the results were obtained with female pigs, expected to gain about 2–3 g more per day than the castrated male, it is remarkable that 40 years ago pigs of Danish Landrace had such a great capability for protein formation.

For reasons of comparison the nitrogen retention observed by different investigators have been compiled in Table 47. The table includes measurements carried out with artificially reared baby pigs (males and females) from 5 to 20 kg and from measurements with castrated males from 20 to 100 kg live weight. Different breeds have been used for the investigations such as »Danish

Table 47. Nitrogen retention (g/daily) in growing pigs at different live weight groups. Compiled from the literature

Tabel 47. Kvælstofaflejring (g/daglig) hos voksende svin i forskellige vægtklasser. Sammenstillet fra litteraturen

Ref nos.	5-10 kg	10-15 kg	15-20 kg	20-30 kg	30-40 kg	40-50 kg	50-60 kg	60-70 kg	70-80 kg	80-90 kg	90-100 kg	Nos. of animals	Investigators	Ref. nos.
1			11.0	17								4	Evans, R. E. (1958)	1
2	10.8	13.0	14.5									8	Ludvigsen, J. & Thorbek, G. (1959)	2
3		11.2										6	Jones, A. S. et al. (1960)	3
4	9.3	11.3	14.8									4	Hencken, H. et al. (1963 a)	4
5		11.3										6	Stein, J. & Gebhardt, G. (1971)	5
6				14	16	15			18	17		4	Ludvigsen, J. & Thorbek, G. (1955)	6
7				19	20	22	21	23		23	22	6	Hencken, H. et al. (1963 b)	7
8						22	20		19	16		4	Rérat, A. & Henry, Y. (1964)	8
9				16	17	18	18	18	18	16	17	8	Oslage, H. J. et al. (1966)	9
10								22	22	22		6	Poppe, S. & Wiesemüller, W. (1968)	10
11						20		21		19		6	Wiesemüller, W. & Poppe, S. (1968)	11
12					20							3	Wiesemüller, W. & Poppe, S. (1969)	12
13				14	18		22		23			8	Bowland, J. P. et al. (1970)	13
14				12	15	18	19	19		20		40	Nielsen, A. J. (1970)	14
15				12	15	16	18					16	Gebhardt, G. & Müller, H. (1971)	15
16						22			22		16	6	McConnell et al. (1971)	16
17					14		17		19		16	8	Homb, T. (1972 a)	17
18				17	19	20		24	21	23		8	Wenk, C. (1973)	18
Mean .... (Ref. nos. 1–18)	10.1	11.7	13.4	15	17	19	19	21	20	20	18			
19				13	16	18	19	20	20	20		48	Thorbek, G. Present invest.	19

Landrace« (ref. nos. 2, 6, 14, 19), Landrace × Wessex (ref. no. 3), »Large White« (ref. no. 8), »Deutsches veredeltes Landschwein« (ref. nos. 4, 7, 9), »Veredeltes Landschwein«, SPF (ref. nos. 13, 18), »Fleischschweintypes« (ref. nos. 5, 15), and »Lean Types« (ref. no. 16). The type of breeds used in ref. nos. 1, 10, 11, 12, 17 is not indicated in the papers. The values shown in Table 47 are mean values taken from the measurements carried out by the different investigators where the intake of protein, including its biological value, and the intake of energy are considered to be on a level securing maximum nitrogen retention for the live weight group in question.

Most of the investigators have found a variation of 3–5 g in nitrogen retention between animals whichs corresponds to the variation we have found in our experiments as discussed on p. 96–98, indicating that the individuals keep their parameter concerning nitrogen retention during the growth period, obviously connected with the genetic structure of the individuals.

As the maximum nitrogen retention found by the different investigators in most cases shows the same picture, mean values have been calculated for each live weight group and the values are shown in Table 47. The figures indicate an increasing nitrogen retention until 60–70 kg live weight with highest increment for the young pigs. After maintaining a »constant plateau« the nitrogen retention shows a declining tendency from about 80–90 kg live weight.

The results obtained from the present investigation with 48 barrows are rather similar to the values found in the literature except for the first periods where we have found lower values, indicating that the maximum level has not been achieved. A lower nitrogen retention may be caused by a low nitrogen and/or energy intake. From Fig. 30 it may be concluded that the nitrogen intake in the present investigation should have been sufficient to secure maximun retention as the higher intake of digestible protein in the compounds with protein mixture has not influenced the nitrogen retention but only caused an increased nitrogen loss in urine. Therefore the conclusion may be that the intake of metabolizable energy in per. I-II must have been below the optimum level for securing maximum nitrogen retention. In period I the energy intake for the compounds with protein mixture was 239 kcal ME/kg$^{0.75}$ and 251 kcal ME/kg$^{0.75}$ for the skim-milk powder compounds both corresponding to about 300 kcal Gross Energy /kg$^{0.75}$. According to the equation given by *Miller & Payne* (1963) a nitrogen retention of about 13 g could be expected at an energy intake of 300 kcal GE/kg$^{0.75}$ at a live weight of 10 kg$^{0.75}$ corresponding to 25 kg, which is exactly the value we have found in the present investigation. To obtain a nitrogen retention of about 16 g at 25 kg the energy intake should be about 350 kcal GE/kg$^{0.75}$ corresponding to 280–300 kcal metabolizable energy depending on the compounds in question. In the present investigation with restricted feeding it is questionable if pigs on grain compounds without energy-rich additives, are able to eat feed enough to secure an energy intake of about 3000 kcal ME daily at 20–25 kg live weight. The possibility of increasing the energy intake in young pigs by adding fat to the feed compounds and thereby influencing the nitrogen retention is still open for discussion.

Excluding period I with the rather low nitrogen retention, caused by the low energy intake, the values obtained in the present investigation up to 50–60 kg live weight fit very well in the linear functions given by *Miller and Payne* (1963) and by *Gebhardt and Müller* (1971) for maximum nitrogen retention, based on data from experiments with pigs from 20 to 60 kg related to metabolic live weight expressed as $kg^{0.73}$ or $kg^{0.67}$. However, as demonstrated in Fig. 31 the linear function does not fit over the whole range of live weight from 20 to 85 kg, (9.5–28.0 $kg^{0.75}$). The curve indicates a quadratic function, which by using all the individual measurements (n = 381) gave max. N-retention, g = 1.479 $kg^{0.75}$ – 0.0266 $kg^{1.50}$, s_b= 0.023 and 0.0011 respectively and ± 1.99 g as S.D. of residual.

Comparatively few measurements of nitrogen retention are made with heavier pigs. In the trial of *Oslage, Fliegel, Farries & Richter* (1966) (Table 47, ref. no. 9) with 8 barrows from 20–100 kg the measurements were continued with 3 of the pigs showing a declining nitrogen retention of 14 g at 150–160 kg, and 12 g at 160–170 kg live weight. In their investigation with pregnant and non-pregnant gilt *Elsley, Anderson, MacDonald, MacPherson & Smart* (1966) found a mean nitrogen retention of 12 g for the non-pregnant gilts at 150–160 kg live weight. Using the quadratic function mentioned above, a maximum nitrogen retention of 13 g and 11 g would be expected at 160 and 170 kg live weight respectively, which is close to the values determined. The quadratic function based on the results from the present investigation seems to fit rather well with the observations made by other investigators concerning the maximum nitrogen retention in pigs from 20–30 kg to 160–170 kg live weight, while the investigations carried out with artifically reared baby pigs, both males and females, indicate values above the figures calculated by means of the function.

In accepting the exsistence of a maximum level for nitrogen retention being a function of the capacity of the cells to form protein, depending on age, cell-masses and genetic structure the main problem in practical feeding is how to combine intake of energy and protein in the most economic way to achieve that maximum retention. On reaching the individual maximum for nitrogen retention, an extra supply of protein will not increase the protein gain, the superfluous nitrogen will be excreted in the urine while the nitrogen-free part will be used for fat formation. As the formation and excretion of urea is an energy consuming process, a protein intake above the requirement will cause an increased heat loss. By using feed compounds with a constant composition, there is a great risk of a high excretion of nitrogen in the urine in the later part of the growth period, combined with a greater heat loss, and a decreased energy utilization of the feed compound in question, as discussed earlier. It may be concluded from the present investigation that an intake of about 125 g digestible protein with 9–10 g total lysine at 20 kg live weight increasing to about 280 g digestible protein with 19–20 g total lysine at 80 kg would secure maximum nitrogen retention if the energy intake is about 300 kcal ME/kg$^{0.75}$ at 20 kg increasing to about 320–330 kcal ME/kg$^{0.75}$ for the heavier pigs depending on the fat deposition wanted.

The amount of total lysine corresponds well with the norm given by *Clausen, Eggum, Hansen & Madsen* (1961) but is slightly higher than the norm indicated by *Poppe & Wiesmüller* (1968). In the present investigation there was no attempt to determine the amount of available lysine, and as discussed by *Eggum* (1967, 1970) it is not possible to form a direct conclusion from the digestibility of nitrogen to the availability of lysine as this proportion shows a great variance from concentrated feedstuffs to grains, which means that a certain content of total lysine does not automatically guarantee a corresponding nutritive value.

It is common to express the efficiency of nitrogen utilization as a percentage of the ratio : Nitrogen retained, g / Apparently digested nitrogen, g (Gross efficiency, $k_{A\text{-total}}$) and to demonstrate a decreasing efficiency by increasing age or live weight. Accepting a maximum level for nitrogen retention it is obvious that an intake of digestible protein above the requirement for maximum retention will decrease the ratio, not as a function of the animal but as a function of the norm applied.

In the present investigation, with a protein norm following the requirement for protein gain rather closely, the $k_{A\text{-total}}$ was 58% for the skim-milk compounds and 54% for the protein mixture compounds in period I decreasing to 45% and 43% respectively in period VIII. In the trials of *Nielsen* (1970) the $k_{A\text{-total}}$ for barrows was 59% at 20–25 kg, decreasing to 34% at 80–90 kg live weight owing to the norm used. With a constant composition of the feed compounds during the growth period the intake of digestible protein was above the requirement for maximum protein gain for the heavier pigs, thereby causing low values for $k_{A\text{-total}}$.

As discussed in detail by *Homb* (1972b) and in accordance with the results obtained in the present investigation it should be possible to reach the level for maximum protein gain and to keep the values for $k_{A\text{-total}}$ in the range from 55–45% during the growth period from 20–90 kg live weight. With the shortage of protein in the world it is of the greatest importance to feed the animals in such a way that the maximum protein gain is achieved with the highest possible efficiency of nitrogen utilization.

7.3. Conclusions

1. The nitrogen metabolism in 48 growing barrows fed 6 different compounds have been measured in 8 balance periods each from 20 to 85 kg live weight.
2. The mean nitrogen retention for the 8 periods increasing from 11 to 20 g daily was determined by a standard deviation ranging from 0.4 to 3 g caused by the great variation between animals.
3. The variation in nitrogen retention between animals ranging from 2–5 g is in accordance with the variation found by other investigators. From the present investigation it has been demonstrated that the observations are not scattered over the whole range of variations but the animals are keeping their individual parameter, being »high«, »medium« or »low«, with fairly small variations around their individual nitrogen retention curve.
4. The values for the nitrogen retention from 20 to 85 kg live weight are compared with values for maximum nitrogen retention measured by other investigators and it is concluded that except for the period from 20–30 kg live weight, a maximum nitrogen retention curve has been achieved.
5. The nitrogen retention curve has been compared with curves and linear functions given by *Miller & Payne* (1963) and by *Gebhardt & Müller* (1971) and it was found that even if the observations from the present investigations fit rather well in linear functions of metabolic live weight for younger animals from 20 to 50 kg live weight, it is not possible to fit a linear function to the whole range from 20 to 90 kg.
6. The nitrogen retention curve obtained indicates a quadratic function. Using all individual measurements (n = 381) the function for maximum nitrogen retention was found as: Max. N-retention, g = $1.479\ kg^{0.75} - 0.0266\ kg^{1.50}$ with s_b as 0.023 and 0.0011 respectively and S.D. of residuals = ± 1.99 g. The function fits rather well to observations made with pigs weighing 150–170 kg by *Oslage et al.* (1966) and *Elsley et al.* (1966).
7. Accepting a maximum nitrogen retention curve it may be concluded that an intake of about 125 g digestible protein with 9–10 g total lysine at 20 kg live weight increasing to about 280 g digestible protein and 19–20 g total lysine at 80 kg would secure maximum nitrogen retention in barrows if the energy intake is about 300 kcal $ME/kg^{0.75}$ at 20 kg increasing to about 320–330 kcal $ME/kg^{0.75}$ for the heavier pigs depending on the fat deposition wanted. In using the norm proposed it should be possible to maintain an efficiency of nitrogen utilization ($k_{A\text{-total}}$) between 55–45%.

CHAPTER 8

Relationship between protein- and fat gain in growing pigs and efficiency of utilization of metabolizable energy for growth

The protein- and fat gain based on the nitrogen- and carbon balances measured in 381 experiments with 48 growing pigs from 20–85 live weight was calculated as described in chapter 3 (p. 37). The heat production was calculated according to the CN-method as difference between metabolizable energy and total energy gain in protein + fat. All the individual figures are given in the main tables.

8.1. Protein- and fat gain

The mean values for intake of metabolizable energy (ME), heat loss, energy gain in protein and fat together with the total energy gain for the 6 different feed compounds investigated during the growth period from 20–85 kg are compiled in Tables 48–53. As shown graphically in Figures 32, 33 and 34 and as discussed in chapter 7 the picture of the protein gain during the experimental time was nearly identical for all 6 compounds. In the first period with a mean live weight of 23 kg the energy gain in protein was on average 400 kcal daily increasing to about 700 kcal in period VI at a live weight about 60 kg, thereafter being fairly constant. As discussed in chapter 7 the curve for the nitrogen retention measu-

Table 48. Energy metabolism in growing pigs in experiments with barley and skim-milk powder. Series C-D-E-F

Tabel 48. Energiomsætning hos voksende svin i forsøg med byg og skummetmælkspulver. Serie C-D-E-F

Period		Live Weight	ME total	Heat loss	Protein gain		Fat gain	Total energy gain	
						% of total gain			% of total ME
no.	n	kg	kcal	kcal	kcal		kcal	kcal	
I	12	24	2663	2270	410	104	– 17	393	15
II	12	29	3377	2543	508	61	326	834	25
III	12	36	4017	2701	577	44	738	1316	33
IV	11	43	4878	3162	611	36	1105	1716	35
V	12	52	5875	3365	685	27	1825	2510	43
VI	12	61	6803	3672	713	23	2418	3131	46
VII	11	73	7736	4060	725	20	2951	3676	48
VIII	12	83	8662	4405	722	17	3536	4257	49

Table 49. Energy metabolism in growing pigs in experiments with barley and protein mixture. Series C-D-E-F

Tabel 49. Energiomsætning hos voksende svin i forsøg med byg og proteinblanding. Serie C-D-E-F

Period		Live Weight	ME total	Heat loss	Protein gain		Fat gain	Total energy gain	
						% of total gain			% of total ME
no.	n	kg	kcal	kcal	kcal		kcal	kcal	
I	12	23	2489	2128	416	115	– 56	361	15
II	12	29	3152	2487	527	79	137	665	21
III	12	35	3750	2725	589	57	436	1025	27
IV	12	43	4597	2999	632	40	966	1598	35
V	12	51	5643	3199	698	29	1746	2444	43
VI	12	60	6511	3608	707	24	2196	2903	45
VII	12	70	7424	3970	746	22	2708	3454	47
VIII	12	80	8355	4309	727	18	3319	4046	48

red in the present investigation may be considered as the maximum protein gain for barrows, except for the first period, where the intake of metabolizable energy was below the energy requirement for maximum protein gain.

With the low energy intake in period I, the range for the individuals being

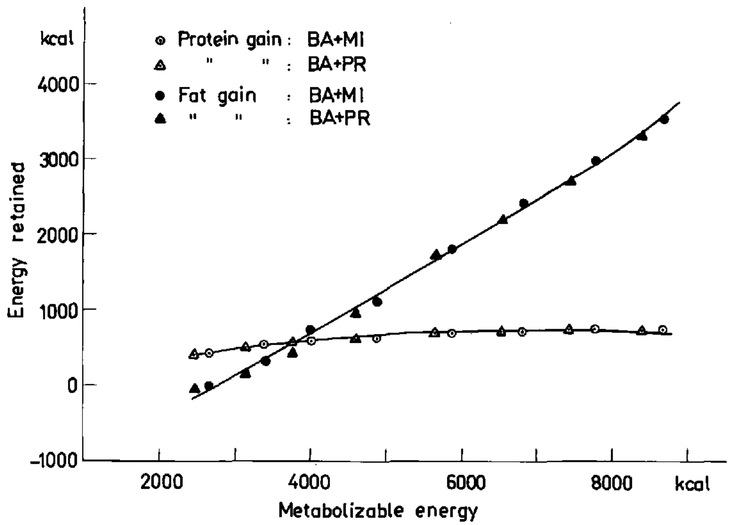

Figure 32.

Energy retained in protein and fat in relation to intake of metabolizable Energy. Barley feed-compounds. Series C-D-E-F.

Aflejret energi i protein og fedt i relation til omsættelig energi. Byg-foderblandinger. Serie C-D-E-F.

Table 50. Energy metabolism in growing pigs in experiments with maize and skim-milk powder. Series C-E

Tabel 50. Energiomsætning hos voksende svin i forsøg med majs og skummetmælkspulver. Serie C-E

Period		Live Weight	ME total	Heat loss	Protein gain		Fat gain	Total energy gain	
no.	n	kg	kcal	kcal	kcal	% of total gain	kcal	kcal	% of total ME
I	6	22	2626	2192	388	89	46	434	17
II	6	27	3337	2435	509	56	393	902	27
III	6	34	4005	2769	530	43	707	1236	31
IV	6	42	4831	2994	559	30	1277	1837	38
V	6	50	5790	3163	611	23	2016	2627	45
VI	6	58	6795	3451	659	20	2685	3344	49
VII	6	68	7631	3650	682	17	3299	3981	52
VIII	6	77	8488	3993	678	15	3817	4495	53

2.3–2.9 Mcal ME (245 kcal ME/kg$^{0.75}$) the fat gain was oscillating around zero. For 21 pigs a slightly positive fat gain of 176 kcal was found, with a variation from 21 to 583 kcal, while for 27 pigs a mean negative fat gain of – 136 kcal was found, with a variation from – 10 to – 323 kcal, indicating that body fat can be oxidized and protein synthesized simultaneously. With the increased energy intake in the following periods the fat gain increased rapidly (Fig. 32, 33,34). In period V at 50 kg live weight with an intake of about 305 kcal ME/kg$^{0.75}$ the mean fat retention was about 1800 kcal or 73% of the total energy gain, increasing to about 3600 kcal or 84% in the last period at 80 kg live weight, where the energy intake was 320 kcal ME/kg$^{0.75}$.

Table 51. Energy metabolism in growing pigs in experiments with maize and protein mixture. Series C-E

Tabel 51. Energiomsætning hos voksende svin i forsøg med majs og proteinblanding. Serie C-E

Period		Live Weight	ME total	Heat loss	Protein gain		Fat gain	Total energy gain	
no.	n	kg	kcal	kcal	kcal	% of total gain	kcal	kcal	% of total ME
I	6	22	2440	2171	415	154	–146	269	11
II	6	27	3102	2402	546	78	154	700	23
III	6	33	3725	2731	580	58	414	994	27
IV	6	41	4514	3073	600	42	841	1441	32
V	6	49	5400	3258	648	30	1495	2142	40
VI	6	57	6501	3424	710	23	2367	3077	47
VII	6	67	7274	3743	695	20	2836	3531	49
VIII	6	77	8226	3852	700	16	3675	4374	53

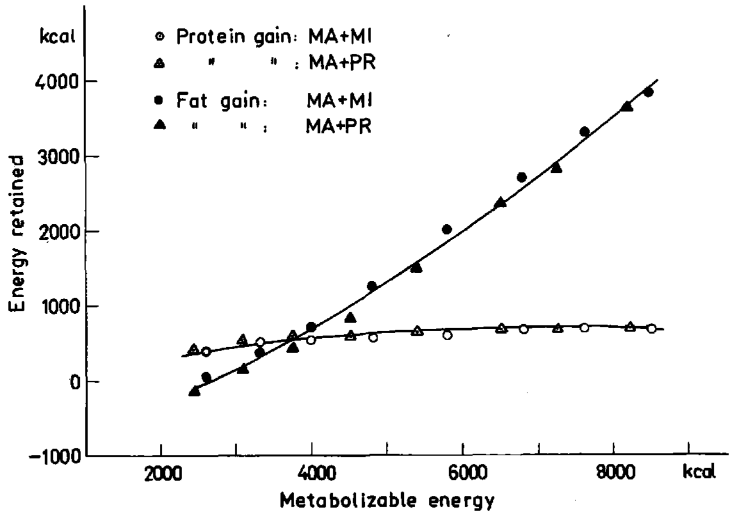

Figure 33.

Energy retained in protein and fat in relation to intake of metabolizable energy. Maize feed-compounds. Series C-E.

Aflejret energi i protein og fedt i relation til omsættelig energi. Majs-foderblandinger. Serie C-E.

Expressed in terms of grams the protein gain in the present investigation increased from 70 to 125 g daily during the experimental time, while the fat gain increased from zero to about 380 g daily in the last period, or three times as much fat as protein.

The mean values for total energy gain obtained in period I and II for the 6 different feed compounds (Tables 48–53) are determined with a rather low accuracy, the coefficient of variation (C.V.) being above 20%. As discussed in chapter 7 there is a great variation between animals in their ability to form protein and differences from 1 to 4 g nitrogen between the highest and lowest nitrogen retention have been measured (cf. Table 46), corresponding to 35–140 kcal, thereby a great variation in the total energy gain can be expected in the first periods, where the protein gain constitutes the greatest part of the total energy gain. From period III with the increasing fat gain, the variation decreased and in most cases the mean total energy gain for the different feed compounds are determined with coefficients of variation between 5–10%.

The mean total energy gain in period I (23 kg live weight) was only 16% of the ME-intake of 2.6 Mcal, indicating that most of the energy intake has been used by the animals to cover their requirement for maintenance. In period V (50 kg live weight) with an intake of 5.8 Mcal ME the total energy gain was 43% of the intake increasing to 50% in period VIII (80 kg live weight) with an intake of 8.6 Mcal ME.

Table 52. Energy metabolism in growing pigs in experiments with sorghum and skim-milk powder. Series D-F

Tabel 52. Energiomsætning hos voksende svin i forsøg med milo og skummetmælkspulver. Serie D-F

Period		Live Weight	ME total	Heat loss	Protein gain		Fat gain	Total energy gain	
						% of total gain			% of total ME
no.	n	kg	kcal	kcal	kcal		kcal	kcal	
I	6	24	2814	2211	386	64	217	603	21
II	6	29	3545	2577	490	51	478	968	27
III	6	35	4210	2740	579	39	891	1470	35
IV	6	43	5161	3167	614	31	1381	1994	39
V	6	51	6141	3304	653	23	2184	2837	46
VI	6	60	7146	3817	712	21	2616	3329	47
VII	6	71	8093	4262	714	19	3117	3831	47
VIII	5	80	9047	4493	731	16	3823	4554	50

From their intensive studies concerning feed evaluation, using adult or near adult animals, the Rostock-group has formed equations for predicting total energy gain in different farm animals. The equations are based on the intake of digestible nutrients and the net energy requirement for maintenance expressed as a function of metabolic live weight ($kg^{0.75}$). For pigs the equation is given, *Schiemann et al.* (1971, p. 134) as:

Total energy gain, kcal $= 2.61x_1 + 8.63x_2 + 2.15x_3 + 2.98x_4 - 66.71\ kg^{0.75}$

where x_1 = g digestible crude protein
x_2 = g digestible crude fat
x_3 = g digestible crude fibre
x_4 = g digestible NFE

Table 53. Energy metabolism in growing pigs in experiments with sorghum and protein mixture. Series D-F

Tabel 53. Energiomsætning hos voksende svin i forsøg med milo og proteinblanding. Serie D-F.

Period		Live Weight	ME total	Heat loss	Protein gain		Fat gain	Total energy gain	
						% of total gain			% of total ME
no.	n	kg	kcal	kcal	kcal		kcal	kcal	
I	6	24	2597	2174	400	95	23	423	16
II	6	29	3291	2538	522	69	232	753	23
III	6	35	3921	2777	613	54	532	1144	29
IV	6	43	4947	3050	658	35	1239	1897	38
V	6	51	5863	3363	693	28	1807	2500	43
VI	6	60	6826	3838	724	24	2265	2988	44
VII	6	71	7797	4258	720	20	2819	3539	45
VIII	6	81	8858	4414	725	16	3720	4444	50

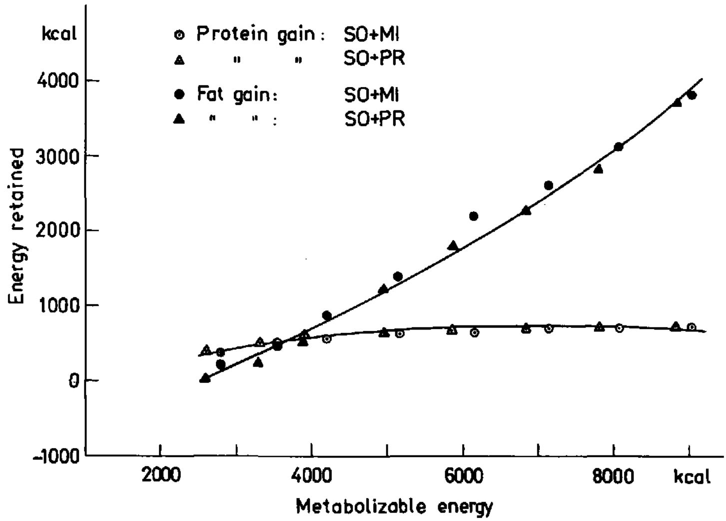

Figure 34.

Energy retained in protein and fat in relation to intake of metabolizable energy. Sorghum feed-compounds. Series D-F.

Aflejret energi i protein og fedt i relation til omsættelig energi. Milo-foderblandinger. Serie D-F.

In the present investigation where the amount of digested nutrients have been determimed in 381 balance experiments together with the total energy gain and corresponding live weight a comparison has been made between measured and predicted total energy gain, according to the equation above and the results are presented in Table 54.

Table 54. Total energy gain measured compared with total energy gain estimated according to the Rostock-equation. Series C-D-E-F. All 6 compounds

Tabel 54. Den målte totale energiaflejring sammenlignet med estimeret energiaflejring beregnet i henhold til Rostock-ligningen. Serie C-D-E-F. Alle 6 foderblandinger

Period no.	n	Live weight kg	ME intake Mcal	Total energy gain		Measured–Estimated	
				Measured kcal	Estimated kcal	kcal	t
I	48	23	2.60	405	1090	–685	–29.5
II	48	29	3.29	790	1443	–653	–32.1
III	48	35	3.93	1191	1748	–557	–25.3
IV	47	43	4.80	1712	2194	–482	–16.1
V	48	51	5.78	2502	2735	–233	– 7.3
VI	48	60	6.74	3101	3247	–146	– 4.6
VII	47	70	7.64	3642	3718	– 76	– 2.2
VIII	47	80	8.58	4304	4194	110	2.2

The calculation shows great and highly significant differences between measured and predicted total energy gain in period I-IV with the pronounced protein gain. In the following periods with the increased proportions of fat in the total energy gain the differences decrease. In period VII and VIII with a fat gain of 80–90% of the total energy gain, conditions more similar to the Rostock-experiments with »adult« animals, a good agreement was found between the measured and predicted values for total energy gain.

8.2. Estimation of the energy requirement for maintenance

Estimation of the efficiency of utilization of metabolizable energy for growth, protein and fat formation must be based on the knowledge of the energy reqiurement for maintenance. Estimates of this requirement can be obtained either by determination of the fasting heat production, measured above the critical temperature, combined with an estimate of the efficiency of utilization of ME for maintenance, or the requirement can be estimated by determination of the energy balances at different intake of ME, using the regression method to calculate the intake of metabolizable energy at zero energy retention.

Breirem (1936) by using the starvation technique, found in his experiments with 8 pigs in the live weight group from 16–169 kg, that the heat production by starvation in relation to live weight was best expressed by raising the live weight to the power of 0.569 giving the function of HP(RQ), kcal = 154.7 $kg^{0.569}$, stressing that a higher regression coefficient could be expected for pigs in the lower weight groups. From his experiments with growing pigs *Breirem* (1939) estimated for maintenance an efficiency of about 80% of ME-intake and concluded that the requirement of metabolizable energy for maintenance could be estimated as:

$$ME_m \text{ kcal} = 196.3 \text{ kg}^{0.569}$$

The curve of this function is demonstrated in Fig. 35.

Before the present investigation was started in 1964 a measurement of the energy metabolism in the 12 young pigs used in series C was carried out and the results are shown in Table 55. The pigs were fed with compounds of barley or maize with skim-milk powder or protein mixture to secure maximum protein retention. The mean live weight was 16.4 kg and the ME-intake was in average 1900 kcal (234 kcal ME/$kg^{0.75}$) causing a protein gain of 337 kcal and a negative fat gain of – 279 kcal giving a total energy gain of 58 kcal. For the individuals the total energy gain oscillated around zero and the energy requirement for maintenance was estimated to be about 1800 kcal ME at a live weight of 16 kg or 225 kcal ME/$kg^{0.75}$. As indicated in Fig. 35 there is a great difference between this estimate and the value given by the function of *Breirem.*

On the evidence from the investigation mentioned, indicating a higher energy

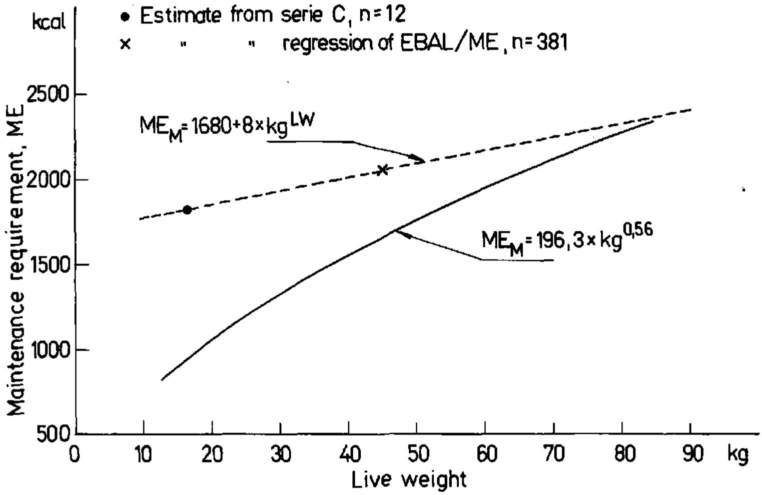

Figure 35.

Estimation of maintenance requirement for pigs at different live weights.

Estimation af vedligeholdelsesbehovet for svin ved forskellige legemsvægte.

requirement for maintenance for the lighter pigs, and discussed earlier by *Thorbek* (1969 c, 1970 a, 1970 b) a trial was started in 1972 with the aim of determining the heat production in pigs starved at different live weights and measured at different environmental temperatures. In the first experiment with 14 barrows from 20–110 kg live weight, measured above the critical temperature, it was found, *Thorbek* (1974) that the heat production at 55–80 kg live weight could be estimated as 153 $kg^{0.56}$, being extremely close to the function found by *Breirem* (1936), but for pigs from 20–30 kg the function was 195 $kg^{0.56}$

Table 55. Energy metabolism in weaned pigs fed at maintenance level

Tabel 55. Energiomsætning hos fravænnede grise fodret på vedligeholdelsesniveau

Compounds	n	Live weight kg	ME total kcal	Heat-loss kcal	Prot. gain kcal	Fat gain kcal	Total energy gain kcal
BA + MI ...	3	16.7	1932	1741	343	–152	191
BA + PR ...	3	17.2	1845	1865	373	–393	– 20
MA + MI ...	3	16.0	2004	1815	314	–125	189
MA + PR ...	3	15.8	1828	1957	316	–445	–129
Mean	12	16.4	1902	1844	337	–279	58
S.D.		0.6	82	127	28	155	119

and the difference between the two functions was highly significant. Using metabolic live weight as base the function was 71 $kg^{0.75}$ for the heavier pigs and 108 $kg^{0.75}$ for the lighter pigs. The conclusion was drawn that independent of the exponent used for live weight it was not possible to include the observations obtained with pigs from 20–30 kg into the function for heat production covering pigs from 50–100 kg live weight. As the experiment is in progress to fill up the gap in observations from 30–60 kg live weight no final conclusion will be drawn from the starvation experiments until more data are available.

The results from the present investigation including all individual figures for ME-intake and total energy gain have finally been used to estimate the intake of metabolizable energy at zero energy retention. A regression of total energy gain in relation to intake of metabolizable energy gave the following equation:

Total energy gain, kcal	= – 1348	+ 0.656 × ME, kcal	(n = 381)
s_b :	36	0.006	
S.D. of residuals :	246		

From the equation it can be calculated, that the intake of ME for zero energy gain was 1348/0.656 = 2055 kcal ME or 113 kcal ME/$kg^{0.75}$ at a mean live weight of 48 kg. Considering the individual variations it seems reasonable to calculate with a maintenance requirement of 2000–2100 kcal ME in the live weight group from 45 to 50 kg, and this value is indicated in Fig. 35.

In an attempt to evaluate from the present investigation the efficiency of utilization of available metabolizable energy for total energy gain as well as for protein and fat formation a preliminar function for maintenance requirement covering the live weight groups in question has been formulated. Accepting a mean value for maintenance requirement of 2400 kcal ME at 80–85 kg live weight, according to the function 196.3 $kg^{0.56}$ and accepting values of 2000–2100 kcal ME for the live weight group of 45 kg and about 1800 kcal ME at 16 kg according to the present investigation a linear function, covering the live weight from 15 to 90 kg, is indicated (Fig. 35), and a temporary function could be expressed as:

$$ME_m\text{, kcal} = 1680 + 8\ \text{LW, kg.}$$

8.3. Efficiency of utilization of metabolizable energy available for growth

The efficiency of utilization of metabolizable energy available for growth ME_p has been calculated according to $ME_p = ME_{intake} - ME_m$. By using the individual corresponding figures for total energy gain, ME_{intake}, and accepting the temporarily function for maintenance requirement, ($ME_m = 1680 + 8 \times$ LW, kg) regression of total energy gain on ME_p for each feed compound has been calculated and the results are given in the upper part of Table 56. For all

Table 56. Efficiency of utilization of available metabolizable energy for growth. Series C-D-E-F. Available ME = Total ME – (1680 + 8 × LW,kg)

Tabel 56. Udnytningsgraden af omsættelig energi til vækst

Compounds	n	Regr. coeff.	s_b
BA + MI	94	0.663	0.0059
BA + PR	96	0.662	0.0077
MA + MI	48	0.712	0.0100
MA + PR	48	0.693	0.0108
SO + MI	47	0.666	0.0083
SO + PR	48	0.653	0.0065
Total	381	0.671	0.0034
BA + MI or PR	190	0.663	0.0048
MA + MI or PR	96	0.703	0.0074
SO + MI or PR	95	0.660	0.0053
BA + SO + MI or PR	285	0.662	0.0036

f-test for differences between regression coefficients

	n_1/n_2	f	
BA +MI /BA +PR	94/96	0.03	Not significant
MA+MI /MA+PR	48/48	1.77	» »
SO +MI /SO +PR	47/48	1.48	» »
BA +XX/SO +XX	190/95	0.16	» »
BA+SO+XX/MA+XX	285/96	28.99	Significant > $f_{.001}$ = 11.1

observations (n = 381) a regression coefficient of 0.671 ± 0.0034 was found with S.D. of residuals = 254 indicating that for the feed compounds applied and for the growth period in question the mean efficiency of utilization of ME was 67% for total energy gain.

f-test for differences between the regression coefficients found for the 6 different feed compounds has been carried out and the results are shown in the lower part of Table 56. No significant differences were found between the regression coefficients depending whether the grains were combined with skim-milk powder (MI) or protein mixture (PR). For barley compounds the regression coefficient was 0.663 ± 0.0048 and f = 0.03, for maize compounds the coefficient was 0.703 ± 0.0074 and f = 1.77, while for the sorghum compounds the coefficient was 0.660 ± 0.0053 and f = 1.48.

Then the regression coefficients for the barley and sorghum compounds have been compared and no significant difference was found, the values being 0.662 ± 0.0036 and f = 0.16.

Finally this regression coefficient of 0.662 found for the barley- and sorghum compounds was compared with the coefficient of 0.703 obtained for the maize compounds (BA+SO+XX / MA+XX), and the difference was highly significant, with $f = 29.0 > f_{.001} = 11.1$. The overall efficiency of utilization of ME from the maize compounds was thus 10–11% higher than for the barley- and sorghum compounds, during the growth period from 20 to 90 kg live weight.

8.4. Efficiency of utilization of metabolizable energy available for protein- and fat formation

An overall efficiency of utilization of metabolizable energy for total energy gain found to be 67% in the present investigation, does not imply, that the efficiency must be the same for protein as for fat formation. A part of the observations from the present investigation has been presented in earlier publications, *Thorbek* (1969 c, 1970 a) indicating that the efficiency of metabolizable energy was dependent on the proportion between protein and fat gain during the growth period.

For a closer inspection of this problem a graph has been drawn in Fig. 36, demonstrating the relationship between the proportions of Total energy gain/ME available for production and Fat gain/Total energy gain. It is obvious that the efficiency of utilization of metabolizable energy increases with an

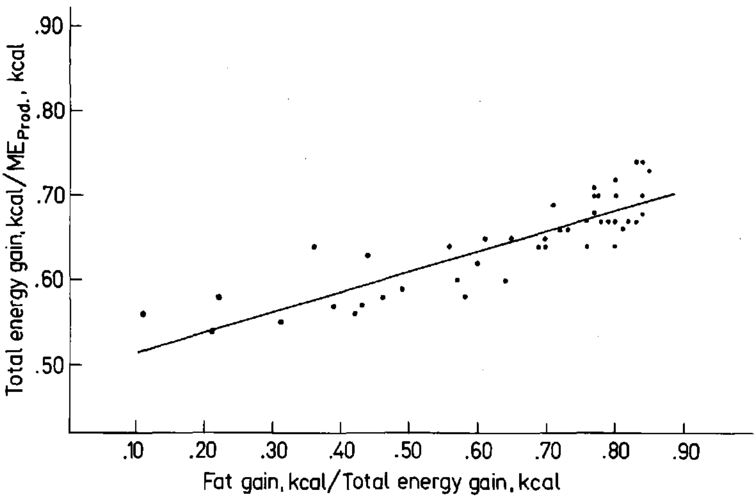

Figure 36.

Efficiency of utilization of metabolizable energy for production in relation to proportion of fat to total energy gain.

Udnytningsgraden af omsættelig energi til produktion i relation til forholdet mellem fedtaflejring og total energiaflejring.

increasing amount of fat in the total energy gain. The efficiency of utilization increased from about 50% to 70% when the fat gain increased from zero to about 84% of the total energy gain.

With the large contrast between protein and fat gain in the present investigation it should be possible to calculate the efficiency of ME_p for the two productions according to the equation:

$$ME_p\text{, kcal} = \alpha \times \text{protein gain, kcal} + \beta \times \text{fat gain, kcal}$$

where $ME_p = ME_{intake} - ME_m$

By means of all individual figures for ME_p, protein gain and fat gain the regression coefficients for each compound have been calculated and the results are shown in the upper part of Table 57.

For all observations the regression gave:

$$ME_p\text{, kcal} = 2.09 \times \text{protein gain, kcal} + 1.30 \times \text{fat gain, kcal}$$

$$s_b \quad 0.050 \qquad\qquad 0.016$$

Table 57. Efficiency of utilization of available metabolizable energy for protein and fat formation. Series C-D-E-F. Available ME = Total ME – (1680 + 8 × LW,kg)

Tabel 57. Udnytningsgraden af omsættelig energi til protein- og fedtdannelse

Compounds	n	Protein formation		Fat formation	
		Regr. coeff.	s_b	Regr. coeff.	s_b
BA + MI	94	2.04	0.093	1.34	0.029
BA + PR	96	2.05	0.014	1.32	0.036
MA + MI	48	2.16	0.157	1.20	0.041
MA + PR	48	2.20	0.105	1.21	0.033
SO + MI	47	1.98	0.181	1.36	0.052
SO + PR	48	1.98	0.102	1.39	0.032
Total	381	2.09	0.050	1.30	0.016
BA + MI or PR	190	2.05	0.070	1.33	0.023
MA + MI or PR	96	2.19	0.089	1.20	0.026
SO + MI or PR	95	1.98	0.097	1.37	0.029
BA + SO + MI or PR	285	2.02	0.057	1.34	0.018

f-test for differences between regression coefficients

	n_1/n_2	f	
BA +MI /BA +PR	94/96	0.32	Not significant
MA+MI /MA+PR	48/48	0.16	» »
SO +MI /SO +PR	47/48	0.62	» »
BA +XX/SO +XX	190/95	1.14	» »
BA+SO+XX/MA+XX	285/96	17.54	Significant $>f_{.001} = 11.1$

indicating that an intake of 2.09 kcal ME is required for the formation of 1 kcal in protein, while only 1.30 kcal ME is required for the formation of 1 kcal in fat, corresponding to an efficiency of utilization of 48% for protein and 77% for fat formation. This corresponds to a requirement of 11.9 kcal ME for formation of 1 g protein and 12.4 kcal ME for formation of 1 g fat.

The regression coefficient of 1.30 for fat formation is estimated with an accuracy of $s_b = 0.016$ which is considered to be fairly high for a biological estimate. For protein formation the coefficient of 2.09 is estimated with a somewhat lower accuracy, $s_b = 0.050$, partly caused by the great variation between animals in their ability for protein formation as discussed in chapter 7.

f-test for differences between the regression coefficients estimated for the 6 different feed compounds have been carried out and the result are shown in the lower part of Table 57. No significant differences were found for each of the 3 grains whether they were combined with skim-milk powder (MI) or protein mixture (PR). For barley compounds the coefficient for protein formation was 2.05 ± 0.070 and 1.33 ± 0.023 for fat formation with f = 0.32, for maize compounds the values were 2.19 ± 0.089 and 1.20 ± 0.026 with f = 0.16 and for the sorghum compounds the coefficients were 1.98 ± 0.097 and 1.37 ± 0.029 with f = 0.62.

Then the regression coefficients for the barley and sorghum compounds have been compared and no significant difference was found. The coefficient for protein formation was 2.02 ± 0.057 and 1.34 ± 0.018 for fat formation corresponding to an efficiency of utilization of 50% for protein formation and 75% for fat formation.

Finally the regression coefficients for the barley and sorghum compounds (BA+SO+XX) have been compared with the regression coefficients for the maize compounds (MA+XX), and the difference was highly significant with $f = 17.5 > f_{.001} = 11.1$. The efficiency of utilization of ME for fat formation was thus 83% for the maize compounds compared with 75% for the barley- and sorghum compounds.

8.5. Discussion

In the last 10 years many results concerning protein and fat gain in growing pigs and efficiency of metabolizable energy for growth have been published. Different terms have been used to describe the results obtained, sometimes making the comparison difficult, but now there is a tendency to use the same abbreviations and difinitions. The partition of metabolizable energy could be written as:

$$ME = ME_m + ME_p$$

where ME = intake of metabolizable energy

ME_m = ME for maintenance

ME_p = ME for production

For growth (g) the production would mainly be:

g = protein gain, kcal + fat gain, kcal

= total energy gain, kcal

Thus the efficiency of utilization of ME for growth could be expressed as:

k_g = Total energy gain, kcal/ME_p

or partially as:

k_g = (protein gain, kcal + fat gain, kcal)/ME_p

Intake of metabolizable energy is often indicated in relation to live weights of the experimental animals in question, but for reason of comparison it could be valuable to use the term of $ME/kg^{0.75}$. The unit for energy in nutritional work has for many years been calories but in the future joule should be adopted as the unit for energy, (J = 0.239 cal, kJ = 0.239 kcal or MJ = 239 kcal).

The energy requirement of metabolizable energy for maintenance can be expressed in the form of $ME_m = aW^b$, where W = live weight. Recently excellent reviews concerning the many different aspects in estimation of ME_m for different species have been published by *Blaxter* (1972) and *van Es* (1972), and the values of a and b have been discussed. In 1932 *Kleiber* proposed a value of b = 0.75 which was accepted by the participants at the »3rd. Symposium on Energy Metabolism in Troon 1964« to be used for adult animals in comparing the metabolism of different species, *Kleiber* (1965).

For growing animals different values of b have been proposed and used. From starvation experiments with pigs form 16 to 169 kg live weight *Breirem* (1936) found, that the heat production in relation to live weight was best expressed by using b = 0.56, commonly used since that time. *Kielanowski & Kotarbinska* (1970) concluded from their slaughter experiments with pigs, that the best fitting value for b was 0.734 while *Fuller & Boyne* (1972) by measuring the energy metabolism in pigs from 20 to 90 kg found that an over-all pooled exponent of 0.57 gave the lowest S.D. of residuals. From intensive studies on the influence of environmental temperature on energy metabolism of growing pigs, *Verstegen* (1971) found that the best fitting values for b was 0.55 for pigs above 50 kg and 0.85 for pigs below 50 kg, but with small variations for S.D. of residuals for the two exponents and for reason of comparison 0.75 was used in the whole range of live weight. *Mount & Holmes* (1969) found values of b from 0.4 to 1.0 according to live weight, levels of feed intake and housing.

In spite of this great variations found for b-values there is now a tendency to accept that ME_m should be expressed as the function a $W^{0.75}$ both for adult and growing animals and differences found according to age should be expressed in the value of a. *Breirem & Homb* (1972). *Blaxter* (1972) as well as *van Es* (1972) apparently prefer to use $W^{0.75}$ and in a recent publication, *Kirchgessner* et al. (1974) expressed the same point of view.

In his review *van Es* (1972) in accepting $W^{0.75}$ has tabulated a-values found by different investigators using different techniques. In the live weight group from 10–40 kg the values for a vary as 90–225, from 40–90 kg there was a variation from 90–126 and above 100 kg a-values from 70–95 was found.

Recently *Sharma et al.* (1971) in slaughter experiments with piglets have found a-values from 109 to 112 for the Lacombe race and 136–139 for Yorkshire piglets (b = 0.75), but the difference was not significant. *Verstegen* (1971) found by using b = 0.75 that the best fitting value for a was 122 at live weights from 20–50 kg and 116 at live weights from 50–90 kg, while *Burlacu* et al. (1973) for piglets at 14 kg, allowed limited movement, has found a = 144, using $W^{0.75}$.

In our first starvation experiment, above the critical temperature (26°C) and with some freedom for the pigs to move around in the respiration plant, a heat production of 108 kcal/$kg^{0.75}$ was found for pigs from 25–30 kg, while the function was 71 kcal/$kg^{0.75}$ for pigs from 55–80 kg live weight, *Thorbek* (1974), indicating that heat production in young pigs could be 50% above the heat production in older pigs. With an estimated k_m = 80% (efficiency of utilization of ME for maintenance) the values of a in the function of $ME_m = aW^{0.75}$ would be 135 and 89, respectively for the two groups, while k_m = 75% would increase the values to 144 and 95. Results from experiments in the last years have thus indicated a great variation in the a-values according to age, race, housing (individuals or groups) and activity, probably connected with cell-activity but for the moment no function for ME_m = covering the whole growth period has been established.

In an earlier attempt to estimate the efficiency of utilization of ME for growth (k_g) it was tried to apply the old function of 196 $kg^{0.56}$ for maintenance, but no consistent value of k_g could be found, *Thorbek* (1970 a, 1970 b), probabaly caused by different functions for maintenance at different live weights corresponding to different ages. A linear function of $ME_m = 1680 + 8W$ found in the present investigation, covering the live weight groups from 20–85 kg have been used temporarily to estimate k_g. It should be stressed that with the technique applied in our experiments the animals are allowed a certain freedom to move around in the respiration plant giving conditions near to practice.

Before discussing results obtained concerning k_g in the present investigation, measurements of total energy gain and protein-fat gain in the live weight group from 20 to 90 kg have been compared with results obtained in the last years by other investigators, as indicated in Table 58. Different techniques have been applied in the determination of gas exchange and energy gain. *Fuller & Boyne* (1972) have used a closed-air-circulating system with restricted movement of the animals, while in the other experiments an open-air-circulating system have

Table 58. Energy metabolism in growing pigs at different live weight groups. (Compiled from the literature)

Tabel 58. Energiomsætning hos voksende svin i forskellige vægtklasser. (Sammenstillet efter litteraturen)

Ref. 1.	Live weight, kg		30-40	40-50	50-60	60-70	70-80	80-90
»	ME, kcal/kg$^{0.75}$		285	285	282	308	310	290
»	Protein gain, kcal		536	599	622	641	635	611
»	Fat gain, kcal		1128	1780	2481	3127	3780	3631
»	Total energy gain, kcal		1664	2378	3103	3768	4415	4242
Ref. 2.	Live weight, kg	25	36	40	51	73	74	
»	ME, kcal/kg$^{0.75}$	291	289	315	308	300	298	
»	Protein gain, kcal	487	649	663	794	782	862	
»	Fat gain, kcal	1328	1436	1262	1990	2294	2574	
»	Total energy gain, kcal	1815	2085	1925	2784	3076	3436	
Ref. 3.	Live weight, kg	25	35	45	55	65	75	85
»	ME, kcal/kg$^{0.75}$	350	350	350	350	350	350	350
»	Total energy gain, kcal	1601	2199	2868	3298	3728	4278	4660
Ref. 4.	Live weight, kg	24	33	43	55	69		83
»	ME, kcal/kg$^{0.75}$	235	258	281	286	288		294
»	Protein gain, kcal	438	547	677	725	736		765
»	Fat gain, kcal	44	410	1027	1655	2173		2882
»	Total energy gain, kcal	482	957	1704	2380	2909		3647
Ref. 5.	Live weight, kg	23	32	43	51	65	80	
»	ME, kcal/kg$^{0.75}$	245	270	288	305	315	320	
»	Protein gain, kcal	405	548	615	671	712	717	
»	Fat gain, kcal	− 1	442	1100	1831	2659	3593	
»	Total energy gain, kcal	404	990	1715	2502	3371	4310	

Ref. nos. 1: Oslage, H. J., et al. (1966) (3 pigs)
» » 2.: Bowland, J. P., et al. (1970) (8 pigs)
» » 3.: Fuller, M. F. & Boyne, A. W. (1972) (2 pigs)
» » 4.: Nielsen, A. J. (1970) (56 pigs)
» » 5.: Thorbek, G. Present investigation (48 pigs)

been applied. In the experiments of *Oslage et al.* (1966) and of *Bowland et al.* (1970) the animals were kept rather confined, while the animals had a certain freedom to move in the experiments of *Nielsen* (1970) and *Thorbek* (Present investigation).

In the experiments of *Oslage et al.* and *Fuller & Boyne* the results were indicated in relation to live weight groups while the results obtained by the 3 other investigators are calculated in relation to mean values of the observed live weights. The data given in the publications concerning ME-intake and live weight have for reason of comparison been calculated as ME, kcal/kg$^{0.75}$. The protein-fat gain and the total energy gain are indicated as kcal per day, but in the future this should be expressed in terms of joule.

In all experiments the protein gain in the growth period in question is nearly identical assumed to be oscillating around the values for maximum protein gain, (discussed in detail in chapter 7) while the fat gain is strongly related to the ME-intake and the conditions in which the animals are kept. For references 1.2 and 3 where the pigs were kept in confined crates the highest total energy gain was found in the experiment of *Fuller & Boyne* at a constant intake of 350 ME, kcal/$kg^{0.75}$, while a lower energy retention was obtained by *Oslage et al.* and *Bowland et al.,* where the energy intake was about 15% lower than in the experiment of *Fuller & Boyne*.

The results of *Nielsen* (1970) have been calculated from his experiment with 56 pigs fed different feed compounds consisting of Danish barley, U.S.5. barley, oat, maize and sorghum (without addition of screenings) combined with protein mixture. The experiment of *Nielsen* was carried out by means of the respiration plant and the same metabolic crates as used in the present investigation with some freedom for the animals to move around, and it is striking how close the results obtained by *Nielsen* are related to our results. In the first period at 23 kg live weight and with an intake of about 240 kcal ME/$kg^{0.75}$ the fat gain was oscillating around zero in both experiments. In the following periods the fat gain and total energy gain was lowest in the experiment of *Nielsen* caused by a lower intake of ME.

Comparing the results obtained in the present investigation with results from the experiments carried out with pigs kept more restricted, Ref. 1, 2 and 3, it is obvious that the great differences in energy gain found for younger pigs disappear with increasing age. This is probably due to the behaviour of domesticated pigs, being older they sleep most of their time as soon as they have been fed, and then there will be no influence on the maintenance requirement in relation to type of confinement and the ME_p will be of the same magnitude.

In an extensive review concerning energy requirement for growth *Breirem & Homb* (1972) have dealt with the many aspects of this problem, starting from a biochemical point of view ending at practical feeding problems connected with meat production in different farm animals. Therefore in this discussion only the efficiency of utilization of ME for growth and for protein- and fat formation found in the present investigation should be compared with results published recently, as presented in Table 59. In the experiments of *Kielanowski* et al. and *Kirchgessner* et al. the slaughter technique was applied, while the other investigators have used different types of respiration plant to determine the energy metabolism. The pigs used in the experiments of *Burlacu* and *Kirchgessner* were below 20 kg live weight, while the other experiments were carried out with pigs above 20 kg.

The mean overall efficiency of utilization of ME for growth (k_g) was found to

Table 59. Efficiency of utilization of ME for growth (k_g) and for protein- and fat formation. (Compiled from the litterature)

Tabel 59. Udnytningsgrad af omsættelig energi til vækst (k_g) og til protein- og fedtproduktion. (Sammenstillet fra litteraturen)

Investigators	Overall efficiency of ME for growth k_g	ME required for formation of 1 g prot.	ME required for formation of 1 kcal prot.	Efficiency of ME for protein formation	ME required for formation of 1 g fat	ME required for formation of 1 kcal fat	Efficiency of ME for fat formation
Oslage et al. (1970)		10.9	1.91	0.52	13.6	1.43	0.70
Kielanowski et al. (1970)		16.0	2.80	0.36	13.0	1.36	0.74
Bowland et al. (1970)	0.69						
Close et al. (1971)	0.66						
Fuller et al. (1972)	0.72						
Verstegen et al. (1973)	0.67						
Wenk (1973)	0.67						
Burlacu et al. (1973)	0.78	7.4	1.30	0.77	12.1	1.27	0.79
Kirchgessner et al. (1974) .	0.59	11.5	2.02	0.50			
Thorbek (Present invest.)	0.67	11.9	2.09	0.48	12.4	1.30	0.77

be 68% for pigs above 20 kg. Considering the different techniques applied a variation of 66 to 72% is comparatively small. An overall efficiency of utilization of metabolizable energy for total energy gain does not imply that the efficiency must be the same for protein as for fat formation, as demonstrated earlier by *Thorbek* (1969 c, 1970 a, 1970 b). This finding seems now to be confirmed by other investigators at least concerning fat formation, where efficiency from 70 to 79% has been found corresponding to a requirement of 13.6–12.1 kcal ME for formation of 1 g fat. For protein formation no consistent results have been obtained until now and efficiencies from 36 to 77% have been reported, probably connected with the uncertainty about ME_m for the younger pigs.

The discrepancy found between measured energy gain in growing pigs and energy gain predicted according to the function given by *Schiemann* et al. (1971) for adult animals may partly be caused by different efficiencies for protein- and fat gain and partly by the function applied for maintenance not being valid for younger pigs.

8.6. Conclusions

The protein- and fat gain have been measured in 48 barrows fed 6 different feed compounds by determining for each animal the nitrogen- and carbon balances in 8 periods from 20 to 85 kg live weight, and from the results it can be concluded:

1. The protein gain increased from about 400 kcal daily (70 g protein) at 23 kg live weight to about 700 kcal daily (125 g protein) at 60 kg live weight, than being fairly constant until 80 kg, after which a slight declining tendency appeared.
2. Starting with a low energy intake of about 245 kcal ME/kg$^{0.75}$ at 23 kg live weight the fat gain oscillated around zero. With an intake of 305 kcal ME/kg$^{0.75}$ at 50 kg live weight the fat gain was about 1800 kcal daily (190 g fat) increasing to about 3600 kcal daily (380 g fat) at 80 kg live weight with an energy intake of 320 kcal ME/kg$^{0.75}$. As fat gain is strongly related to energy intake while the protein gain has an upper biological determined limit nearly any proportions between the protein and fat gain can be obtained depending on the feeding system applied.
3. The total energy gain at 23 kg live weight was only 16% of the ME-intake of 2.6 Mcal indicating that most of the energy intake has been used to cover the animals need for maintenance, including movements. At 80 kg live weight, with an intake of 8.6 Mcal ME the energy retention increased to 50% of the ME-intake.
4. The equation given for predicting total energy gain in adult pigs based on digested nutrients and requirement for maintenance, *Schiemann et al.* (1971) is compared with the results obtained in the present investigation with growing pigs. While a good agreement was found between measured and predicted values when fat gain was pronounced, no agreement could be found when protein gain was great in relation to fat gain.
5. Metabolizable energy for maintenance (ME_m) for just weaned pigs at 16 kg live weight was estimated to be about 1800 kcal or 225 kcal ME/kg$^{0.75}$ when pigs were fed at maintenance level and kept in cages allowing freedom for movement as in practice.
6. Total energy gain in pigs kept on growth level was regressed on the intake of ME (n = 381) and the ME_m was estimated to be 2055 kcal at a mean live weight of 48 kg or 113 kcal ME/kg$^{0.75}$.
7. For the moment no constant value of a in the function $ME_m = aW^{0.75}$ has been established for pigs from 20 to 90 kg live weight. A linear function for $ME_m = 1680 + 8W$ has been used temporarily to estimate the efficiency of utilization of metabolizable energy for production ($ME_p = ME - ME_m$).
8. All observations (n = 381) of total energy gain were regressed on ME_p and a regressioncoefficient of 0.671 ± 0.0034 was found for the 6 feed compounds in question. No significant difference was found between the barley- and sorghum compounds concerning the efficiency of utilization of ME_p, the regression coefficient being 0.662 ± 0.0036 (n = 285). For the maize compounds (n = 96) a regression coefficient of 0.703 ± 0.0074 was found, and the difference between the regression coefficients for maize compounds and barley-sorghum compounds was highly significant.

9. All observations of protein- and fat gain in relation to ME_p gave a regression equation of:

   $$ME_p\text{, kcal} = 2.09 \times \text{protein gain, kcal} + 1.30 \times \text{fat gain, kcal}$$

   $$s_b \qquad 0.050 \qquad\qquad 0.016$$

   indicating that an intake of 2.09 kcal ME is required for formation of 1 kcal in protein, while only 1.30 kcal ME is needed for formation of 1 kcal in fat, corresponding to an efficiency of utilization of 48% for protein and 77% for fat formation. This correspond to a requirement of 11.9 kcal ME for formation of 1 g protein and 12.4 kcal ME for formation of 1 g fat.
10. The efficiency of utilization of ME_p in the 6 different feed compounds with regard to protein and fat formation was compared and no significant difference between the barley- and sorghum compounds was found, while the utilization of ME in the maize compounds was 10–11% higher than in the barley-sorghum compounds and this difference was highly significant.

CHAPTER 9

Dansk sammendrag

Kapitel 1

Indledning

I 1958 modtog Forsøgslaboratoriets daværende dyrefysiologiske afdeling bevilling fra Landbrugsministeriet til at bygge et nyt respirationsanlæg til svin. Under opbygningen gennemførtes orienterende forsøg med voksende svin til vurdering af hvilke metoder, der burde anvendes ved de kommende balance- og respirationsforsøg, og resultaterne heraf er meddelt i kapitel 2.

I 1962/63 blev der gennemført en lang række tekniske afprøvninger samt kalibreringer af respirationsanlæggene og i 1964 blev anlæggene taget i brug. Siden *Breirem* (1935, 1936, 1939) havde gennemført sine systematiske undersøgelser vedrørende energiomsætningen hos svin af dansk landrace, havde der ikke været gennemført sådanne undersøgelser, og det blev derfor besluttet at gennemføre en serie forsøg med 48 voksende svin fra 20–90 kg til bestemmelse af deres protein- og energiomsætning indenfor denne vækstperiode.

Som foder er anvendt byg, majs eller milo i forbindelse med skummetmælkspulver eller proteinblanding, og resultaterne fra fordøjelighedsforsøgene samt vurdering af fodermidlernes omsættelige energi er fremlagt i kapitel 5. På basis af samtlige respirationsforsøg til måling af CO_2- produktionen, O_2-forbruget og varmeproduktionen er der opstillet ligninger til beregning af disse størrelser baseret på kendskab til dyrenes legemsvægt, og disse resultater er meddelt i kapitel 6.

Kvælstofomsætningen har været bestemt i 381 balanceperioder, og den målte kvælstofaflejring og dermed proteinaflejringen er sammenlignet med resultater fra litteraturen. Det er i kapitel 7 diskuteret, hvorvidt kvælstofaflejringen alene er en funktion af protein- og energi-tilførslen, eller om der er en øvre maximal grænse betinget af genetiske og biologiske forhold, og samtidig er det undersøgt, om det er muligt at give en matematisk formulering af denne maximale grænse.

Resultaterne fra kvælstof- og kulstofbalancerne er benyttet til en vurdering af protein- og fedtaflejringen i den omhandlede vækstperiode, og i kapitel 8 er de opnåede værdier sammenlignet med resultater fra litteraturen, specielt med henblik på relationen mellem aflejring og tilførsel af omsættelig energi samt typen af opsamlingsbure og respirationsanlæg. Til slut er der foretaget en vurdering af vedligeholdelsesbehovet og udnytningsgraden af omsættelig energi til protein- og fedtaflejring.

Kapitel 2

Undersøgelser vedrørende teknik i balanceforsøg med voksende svin

I fordøjeligheds- og balanceforsøg med svin er den konventionelle metode, at holde dyrene i enkeltbåse i forperioden og derefter anbringe dem i ret snævre opsamlingsbure, hvor gødning og urin opsamles separat over et vist tidsrum. Såvel i forperioden som i forsøgsperioden er det almindeligt at give dyrene et konstant foder. Der opstår adskillige spørgsmål i forbindelse med denne forsøgsmetodik, og i en foreløbig undersøgelse forsøgte vi at nå frem til en relevant teknik med hensyn til opsamlingsburenes størrelse, opsamlingsperiodens længde og konstant eller jævnt stigende fodring.

Der foreligger fra de senere år adskillige beskrivelser af opsamlingsbure for svin med indstillelige rørsystemer eller sider, *Farries & Oslage* (1961), *Allen* et al. (1963) og *Madsen* (1963) eller med anvendelse af selesystem og urinaler, *Allen* (1963) og *Braude & Mitchell* (1964). Som imidlertid fremhævet af *Cole* et al. (1967) kan man risikere, at svin, der holdes meget snævert, får nedsat muskeltonus med deraf følgende nedsættelse af den hastighed, hvormed foderet passerer dyrets tarmkanal og dette kan medføre, at man finder fordøjelighedskvotienter, der ikke modsvarer de praktiske forhold.

Ved tidligere undersøgelser med anvendelse af to størrelser af opsamlingsbure på henholdsvis 0.5 og 0.7 m², som beskrevet af *Spildo* (1933) og *Breirem* (1935), er det fundet, *Ludvigsen & Thorbek* (1955), at den daglige gødningsudskillelse aftager i løbet af opsamlingsperioden, og at dyret »kvitterer« med en meget stor gødningsudskillelse, såsnart det bliver taget ud af buret og har bevæget sig lidt rundt i den almindelige staldbås. Denne gødningsmængde tilhører faktisk opsamlingsperioden, og såfremt den ikke medregnes, vil man få fejlagtige fordøjeligheds- og balanceværdier.

Forsøgsperiodens længde kan variere mellem de forskellige laboratorier fra 5–21 døgn i forperioden og fra 4–10 døgn i opsamlingsperioden, som beskrevet af *Madsen* (1963). Da vi ønskede at gennemføre så mange perioder som muligt i forsøgstiden, og da dette vil være afhængig af forsøgsperiodens længde, har vi undersøgt, hvilken indflydelse periodens længde har på resultaternes nøjagtighed.

Såfremt man i balanceforsøg til måling af protein- og fedtaflejringen benytter en teknik med konstant fodring indenfor hver periode, kan det ikke undgås, at man i opsamlingsperioden måler i en periode, hvor tilvæksten er lavere end i forperioden. Dette skyldes, at dyrets forøgede vægt medfører et større vedligeholdelsesbehov, hvorved der bliver mindre protein og energi til rådighed for væksten. I forsøg med tidligt fravænnede, kunstigt ernærede pattegrise har det været muligt at opnå en meget jævn tilvækstkurve ved anvendelse af dagligt stigende fodernormer gennem forsøgsperioderne, *Ludvigsen & Thorbek* (1960), hvorfor det er blevet undersøgt, om det var muligt, at anvende en lignende fodringsteknik overfor svin fra 20–90 kg legemsvægt.

Disse tekniske undersøgelser omfattede 12 svin fra 20–50 kg legemsvægt, og der gennemførtes to 14-dages perioder med daglig, individuel opsamling af gødning og urin fra opsamlingsbure, hvis grundareal var 1 m^2. I den første periode anvendtes konstant fodring og i den anden periode glidende fodring med en daglig stigning på 20 g kornblanding og 5 g skummetmælkspulver. De daglige variationer i kvælstofudskillelsen i gødningen blev benyttet som undersøgelseskriterium, idet enhver tilblanding af urin med det store kvælstofindhold vil påvirke de registrerede kvælstofudskillelser i gødningen ganske betydeligt.

Resultaterne er angivet i figur 1, 5 og 6 samt i tabel 1 og 2, hvor spredningen på resultaterne er beregnet efter en særlig model, som angivet af professor *G. Rasch* i sektion 2.3. Det fremgår af undersøgelserne, at man ved konstant fodring må regne med at anvende en forperiode på 5–7 døgn efter det foregående foderskifte, inden der er opnået et konstant niveau af kvælstofudskillelsen i gødningen. Ved en glidende fodring med små daglige foderstigninger er der ikke tale om nogen egentlig forperiode, og en opsamlingsperiode udover 5 døgn medfører ingen forøget nøjagtighed på bestemmelsen af fordøjelighedskvotienten. Der er opnået noget større nøjagtighed ved at anvende glidende fodring fremfor konstant fodring med 5 døgns opsamling, idet spredningen var henholdsvis 2.5% og 3.4%.

På grundlag af disse resultater blev det besluttet, at man ved de kommende forsøg ville anvende opsamlingsbure med en grundflade på 140 × 70 cm, således at de mindre dyr havde en vis bevægelsesfrihed, og at de store dyr ikke var for stærkt indsnævret. Man ville desuden foretrække en fodringsteknik med dagligt stigende fodermængder og af praktiske grunde anvende en 7 døgns opsamlingsperiode med et respirationsforsøg i midten af hver periode.

Kapitel 3

Metoder og dyremateriale anvendt i serie C–D–E–F. 1964–66

Som forsøgsdyr er anvendt 48 galte af dansk landrace, og for i videst muligt omfang at kunne generalisere fra forsøgsresultaterne, er det tilstræbt at have en vis variation mellem dyrene, hvorfor der er udvalgt 4 galte fra 12 kuld stammende fra gode brugsbesætninger. Som foder er anvendt byg, majs eller milo med tilskud af skummetmælkspulver eller proteinblanding ($^2/_3$ sojaskrå + $^1/_3$ kød-benmel), Dyrenes fordeling på de forskellige serier og de anvendte foderplaner fremgår af tabel 4, 5 og 6.

Som diskuteret i kapitel 2 er dyrene fodret med en dagligt stigende mængde, der i periode I og II udgjorde 10 g korn og 5 g proteintilskud. Fra periode III, hvor proteintilskuddet blev holdt konstant på 350 g, blev korntilførslen forøget med 20 g daglig. De angivne normer refererer til den gennemsnitlige foderoptagelse i opsamlingsperioderne. I serie C er der fodret noget svagere, idet vi på det tidspunkt ikke var helt sikre på, hvor meget dyrene var i stand til at æde, og vi ønskede at undgå foderrester.

Fodermidlernes kemiske sammensætning er bestemt i hver periode og middeltallene for hver serie er angivet i tabel 7 og 8. Det anvendte skummetmælkspulver var af dansk oprindelse og spraytørret, medens proteinblandingen var af samme type som anvendt ved Afkomsprøvestationen i Roskilde. Der blev givet et dagligt tilskud af 2000 i.e. A-vitaminer og 500 i.e. D_2-vitaminer. Behovet for kalcium og fosfor, baseret på tidligere undersøgelser, er angivet i sektion 3.3. og på grundlag af Ca- og P-analyser i de anvendte fodermidler blev rationerne afbalanceret ved hjælp af $CaCO_3$ og Na_2HPO_4, således at behovet skulle været dækket. Desuden blev der givet et dagligt tilskud af salt med henholdsvis 6,9 og 12 g i perioderne I-III, IV-VI og VII-VIII., Vandtilførslen udgjorde ca. 3 gange tilført foder.

Det var planlagt at gennemføre 8 balanceperioder med samtlige 48 galte svarende til 384 perioder, og det lykkedes at gennemføre ialt 381 balanceforsøg. Af tekniske årsager var det nødvendigt at udelade 2 respirationsforsøg i serie C og D indenfor gruppen, der fik byg + skummetmælkspulver. I serie D udgik desuden dyr nr. 6 (milo + mælk) i periode VIII på grund af foderrest og meget hård, knoldet gødning.

Ved dyrenes ankomst til laboratoriet blev de behandlet med piperazin-dihydroclorid mod ormeæg, men ellers er forsøgene gennemførte uden anvendelse af medicin. Bortset fra enkelte lettere tilfælde af diarré i forperioden samt nedsat appetit, kureret ved fjernelse af foderet i ½ dag, har dyrene været sunde og raske i hele forsøgstiden.

Respirationsforsøgene er gennemførte ved hjælp af de nybyggede respirationsanlæg og med den teknik, der er beskrevet af *Thorbek* (1969). De 2 anlæg er regelmæssigt kalibrerede under forsøgets gang, og der er ialt gennemført 34 kalibreringer, som angivet i figur 7. Beregningerne viste, at der var ingen signifikant forskel imellem de to anlæg. Dyrenes respiratoriske stofskifte er målt over 24 timer, på den midterste dag i opsamlingsperioden. For at undgå ophidselse af dyrene er de transporteret fra stald til anlæg ved hjælp af en lille vogn, og de har opholdt sig 2 timer i anlæggene, inden selve målingerne er påbegyndte.

I tabel 9, 10 og 11 er angivet den nøjagtighed, der er opnået ved de kemiske bestemmelser af kvælstof, kulstof og energi i foder, gødning og urin, og i tabel 12 er angivet nøjagtigheden på CO_2- og O_2 analyserne med anvendelse af den metode, der er angivet af *Rasch* et al. (1958). Beregningerne af energiomsætningen, der er gennemførte med de internationalt vedtagne faktorer, *Brouwer* (1965), fremgår af sektion 3.8.

Kapitel 4

Energi- og proteintilførsel, tilvækst og foderudnyttelse

Dyrene er i alle serier vejet før og efter hver opsamlingsperiode, og de beregnede middelværdier for legemsvægt og alder i de enkelte perioder er angivet individuelt i hovedtabel I og II. På grundlag af disse enkeltværdier er middelværdierne beregnet for hver periode inden for de 6 fodringsgrupper, som angivet i tabel 13, 14 og 15 og vist grafisk i figur 8, 9 og 10.

Den gennemsnitlige alder i periode I varierede fra 85–99 dage, medens legemsvægten varierede fra 21.7–24.0 kg, men der var ingen signifikante forskelle imellem de 6 grupper. Ved forsøgets afslutning var gennemsnitsvægten for dyrene i byggruppen (BA+MI/PR) 83.1 og 80.2, for majsgrupperne (MA+MI/PR) var slutvægten 77.4 og 77.2 kg, medens dyrene i milo-grupperne (SO+MI/PR) gennemsnitligt vejede 80.4 og 81.2 kg. Forskellen mellem (BA+MI) og (MA+MI) på 5.7 kg var signifikant, medens de øvrige forskelle mellem grupperne ikke var signifikante.

I samtlige 381 balanceforsøg er mængderne af de optagne og fordøjede næringsstoffer samt optaget og fordøjet energimængde bestemt, og de individuelle værdier er angivet i hovedtabel I. Den omsættelige energi (OE=ME=metabolizable energy = bruttoenergi – energi i gødning – energi i urin) er bestemt i samtlige forsøg, og værdierne angivet i hovedtabel II. På grundlag heraf er middelværdierne for foderoptagelse og tilført omsættelig energi beregnet for hver periode og hver fodergruppe, og værdierne findes i tabel 16, 17 og 18 sammen med værdierne for foderets indhold af netto-energi (NEFs), der er beregnet på grundlag af værdierne i *Futtermitteltabellenwerk* (1970).

I periode I varierede energitilførslen fra 2.4–2.8 Mcal ME, medens variationen i periode VIII var fra 8.2–9.1 Mcal ME. Ved at vurdere tilførslen af omsættelig energi (ME) for samtlige fodergrupper i relation til de tilsvarende legemsvægte fås en kurve som vist i figur 12. Til sammenligning er indtegnet de kurver, der findes ved en tilsvarende beregning af materialet fra *Breirems* (1935) og *Nielsens* (1970) undersøgelser. Det ses, at kurven fra de foreliggende undersøgelser helt falder sammen med *Nielsens* kurve ved 20 kg, hvor normen er ca. 2.0 Mcal ME daglig, men derefter afviger kurverne fra hinanden, således at normen i de foreliggende forsøg var 8.9 Mcal ME ved 85 kg legemsvægt mod 8.2 Mcal ME i den af *Nielsen* anvendte norm, der svarer til den norm afkomsprøve-stationerne anvender. Den af *Breirem* benyttede norm svarer til 2.7 Mcal ME ved 20 kg legemsvægt, men med en lavere stigning slutter den ved 7.5 Mcal ME ved 85 kg.

I de foreliggende undersøgelser har vi forsøgt at anvende en proteinnorm, der i henhold til vore erfaringer, skulle sikre en maximal proteinaflejring, uden at der tilførtes overskud af protein. Såfremt dyrene får tilført mere protein end de kan udnytte til maximal aflejring, vil det nedbrydes, og den kvælstofholdige del vil blive udskilt i urinen og dermed forøge såvel kvælstoftabet som energitabet. Ved at sammenligne forholdet mellem omsættelig energi (ME) og fordøjelig energi (DE) vil man få bestemt hvor meget energi, der er gået tabt gennem urinen, og dermed få et udtryk for om den anvendte norm har været for stor i forhold til behovet. At normen, inkluderet dens biologiske værdi, har været tilstrækkelig til at sikre maximal proteinaflejring vil blive diskuteret i kapitel 7.

Relationen mellem ME og DE for samtlige fodergrupper er vist grafisk i figur 13 og det ses, at der for alle grupper er en udpræget fælles linearitet gennem forsøgstiden. En regressionsberegning med anvendelse af samtlige individuelle målinger gav en regressionscoefficient på 0.972 ± 0.00024 svarende til et energitab i urinen på 2.8%, (tabel 19), hvilket må anses for at være lavt, indicerende at den anvendte proteinnorm ikke har været for stor. *Nielsen* (1970) angiver et energitab i urinen på 2.6–4.6%, hvilket antagelig må henføres til, at der er anvendt foderblandinger med konstant sammensætning gennem hele forsøgstiden.

Som tidligere omtalt er den anvendte fodernorm karakteriseret ved en jævnt stigende korntilførsel, medens proteintilskuddet, der er stigende i periode I og II, er holdt konstant på 350 g daglig fra periode III. I periode I udgjorde proteintilskuddet 30% af den tilførte fodermængde jævnt aftagende til 13% i periode VIII, hvilket svarer til at den anvendte foderblanding indeholdt 15–17% fordøjeligt protein i periode I aftagende til 11–12% i periode VIII.

Samtlige indviduelle værdier for tilført og fordøjet kvælstof er angivet i hovedtabel I, og på grundlag heraf er middelværdierne for fordøjeligt protein beregnet for de enkelte perioder og for de 6 fodergrupper, som vist i tabel 21, 22 og 23. I tabellerne er samtidigt angivet tilførsel af lysin og metionin + cystin, idet der ved stor imødekommenhed fra *Bjørn O. Eggums* side er foretaget aminosyreanalyser i samtlige anvendte fodermidler.

Ved at sætte de fordøjede proteinmængder i relation til omsættelig energi (ME) fås i de i figur 15 viste kurver. Forholdet mellem g fordøjeligt protein/Mcal, ME aftager fra 44–32 for de rationer, hvor proteintilskuddet var skummetmælkspulver (MI), medens forholdet aftager fra 53–35 for de rationer, der indeholdt proteinblanding (PR). Til sammenligning er angivet den lineære relation, der opnås ved at benytte *Nielsens* (1970) data med anvendelse af de forsøg (56 svin), hvor foderblandingerne ikke indeholdt afrensning fra U.S. 5 byg. Selv om proteintilskuddet har varieret fra 14–24% er forholdet mellem g fordøjeligt protein/Mcal, ME temmelig konstant med en værdi omkring 47.

Den gennemsnitlige daglige tilvækst i relation til legemsvægt er vist i figur 16, og fra den udjævnede kurve er den daglige tilvækst angivet i tabel 24 sammen med de tilsvarende optagne fodermængder udtrykt som kg eller i energi-enheder. Den gennemsnitlige daglige tilvækst for alle fodergrupper var 571 g med en foderudnytning fra 2.6 til 3.4 kg foder pr. kg tilvækst, svarende til 8.0 Mcal ME ved 20 kg legemsvægt stigende til 11.0 Mcal ME pr. kg tilvækst ved 80 kg.

Nielsen (1970) angiver en gennemsnitlig (korrigeret) daglig tilvækst på 629 g for alle sine forsøg (so + galtgrise) med en gennemsnitlig foderudnytning af 2.77 sk.f.e. pr. kg tilvækst.

Kapitel 5

Fordøjelighed og omsættelig energi i byg, majs, milo, skummetmælkspulver og proteinblanding

På grundlag af målinger i 381 balanceforsøg er de optagne og fordøjede mængder af de forskellige næringsstoffer og energi beregnet individuelt og angivet i hovedtabel I, samtidig er den omsættelige energi (ME) beregnet og angivet i hovedtabel II. Disse målinger er benyttet til at vurdere fordøjelighed og omsættelig energi såvel i de anvendte foderblandinger som i de enkelte foderkomponenter.

5.1. Fordøjelighed af de anvendte foderblandinger

I tabellerne 25–30 er angivet de beregnede middelværdier for optagelse og fordøjelighed af de forskellige næringsstoffer og energi i de 6 anvendte fodertyper. Generelt er det fundet, at fordøjeligheden af organisk stof (OMD), kvælstof-fri-ekstraktstoffer (NFED), kvælstof (ND) og brutto-energi (GED) i de forskellige foderblandinger er højest, hvor de respektive kornarter er givet i kombination med skummetmælkspulver fremfor i kombinationen med proteinblanding, hvilket kan henføres til forskelle i fordøjeligheden af disse to proteinfodermidler, som vist i næste sektion.

Som det fremgår af tabellerne 25–30 og desuden vist grafisk i figur 17, 18 og 19, er der i samtlige forsøg opnået størst nøjagtighed ved bestemmelse af fordøjelighedskvotienterne for kvælstoffri-ekstraktstoffer (NFED), idet spredningen i de fleste tilfælde var under 1% (abs.) Fordøjelighedskvotienterne for organisk stof (OMD) og brutto-energi (GED) er bestemt med en lidt mindre nøjagtighed, idet 30% af bestemmelserne har en spredning under 1%, 47% ligger mellem 1.0–1.5%, 17% mellem 1.5–2.0% og 6% er bestemt med en spredning fra 2.0–2.5%.

I overensstemmelse med resultaterne fra de foreløbige undersøgelser vedrørende forsøgsteknik, er der fundet en lavere nøjagtighed på bestemmelserne af kvælstoffets fordøjelighed, idet kun 23% af bestemmelserne har en spredning mellem 1.0–2.0%, 46% ligger mellem 2.0–3.0% og 31% ligger over 3%. Det skal inidlertid understreges, at denne usikkerhed ikke påvirker nøjagtigheden på bestemmelsen af kvælstofbalancen, og som diskuteret i kapitel 2, har vi foretrukket, at dyrene har en vis bevægelsesfrihed svarende til praktiske forhold.

Betragter man nøjagtigheden på bestemmelserne af fordøjelighedskvorienterne for fedt og kvælstof, vil man se, at den er meget ringe. For fedtets vedkommende skyldes det antageligt, at den anvendte æterekstrakt-metode er en meget dårlig analyse-metode som allerede påvist af *Nehring* et al. (1963) og grundigt diskuteret af *Nielsen* (1970). De resultater, der er opnået af *Thomsen* (1971), viser tydeligt, at man ved fordøjelighedsforsøg med svin bør gå over til at anvende en metode med saltsyre-hydrolyse inden æter-ekstration. Med hensyn til træstoffet må en del af unøjagtigheden antagelig tilskrives selve analysemetoden, men en del skyldes sikkert variationer i den træstofnedbrydende mikroflora, der findes hos de forskellige svin.

5.2. Fordøjelighed af de anvendte foderkomponenter

I de foreliggende forsøg, hvor der ikke er anvendt foderblandinger med konstant sammensætning, skulle det være muligt, at bestemme fordøjeligheden af de enkelte fodermidler ved hjælp af regressionsligningen:

$$y = \alpha x_1 + \beta x_2 \quad (1)$$

hvor y er total fordøjet mængde af det pågældende næringsstof, medens x_1 og x_2 er de optagne mængder af de to foderkomponenter.
Ved transformering af (1) fås

$$1 = \alpha \frac{x_1}{y} + \beta \frac{x_2}{y} \quad (2)$$

og inden beregningerne er påbegyndt, er der foretaget en grafisk vurdering af ovenstående funktion, som vist i figur 20 og 21. Indenfor det målte område er der for alle 6 fodergrupper fundet en udpræget linearitet med hensyn til organisk stof, kvælstof, kvælstoffri ekstraktstoffer og energi og beregningerne er derefter gennemførte med anvendelse af samtlige enkeltværdier. På grund af den ringe nøjagtighed ved bestemmelse af fedt- og træstoffordøjeligheden er tilsvarende beregninger ikke gennemførte for disse næringsstoffers vedkommende.

De opnåede resultater for samtlige kombinationer er vist i tabel 31, og det er ved hjælp af t-test undersøgt, om der er signifikante forskelle imellem de fundne fordøjelighedskvotienter for de enkelte fodermidler afhængig af den foreliggende kombination. For byg, majs og milo fandtes ingen signifikante forskelle, og det vil sige, at de beregnede fordøjelighedskvotienter var uafhængig af, om disse kornarter var givet i forbindelse med skummetmælkspulver eller proteinblanding.

For skummetmælkspulver fandtes en fordøjelighed af kvælstoffet på 83.7% i kombination med byg, medens kombinationen med majs gav en værdi på 89.2%, og denne forskel var signifikant ($t = 2.87 > t_{.01} = 2.63$). For de øvrige næringsstoffer samt for energien fandtes ingen signifikante forskelle afhængig af kombinationen.

For proteinblandingen i forbindelse med byg fandtes en fordøjelighed på 78.7% for NFE, og denne værdi var signifikant forskellig fra 63.8% og 67.1% fundet i kombination med majs og milo ($t = 3.63 > t_{.001} = 39$ henholdsvis $t = 2.77 > t_{.01} = 2.63$). Derudover fandtes ingen signifikante forskelle.

En vurdering af spredningen på regressionskvotienter (s_b) viser, at der for kornarternes vedkommende er opnået en stor nøjagtighed ved bestemmelse af fordøjelighedskvotienterne for organisk stof (OMD), N-fri ekstraktstoffer (NFED) og brutto-energi (GED), idet spredningerne overalt er under 1%. For kvælstoffets vedkommende er fordøjelighedskvotienterne (ND) bestemt med en noget lavere nøjagtighed, som diskuteret i den foregående sektion, med spredninger der overvejende ligger mellem 1.5–2.5%. Fordøjelighedskvotienterne for skummetmælkspulver og proteinblanding er overalt bestemt med en mindre nøjagtighed end for kornarternes vedkommende, hvilket delvis må tilskrives, at der tilføres mindre mængder af de forskellige næringsstoffer og energi fra proteinfodermidlerne end fra kornarterne.

De fundne fordøjelighedskvotienter er i tabel 32 sammenstillet med værdier fra forskellige tabelværker samt med de værdier, *Madsen* (1963) har opnået ved sine omfattende fordøjelighedsforsøg, angivet med højest og lavest værdi bestemt ved regressionsmetoden. Sammenstillingen viser, at selv for de fire anførte, stærkt benyttede fodermidler forekommer der en betydelig variation i angivelserne, og da al fodermiddelvurdeirng, uanset hvilket system man vælger, fundamentalt hviler på kendskab til fordøjeligheden af de enkelte fodermidler, ville det være ønskeligt, om arbejdet indenfor dette område kunne intensiveres, således at man kunne nå til en vis »europæisk standard«.

5.3. Omsættelig energi i de anvendte foderblandinger

På grundlag af omfattende undersøgelser med »udvoksede« svin har *Schiemann* et al. (1971) fremsat deres velkendte regressionsligning til beregning af omsættelig energi baseret på kendskab til mængden af de fordøjede næringsstoffer. I de foreliggende undersøgelser, hvor såvel den omsættelige energi, som de fordøjede næringsstoffer er bestemt individuelt gennem hele forsøgsperioden for de 6 anvendte fodertyper, er det nærliggende at undersøge, om tilsvarende ligninger kan etableres for voksende svin.

Inden gennemførelsen af beregningerne er der foretaget en grafisk vurdering af, hvorvidt der skulle være udpræget korrelation mellem fordøjet NFE og kvælstof, der udgør hovedparten af de fordøjede næringsstoffer, idet en udpræget korrelation vil kontraindicere en regressionsberegning. Undersøgelsen viste, at der var en svag korrelation i periode I, men den aftog gennem perioderne, og i periode VIII er observationerne spredt ud over hele arealet, som vist i figur 22 og 23.

Beregningerne er derefter gemmemførte for samtlige perioder med anvendelse af regressionsmodel 1 og 2, med og uden intercept (Statistical appendix, section 10.2), og resultaterne er angivet i tabel 33. Beregningerne i henhold til model 1 viser, at samtlige intercept er signifikante, og fra et statistisk synspunkt burde denne model foretrækkes, men de fundne værdier for fordøjet protein og NFE er biologisk uakceptable, idet de ligger over de teoretiske værdier for fuldstændig forbrænding, og modellen må derfor forkastes i denne sammenhæng til fordel for model 2.

En lignende beregning har været gennemført med data fra *Nielsens* (1970) undersøgelse omfattende 80 svin på 20 forskellige foderkombinationer, og resultaterne vedrørende første og sidste forsøgsperiode er i tabel 34 sammenstillet med *Roctock-gruppens* resultater. Som det vil ses, er der for samtlige ligninger en god overensstemmelse mellem de målte og beregnede værdier for omsættelig energi, idet spredningerne på residualerne ligger mellem 0.9–1.3% af middelværdierne for omsættelig energi.

Såvel i *Nielsens* som i egne undersøgelser er regressionskoefficienten for NFED bestemt med stor nøjagtighed, med s_b varierende fra 0.06–0.19. Nøjagtigheden på bestemmelsen af koefficienten for fordøjet protein (ND) er væsentlig mindre, idet s_b varierer fra 0.4–0.7, men det skal her tages i betragtning, at fordøjet protein kun leverer 10–15% af den omsættelige energi, hvorved den relative nøjagtighed bliver af samme størrelsesorden. Koefficienterne for fordøjet fedt og træstof er bestemt med nogen usikkerhed, således varierer s_b fra 0.6–1.7 for fedtets vedkommende og fra 1.0–3.9 for træstoffets vedkommende. Denne usikkerhed er imidlertid af mindre betydning under praktiske fodringsforhold, hvor næppe mere end 8–10% af den omsættelige energi stammer fra fedtindholdet og mindre end 2% fra træstoffet. Det er dog ikke relevant at angive disse koefficienter med mere end 1 decimal.

Det vil af tabel 34 ses, at de fundne koefficienter er noget afhængig af alderen samt af de anvendte normer, specielt med henblik på proteinnormen. Såfremt proteinnormen er lav i forhold til behovet, vil der opnås høje koefficienter og omvendt såfremt proteinnormen er væsentlig over behovet, samtidig er koefficienten afhængig af proteinets biologiske værdi, og det synes derfor ikke at være rimeligt at angive proteinfaktoren med mere end 1 decimal.

5.4. Omsættelig energi i de anvendte foderkomponenter

I de foreliggende undersøgelser med den store kontrast mellem tilførslen af korn og proteinfodermidler skulle det være muligt at beregne den omsættelige energi i de enkelte fodermidler efter samme regressionsmodel som omtalt i sektion 5.2.

En sådan beregning er gennemført og resultaterne er vist i tabel 35 sammen med den fundne kemiske sammensætning og fordøjelighed for de pågældende fodermidler. Det vil ses, at den omsættelige energi er bestemt med stor nøjagtighed for kornarternes vedkommende, spredningen er under 1%, medens nøjagtigheden er noget mindre for proteinmidlerne, hvor spredningen er 2.0–2.6%.

De fundne værdier for omsættelig energi i byg, majs og milo er 6–12% højere end de i fodermiddeltabellerne angivne værdier, medens der ingen forskel er fundet med hensyn til skummetmælkspulver.

Kapitel 6

Luftstofskifte og varmeproduktion hos voksende svin fodret med forskellige foderblandinger

Som tidligere omtalt er der i de foreliggende undersøgelser gennemført 381 balanceforsøg og respirationsforsøg til måling af luftstofskiftet i hver periode. På grund af forskellige tekniske vanskeligheder har iltmålingerne ikke kunnet gennemføres i 14 forsøg, således som det fremgår af hovedtabel II, hvor samtlige individuelle målinger er angivet. Den samlede varmeproduktion er dels beregnet efter RQ-metoden (HP, RQ) som angivet i sektion 3.8 og dels på grundlag af CN-metoden (HP, CN), der er baseret på differencen mellem omsættelig energi (ME) og summen af den aflejrede energi i fedt og protein, beregnet på grundlag af kulstof (C)-balancen og kvælstof (N)-balancen. Baseret på de 367 fuldstændige målinger af det respiratoriske stofskifte er dette samt den beregnede varmeproduktion vurderet i relation til dyrenes legemsvægt, metaboliske legemsvægt samt tilførsel af omsættelige energi.

6.1. Luftstofskifte og varmeproduktion i relation til legemsvægt og ME

På grundlag af enkeltmålingerne af det respiratoriske stofskifte er middelværdierne og spredninger beregnet for hver periode omfattende samtlige 6 fodergrupper, og værdierne er angivet i tabel 36 tilligemed de beregnede værdier for varmeproduktion, tilsvarende legemsvægte og indtagelse af omsættelig energi.

Værdierne for CO_2-produktion, O_2-optagelse og varmeproduktion er grafisk angivet i figur 24, 25 og 26 i relation til legemsvægten. Til sammenligning er indtegnet de tilsvarende kurver baseret på data fra *Breirems* (1935) forsøg omfattende 5 svin på lav proteinnorm målt i 26 respirationsmålinger samt fra *Nielsens* (1970) materiale, der omfatter 80 svin målt i 6 perioder, opgivet som middeltal for 4 dyr i hver gruppe.

Det ses tydeligt, at *Breirems* kurver ligger betydeligt under de kurver, der er fundet i de foreliggende forsøg selv i de lavere vægtklasser, hvor *Breirems* energinorm er højest (jvf. figur 12). På den anden side har *Breirem* anvendt en proteinnorm, der ligger 35% under den norm, der er anvendt i de foreliggende undersøgelser, og dette har åbenbart medført en lavere proteinomsætning og dermed en lavere varmeproduktion

En sammenligning mellem *Nielsens* og egne resultater viser en udpræget overensstemmelse med hensyn til kurverne for CO_2-produktionen. For O_2-optagelsen er kurverne sammenfaldende i de lavere vægtklasser, men derefter er der en lidt stærkere stigning i kurven for *Nielsens* observationer, således at O_2-forbruget ved 80 kg legemsvægt er omkring 50 l større pr. dag svarende til et varmetab på ca. 200 kcal (figur 26). Med den lavere energinorm, der er anvendt af *Nielsen* (jvf. figur 12), skulle man have forventet et lavere respiratorisk stofskifte og et mindre varmetab; når dette ikke er tilfældet, skyldes det antageligt, at der er anvendt foderblandinger med konstant sammensætning, der har medført, at proteintilførslen fra 40–50 kg legemsvægt har været større end behovet. Som tidligere omtalt vil dette medføre, at det overflødige protein omdannes og udskilles som urinstof i urinen, og denne proces er ret iltkrævende, således som det er registreret ved et større iltforbrug og et større varmetab.

For at kunne sammenligne de fundne værdier for luftstofskifte og varmeproduktion med de hidtil anvendte normer ved ventilering af svinestalde er der i tabel 37 foretaget en sammenstilling af disse værdier indenfor de forskellige vægtklasser. Baseret på en varmeproduktion af 775 kcal pr. time hos en malkeko på 500 kg, som angivet af *Cords-Parchim* (1947), foreslog *Korsgaard* (1951) at indføre en varmeproduktionsenhed, V_{pe} = 800 kcal pr. time og at regne proportionalt med 0.15 V_{pe} for et svin på 45 kg, svarende til 120 kcal pr. time eller 2.88 Mcal pr. 24 timer. Ved tidligere undersøgelser, *Ludvigsen & Thorbek* (1955) er fundet døgnværdier omkring 2.8 Mcal for svin på 45 kg, men såvel fra *Nielsens* som fra de foreliggende undersøgelser ser det ud til, at man i dag må regne med en varmeproduktion på 3.1–3.2 Mcal.

Det ses tydeligt, at luftstofskiftet og varmeproduktionen ikke er proportionalt med legemsvægten, men relativt større for de små dyr og lavere for de større svin. Såfremt det drejer sig om blandede stalde med små og store svin, vil der ikke ske større fejlvurdering ved at regne proportionalt. Drejer det sig derimod om »all in – all out« stalde, bør der næppe regnes med et luftstofskifte og en varmeproduktion proportionalt med værdierne ved 45 kg legemsvægt, men derimod anvendes en funktion i relation til metabolisk legemsvægt, som diskuteret i næste sektion.

6.2. Luftstofskifte og varmeproduktion i relation til metabolisk legemsvægt

Ved transformering af de observerede legemsvægte til metabolisk legemsvægt ($kg^{0.75}$) og ved at angive de tilhørende middelværdier for luftstofskifte og varmeproduktion i relation hertil fås de i figur 27 og 28 viste relationer. Til sammenligning er indtegnet de værdier for varmeproduktion, der opnås ved en lignende behandling af data fra *Nielsens* (1970) forsøg og fra *Verstegens* (1971) undersøgelser omfattende 109 målinger på svin holdt som par.

Denne transformering viser udpræget lineære relationer, og på grundlag af enkeltobservationerne er regressionsligningerne for luftstofskiftet og varmeproduktionen beregnet og angivet i tabel 38. De to ligningssæt henholdsvis fra *Nielsens* og fra egne undersøgelser viser samme grad af nøjagtighed såvel med hensyn til bestemmelse af regressionskoefficienterne som på det samlede estimat, og det må anses for mere relevant at anvende sådanne ligningssæt til beregning af luftstofskifte og varmeproduktion i stalde fremfor at benytte proportional-beregninger, som diskuteret i det foregående afsnit.

Den ligning for varmeproduktion, der kan beregnes på grundlag af *Verste-*

gens undersøgelser er behæftet med større usikkerhed, hvilket muligvis er begrundet i tekniske forhold. Det lavere niveau især for de mindre dyr, skyldes antagelig en lav proteinnorm, idet tilførslen af omsættelig energi svarer til den norm, der har været anvendt ved de danske undersøgelser.

6.3. Sammenligning af varmeproduktion beregnet efter RQ- eller CN-metoden

I denne sektion er der foretaget en vurdering af hvilke forskelle, der måtte findes ved at beregne varmeproduktionen på grundlag af luftstofskiftet (RQ-metoden) eller på grundlag af kulstof- og kvælstofbalancerne (CN-metoden). Resultaterne er vist grafisk i figur 29 og i tabel 39 ved regressionsberegninger såvel for de enkelte perioder som for de forskellige fodertyper. Det vil heraf ses, at der igennem perioderne omfattende alle fodertyper er en stigende forskel, således af CN-metoden i periode I giver en varmeproduktion, der er 1.7% over RQ-metoden og i periode VIII 4.4% under RQ-metoden. For samtlige observationer er der fundet en forskel på 2.4%.

En dybere analyse viser, at der ikke er signifikant forskel mellem regressionskoefficienterne for byg og miloblandingerne, og her er forskellen mellem de to beregningsmetoder 1.8%, medens den ved majsblandingerne for samtlige perioder er 4.2%. Som vist i den grafiske fremstilling synes differencen for majsblandingernes vedkommende at være stor i de senere perioder, og en opdeling af beregningerne mellem periode I–V og VI–VIII viser, at forskellen kun er 0.3% i de første 5 perioder, men stiger til 7.5% i de sidste perioder og denne forskel er stærkt signifikant.

Denne undersøgelse tyder på, at afvigelserne mellem de to beregningsmetoder er afhængig af hvilke fodermidler, der anvendes, og det er muligt, at det er fedtets sammensætning, der fremkalder disse differencer, idet de fastlagte beregningsfaktorer for RQ-metoden er baseret på de værdier, der opnås ved fuldstændig forbrænding af palmitinsyre.

Kapitel 7

Kvælstofomsætningen hos voksende svin fodret med forskellige foderblandinger

7.1. Egne undersøgelser

Som tidligere omtalt er der gennemført 381 balanceforsøg med tilhørende bestemmelse af kvælstofomsætningen. Enkeltværdierne for optaget og udskilt kvælstof samt kvælstofbalancerne findes i hovedtabel I og II, og de beregnede middelværdier indenfor hver periode og hver af de 6 fodertyper er angivet i tabel 40–45 tilligemed værdierne for legemsvægt og omsættelig energi.

I forsøgene med skummetmælkspulver blev der i gennemsnit tilført 19.1 g fordøjeligt N svarende til 119 g protein i periode I, stigende til 44.6 g fordøjeligt

N eller 279 g fordøjeligt protein i periode VIII. De tilsvarende tal fra forsøgene med proteinblanding var 21.2 g fordøjeligt N eller 133 g fordøjeligt protein i periode I og 47.6 g fordøjeligt N svarende til 298 g fordøjeligt protein i periode VIII.

Tilførslen af lysin var 9.6 g i periode I stigende til 19.8 g i periode VIII i forsøgene med byg og 8.8 g stigende til 16.5 g i forsøgene med majs og milo. Der er i de foreliggende undersøgelser ikke foretaget nogen bestemmelse af lysinets tilgængelighed.

Energitilførslen var i forsøgene med skummetmælkspulver 2.69 Mcal ME i periode I stigende til 8.72 Mcal i periode VIII og 2.51 Mcal stigende til 8.45 Mcal ME for rationerne med proteinblanding. I relation til metabolisk legemsvægt svarede dette til 251 henholdsvis 239 kcal ME/kg$^{0.75}$ i periode I og 324 henholdsvis 318 kcal ME/kg$^{0.75}$ i periode VIII.

Kvælstofbalancerne var for hver periode af samme størrelsesorden, og der var ingen signifikante forskelle mellem de 6 forskellige fodertyper. I periode I med en gennemsnitlig legemsvægt på 23 kg var kvælstofaflejringen 11 g svarende til 69 g protein. Aflejringen steg jævnt til omkring 20 g N eller 125 g protein i periode VI ved en legemsvægt på ca. 60 kg, hvorefter den var nogenlunde konstant, dog med en vis aftagende tendens for enkelte dyr.

Nøjagtigheden på bestemmelserne af kvælstofbalancerne er karakteriseret ved, at spredningen var under 1.5 g i 46% af bestemmelserne, mellem 1.5–2.0 g i 25% og mellem 2.0–3.0 g i 29% af bestemmelserne. Det er nærmere undersøgt, om denne spredning skyldes, at det enkelte dyr varierer op og ned mellem de angivne grænser, eller om det gennem alle perioder fastholder sit parameter, således at spredningen angiver variationen mellem de enkelte dyrs parametre. Resultaterne af en sådan undersøgelse er vist i tabel 46, der angiver de højeste og laveste individuelle værdier for kvælstofaflejringen målt i forsøg med byg og skummetmælkspulver. Det vil ses, at de enkelte dyr er karakteriseret ved at give en høj eller lav kvælstofbalance, værdierne blandes ikke og forskellen mellem høj og lav aflejring indenfor serierne er signifikant eller stærkt signifikant. En tilsvarende undersøgelse for de øvrige fodertyper gav lignende resultater.

Udnyttelsesgraden af kvælstoffet, bestemt som relationen mellem aflejret kvælstof og fordøjet kvælstof, var i de foreliggende undersøgelser omkring 56% i periode I aftagende til 44% i periode VIII.

Kvælstofaflejringen i relation til legemsvægten er vist grafisk i figur 30, det ses tydeligt, at kurven er krumlinet og sammenfaldende for alle fodringstyper. Den højere tilførsel af protein i rationerne med proteinblanding har medført en større udskillelse af kvælstof i gødningen (lavere fordøjelighed) samt en større udskillelse af kvælstof i urinen, hvilket tyder på, at kurven angiver den maximale kvælstofaflejring.

Ved at sætte de målte kvælstofaflejringer i relation til metabolisk legemsvægt

($kg^{0.75}$), som vist i figur 31, ses det tydeligt, at det ikke er muligt at anvende en lineær funktion til dækning af hele forsøgsperioden, men kurven indicerer anvendelse af en kvadratisk funktion af formen: $y = ax + bx^2 + c$. En sådan ligning er beregnet med anvendelse af samtlige enkeltobservationer for kvælstofaflejring og metabolisk legemsvægt, idet konstantleddet (c) er forudsat lig med nul ved konceptionen. Beregningen gav følgende ligning:

$$\text{Kvælstofaflejring, g/dgl.} = (1.479\ kg^{0.75} - 0.0266\ kg^{1.50}) \pm 1.99$$
$$s_b \quad 0.023 \qquad 0.0011$$

hvoraf det kan udledes, at den teoretisk maximale aflejring er 20.6 g kvælstof ved en metabolisk legemsvægt på 27.8 $kg^{0.75}$, svarende til 84 kg legemsvægt.

7.2. Diskussion og konklusion

Det har i en årrække været diskuteret, om dyrenes kvælstofaflejring skulle udtrykkes som en funktion af protein- og energitilførsel, *Miller & Payne* (1963), *Gebhardt* (1966), *Hock & Pürschner* (1966) eller som en funktion af biologiske faktorer, d.v.s. af cellernes maximale evne til at aflejre protein, afhængig af dyrets alder, legemsvægt og genetiske struktur, *Møllgaard* (1955).

Disse to modstridende synspunkter har *Kielanowski* (1972) forsøgt at forene, idet han antager, at cellerne hos de unge dyr har en så stor evne til at danne protein, at dyret ikke er i stand til at optage så meget foder, at det modsvarer denne vækstintensitet, hvorved proteinaflejringen hos de unge dyr bliver en funktion af tilført protein og energi, som angivet af *Miller og Payne* (1963). Med stigende alder aftager cellernes vækstintensitet, og dyrene kan nu æde tilstrækkeligt til at nå den maximale grænse for proteinaflejring, der ikke overskrides selv ved forøget tilførsel af protein. Dette vil resultere i en maximal aflejringskurve for kvælstof, betinget af dyrets alder/vægt som fremført af *Møllgaard* (1955).

Inden det diskuteres, hvorvidt den funktion, vi har beregnet for kvælstofaflejring, kan anses for at angive den maximale aflejring, er der foretaget en sammenligning med værdier fra litteraturen. Disse værdier er taget fra undersøgelser, hvor det skønnes, at den tilførte protein- og energimængde samt foderets biologiske værdi har været tilstrækkelig stor til at sikre maximal kvælstofaflejring for den pågældende legemsvægt. Undersøgelserne er foretaget med svin af forskellige racer, og resultaterne er i tabel 47 ordnet i de respektive vægtklasser.

De fleste forskere angiver at have fundet individuelle variationer i kvælstofaflejringen på 3 til 5 g indenfor samme vægtklasse. I de foreliggende undersøgelser er der som omtalt fundet spredninger på indtil 3 g, antagelig forårsaget af forskelle i den genetiske struktur.

De værdier, der er fundet i litteraturen, viser et ret ensartet billede, og middelværdierne for kvælstofaflejringen er derfor beregnet, som angivet i tabel 47. Bortset fra periode I, er der god overensstemmelse mellem disse værdier og de værdier, der er fundet i de foreliggende undersøgelser. Den lave proteinaflejring på 13 g N fundet i periode I kan næppe tilskrives en for lav proteinnorm, idet den størreN-tilførsel i rationerne med proteinblanding ikke har forøget N-aflejringen, men kun foranlediget en større N-udskillelse i urinen (Figur 30). Dette viser hen til at energitilførslen i denne periode antagelig har været for lav til at sikre en maximal proteinaflejring. Som tidligere omtalt var energitilførslen i periode I 239 kcal ME/kg$^{0.75}$ i rationerne med proteinblanding og 251 kcal ME/kg$^{0.75}$ i rationerne med skummetmælkspulver, hvilket stort set svarede til 300 kcal bruttoenergi (GE)/kg$^{0.75}$. I henhold til den funktion, der er givet af *Miller & Payne* (1963) skulle man ved 25 kg kunne opnå en kvælstofaflejring på 13 g N ved en energitilførsel på 300 kcal GE/kg$^{0.75}$, hvilket er nøjagtig det resultat, der er opnået i de foreliggende undersøgelser. For at opnå en kvælstofaflejring på 16 g i denne vægtklasse kan det af *Miller & Payne's* kurve aflæses, at der må tilføres 350 kcal GE/kg$^{0.75}$, svarende til 280–300 kcal ME/kg$^{0.75}$.

Der foreligger kun få undersøgelser over N-aflejringen hos større svin, dog har *Oslage* et al. (1966) i forsøg med galte fundet en N-aflejring på 14 g ved 150–160 kg legemsvægt og *Elsley* et al. (1966) har fundet en N-aflejring på 12 g hos ikke-drægtige gylte ved 150–160 kg. Anvendes den tidligere omtalte kvadratiske funktion (Figur 31) finder man, at den maximale N-aflejring skulle ligge omkring 13–11 g ved legemsvægt fra 150–160 kg, svarende til de fundne værdier.

Den kvadratiske funktion, der er fundet på grundlag af de målte N-balancer i de foreliggende undersøgelser, ser således ud til i det væsentlige at beskrive den maximale protein-aflejring hos galte fra 20–160 kg legemsvægt. En sådan maximal aflejring kan forventes opnået ved en tilførsel af 125 g fordøjeligt protein med 9–10 g total lysin og en energitilførsel af ca. 300 kcal ME/kg$^{0.75}$ ved 20 kg legemsvægt stigende til 280 g fordøjeligt protein med 19–20 g total lysin og 300–320 kcal ME/kg$^{0.75}$ ved 80 kg legemsvægt, afhængig af hvor meget fedt, der ønskes aflejret. Ved anvendelse af en sådan norm, skulle det samtidig være muligt at opnå en udnyttelsesgrad på 55–45% af det fordøjede kvælstof.

Kapitel 8

Protein- og fedtaflejringen under vækst og udnyttelsesgraden af den omsættelige energi

Baseret på 381 målinger af kvælstof- og kulstofbalancerne er protein- og fedtaflejringen beregnet med faktorer, som angivet i kapitel 3.8, *Brouwer* (1965). Varmeproduktionen er beregnet efter CN-metoden som differens mellem omsættelig energi og den totale energiaflejring i protein + fedt. Samtlige enkeltværdier er angivet i hovedtabel II.

8.1. Protein- og fedtaflejringen

Middelværdierne for protein- og fedtaflejringen, der er beregnet for hver periode og for hver af de 6 anvendte fodertyper er angivet i tabel 48–53 og grafisk vist i figur 32, 33 og 34. Som diskuteret i det foregående kapitel, er der ikke påvist signifikante forskelle i proteinaflejringen, afhængig af de anvendte rationer. Proteinaflejringen er i middel 400 kcal i periode I stigende til 700 kcal i periode VI ved ca. 60 kg legemsvægt, hvorefter den er relativ konstant.

Med den lave energitilførsel i periode I, gennemsnitlig 245 kcal ME/kg$^{0.75}$, svingede fedtaflejringen omkring nul, idet 21 svin havde en gennemsnitlig positiv aflejring på 176 kcal, medens 27 svin havde en negativ aflejring på 136 kcal i middel, hvilket viser, at der samtidig kan foregå opbygning af vævsprotein og nedbrydning af legemsfedt. Med stigende energitilførsel steg fedtaflejringen stærkt, således at der ved en legemsvægt på 50 kg og en tilførsel på 305 kcal ME/kg$^{0.75}$ var en fedtaflejring på omkring 1800 kcal svarende til 73% af den samlede energiaflejring, og denne steg yderligere til 3600 kcal eller 84% af den samlede energiaflejring ved en legemsvægt på 80 kg og en energitilførsel på 320 kcal ME/kg$^{0.75}$. Udtrykt i vægtenheder steg proteinaflejringen fra 70 til 125 g daglig, medens fedtaflejringen steg fra 0 til 380 g daglig.

På grundlag af de omfattende undersøgelser i Rostock med måling af energiaflejringen hos udvoksede eller nær udvoksede svin og de tilhørende værdier for fordøjede næringsstoffer er der fremsat en regressionsligning til beregning af aflejret energi baseret på kendskab til vedligeholdelsesbehovet og mængden af fordøjede næringsstoffer. Ligningen har følgende form, *Schieman* et al. (1971):

Aflejret total energi, kcal = $2.61x_1 + 8.63x_2 + 2.15x_3 + 2.98x_4 - 66.71\ kg^{0.75}$, hvor x_1 til x_4 angiver mængden af fordøjeligt protein, fedt, træstof og NFE, og det sidste led vedligeholdelsesbehovet udtrykt i netto-energi til fedning (NEF).

I de foreliggende undersøgelser, hvor såvel mængden af de fordøjede næringsstoffer som aflejret energi er målt, er der foretaget en vurdering af, om den nævnte ligning har gyldighed for voksende svin, og resultaterne vedrørende målt og beregnet energiaflejring er vist i tabel 54. Det fremgår heraf, at i de første 4 perioder, hvor proteinaflejringen er relativ stor i forhold til fedtaflejringen, er der en stor, stærk signifikant forskel mellem målt og beregnet energiaflejring. I periode VII og VIII, hvor fedtaflejringen er stor og udgør 80–85% af den samlede energiaflejring, er der god overensstemmelse mellem målte og beregnede værdier.

8.2. Vurdering af energibehovet til vedligeholdelse

Såfremt man ønsker at vurdere udnyttelsesgraden af tilført ME til vækst, er det nødvendigt at kende ME-behovet til vedligeholdelse, defineret som den energimængde, der skal tilføres dyret for at give en energibalance på nul. Dette behov kan enten vurderes udfra hungerforsøg med bestemmelse af varmeproduktionen eller udfra balanceforsøg, hvor energibalancen måles i relation til varierende ME-tilførsel.

Breirem (1936) benyttede hungermetoden i forsøg med 8 svin ved forskellige legemsvægte og fandt, at varmeproduktionen kunne udtrykkes ved funktionen: HP(RQ), kcal = 154.7 $kg^{0.569}$, men understregede at det var muligt, at funktionen ikke havde fuld gyldighed for yngre svin. Ved at anvende resultaterne fra forsøg med voksende svin anslog *Breirem* (1939), at man til vedligehold kunne regne med en udnyttelsesgrad på omkring 80% af tilført ME og kom derved til, at behovet til vedligeholdelse (maintenance = m) kunne angives som:

$$ME_m\text{,kcal} = 196.3\ kg^{0.569}$$

Denne funktion, der er vist grafisk i figur 35, har siden da været benyttet som udtryk for svins energibehov til vedligeholdelse.

Ved starten af de foreliggende undersøgelser blev der gennemført en måling af energiomsætningen hos de 12 svin, der skulle indgå i serie C. Resultaterne er vist i tabel 55, og det fremgår heraf, at dyrene ved en gennemsnitlig legemsvægt på 16.4 kg havde fået tilført 1900 kcal omsættelig energi. Energiaflejringen svingede omkring nul, i gennemsnit var der en svag positiv balance på 58 kcal, og det måtte på grundlag af disse resultater skønnes, at energibehovet til vedligeholdelse var omkring 1800 kcal ME for svin på 16 kg svarende til ME_m,kcal = 225 $kg^{0.75}$. Som det vil ses, afviger denne værdi, der er angivet i figur 35, ganske betydeligt fra *Breirem's* funktion.

På grundlag af de foreliggende undersøgelser (n = 381) er der foretaget en regressionsberegning af total energibalance i relation til tilført omsættelig energi med følgende resultat:

$$\text{Aflejret total energi, kcal} = -\ 1348 + 0.656\ \text{kcal ME}$$
$$s_b \qquad 36 \qquad 0.006$$

Den gennemsnitlige legemsvægt var 48 kg, og det kan fra denne ligning beregnes, at der skal tilføres 1348/0.656 = 2055 kcal ME for at energibalancen kan blive nul. Med de foreliggende individuelle variationer må det skønnes, at vedligeholdelsesbehovet er omkring 2000–2100 kcal ME ved 40–50 kg legemsvægt, som angivet i figur 35.

Det er ved senere hungerforsøg, *Thorbek* (1974) fundet, at varmeproduktionen i relation til metabolisk legemsvægt er ca. 50% større hos svin fra 20–30 kg end hos svin fra 50–100 kg, hvilket tydeligt viser, at de yngre dyr har et relativt større vedligeholdelsesbehov end de ældre dyr. Forsøgene er endnu ikke afsluttede, hvorfor der indtil videre må afstås fra at angive en generel funktion.

De tidligere omtalte resultater vedrørende overensstemmelse mellem aflejret og beregnet energiaflejring (jvf. tabel 54), tyder på, at den anvendte vedligeholdelsesfunktion, der svarer til *Breirems* funktion udtrykt i netto-energi-enheder først er gyldig fra omkring 70–80 kg legemsvægt. Sammenfattes de her nævnte observationer, synes det at være rimeligt, som et foreløbigt skøn for at kunne gennemføre de følgende beregninger, at angive et lineært vedligeholdelsesbehov som vist i figur 35 og udtrykt ved

$$ME_m\text{,kcal} = 1680 + 8\ \text{kg LW}\ (=\text{legemsvægt}).$$

8.3. Udnyttelsesgraden af omsættelig energi til vækst

Ved at benytte den angivne funktion for energibehov til vedligeholdelse, er det muligt at beregne den energimængde, der er til rådighed for væksten, udfra den almindelige ligning: $ME = ME_m + ME_p$, hvor ME er total tilførsel af omsættelig energi, ME_m = omsættelig energi til vedligeholdelsesbehov og ME_p = omsættelig energi til rådighed for produktionen.

Med anvendelse af samtlige enkeltobservationer er der foretaget en regressionsberegning af aflejret total energi i relation til ME_p, og resultaterne er vist i tabel 56. For samtlige perioder og alle 6 fodertyper er der fundet en regressionskoefficient på 0.671 ± 0.0034, hvilket viser en udnyttelsesgrad af ME_p på 67% for den omhandlede vækstperiode.

En nærmere analyse af de opnåede resultater viste, at der var ingen signifikante forskelle imellem regressionskoefficienterne afhængig af om kornarterne var givet i blanding med skummetmælkspulver eller proteinblanding; ligeledes var der ingen signifikant forskel mellem regressionskoefficienterne for byg-rationerne (0.663) og milo-rationerne (0.660), derimod var der stærk signifikant forskel mellem regressionskoefficienterne for byg + milo-rationerne (0.662) og majs-rationerne (0.703), svarende til at den omsættelige energi i majs-rationerne har en udnyttelsesgrad, der er ca. 6% højere end udnyttelsesgraden for byg- og milo-rationerne.

8.4. Udnyttelsesgraden af omsættelig energi til protein- og fedtproduktion

Selv om der er fundet en »over-all« udnyttelsesgrad af ME_p på 67% for den omhandlede vækstperiode, behøver dette ikke at betyde, at der er samme udnyttelsesgrad ved proteinsyntesen som ved fedtsyntesen. Det er tidligere demonstreret, *Thorbek* (1969c, 1970a) at udnyttelsesgraden for vækst synes at være afhængig af forholdet mellem protein- og fedtaflejringen. Som det er vist i figur 36, stiger udnyttelsesgraden af ME_p fra omkring 50% til omkring 70%, når fedtaflejringen stiger fra omkring 10% til 84% af den samlede energiaflejring.

Som vist tidligere er der i de foreliggende undersøgelser en stor kontrast mellem aflejret protein og fedt, og det skulle derfor være muligt at gennemføre en regressionsberegning efter følgende model:

$$ME_p\text{,kcal} = k_1 \times \text{protein aflejret,kcal} + k_2 \times \text{fedt aflejret,kcal}$$

En sådan beregning er gennemført, og resultaterne er vist i tabel 57.

Samtlige observationer gav følgende ligning:

$$\begin{array}{lcl} ME_p\text{,kcal} = 2.09 \times \text{protein aflejret,kcal} & + & 1.30 \times \text{fedt aflejret,kcal} \\ s_b \quad 0.050 & & 0.016 \end{array}$$

der angiver, at 2.09 kcal ME er nødvendig til aflejring af 1 kcal i protein, svarende til en energetisk udnyttelsesgrad på 48%, medens der kun anvendes 1.30 kcal ME for at producere 1 kcal i fedt, svarende til en energetisk udnyttelsesgrad på 77%.

Da fedt indeholder 9.5 kcal pr. g, medens protein kun indeholder 5.7 kcal, svarer disse resultater til, at der medgår 11.9 kcal ME til at producere 1 g protein og 12.4 kcal ME til produktion af 1 g fedt. Tages det endelig i betragtning, at rent kød kun indeholder ca. 25% protein, når man til den velkendte observation, at det er »billigere« at producere kød end fedt.

8.5. Diskussion og konklusion

De opnåede resultater vedrørende protein- og fedtaflejring er i tabel 58 sammenlignede med resultater fra litteraturen, idet observationerne er ordnede i henhold til de legemsvægte, der er angivet. For at danne et ensartet grundlag for vurdering af energitilførsel, er denne beregnet som omsættelig energi i relation til metabolisk legemsvægt. Med hensyn til den anvendte teknik, skal det anføres, at *Fuller & Boyne* (1972) anvender snævre respirationsanlæg med »lukket« luftcirkulation, *Oslage* et al. (1966) og *Bowland* et al. (1970) anvender »åben« luftcirkulation, men med ret snævre kamre, medens anlægget i København, som er benyttet af *Nielsen* (1970) og forfatteren, har relativt store kamre, der tillader dyrene en vis bevægelsesfrihed for at bringe resultaterne så nær de praktiske forhold som muligt.

Samtlige målinger vedrørende proteinaflejring viser stort set det samme resultat med værdier som svinger omkring den maximale proteinaflejring, som diskuteret i det foregående kapitel, derimod er der store forskelle i fedtaflejring afhængig af energitilførsel og bevægelsesfrihed. I *Fuller & Boyne's* forsøg, hvor dyrene er holdt meget snævert, og hvor energitilførslen var størst med 350 kcal ME/kg$^{0.75}$ i hele forsøgsperioden, er der registreret en meget stor energiaflejring, selv i periode I ved 25 kg legemsvægt. I forsøgene fra *Oslage* et al. og *Bowland* et al., hvor dyrene også er holdt relativt snævert, er energiaflejringen noget lavere end i *Fuller & Boyne's* undersøgelser, men dette kan henføres til, at der er anvendt 15% lavere energinorm.

Resultaterne fra København viser for begge undersøgelsesrækker en fedtaflejring, der svinger omkring nul i periode I stigende til 400 kcal i periode II. Selv om energinormen er lidt lavere end i de øvrige undersøgelser, skyldes den store forskel i fedtaflejringen utvivlsomt, at dyrene i respirationsanlægget i København har kunnet bevæge sig omtrent som i praksis, hertil er benyttet energi, således at der er blevet mindre tilovers til fedtaflejringen. Denne forskel i fedtaflejringen forsvinder imidlertid, når dyrene bliver ældre og kun rejser sig, når de skal æde, hvorved kammerets størrelse ingen indflydelse får på dyrenes fedtaflejring, men denne vil alene være afhængig af energitilførslen. Da proteinaflejringen har en øvre maximal grænse, medens fedtaflejringen er afhængig af energitilførsel, vil tilvækstens sammensætning med hensyn til kød og fedt være stærkt afhængig af den fodernorm, der benyttes.

Det har været almindelig accepteret at udtrykke dyrenes vedligeholdelsesbehov som $ME_m = aW^b$, *Blaxter* (1972), men det har længe været diskuteret, hvilken værdi man skulle tillægge eksponenten b. Publikationer fra de seneste år, *Blaxter* (1972), *van Es* (1972) og *Breirem & Homb* (1972) tyder på, at der nu er en vis enighed om, at man vil anvende eksponenten b = 0.75. Som understreget af *van Es* tyder de senere års undersøgelser på at a ikke kan tillægges en konstant værdi, men er betydelig større for yngre svin, og dette understøttes af de foreliggende undersøgelser.

De afvigelser, der er fundet imellem beregnet energiaflejring i henhold til ligningen fra Rostock, *Schiemann* et al. (1971) og de målte energiaflejringer, skyldes antagelig, dels at den angivne funktion for vedligeholdelsesbehov ikke har gyldighed for hele vækstområdet, og dels at der er forskellig udnyttelsesgrad afhængig af tilvækstens sammensætning.

Fra de seneste år foreligger der en del undersøgelser over udnyttelsesgraden af omsættelig energi til vækst samt til protein- og fedtdannelse, og en del af disse resultater er sammenstillet i tabel 59. Til trods for den omtalte usikkerhed vedrørende funktionen for behovet til vedligeholdelse er der dog en generel tendens, der viser, at den energi, der er til rådighed for væksten, udnyttes med 66–69% beregnet for hele vækstperioden 20–90 kg.

Der foreligger færre undersøgelser vedrørende udnyttelsesgraden af omsættelig energi til protein- og fedtaflejringen, men bortset fra resultaterne fra *Burlacu* et al. (1973) synes forsøgene at vise, at den energetiske udnyttelsesgrad ligger omkring 45–55% ved proteindannelse og omkring 75–85% for fedtdannelse.

Oversættelsesliste vedrørende tabeller

Abbreviation	Forkortelse
Age	Alder
Ash	Aske
Average	Middeltal
Barley	Byg
Class	Klasse
Collection	Opsamling
Combined	Kombineret
Components	Komponenter
Composition	Sammensætning
Consumption	Optagelse
Conversion	Omdannelse
Crude fat	Råfedt
Crude fibre	Træstof
Crude protein	Råprotein
C.V.	Variationskoefficient
Daily	Daglig
Days	Dage
Determination	Bestemmelse
D.F.	Frihedsgrader
Digested	Fordøjet
Digestibility	Fordøjelighed
Dry matter	Tørstof
Estimated	Skønnet, beregnet
Ether-Extract	Æter-ekstrakt
Faeces	Gødning
Fat	Fedt
Feed	Foder
Gain	Aflejring
Gross Energy	Brutto-energi
Heatproduction (= HP)	Varmeproduktion

Intake	Indtagelse
Investigation	Undersøgelse
Litter	Kuld
Live weight	Legemsvægt
Loss	Tab
Maize	Majs
Mean	Middeltal
Measured	Målt
Meat-bone meal	Kød-benmel
Metabolizable energy (= ME)	Omsættelig energi
NEF	Netto energi til fedning
Nitrogen	Kvælstof
Nitrogen-free extract (= NFE)	Kvælstoffri ekstraktstoffer
Number	Antal
Organic matter	Organisk stof
Pig	Svin
Present	Foreliggende
Production	Produktion
Protein mixture	Proteinblanding
Retained	Aflejret
Skim-milk powder	Skummetmælkspulver
Sorghum	Milo
Soyabean meal	Sojaskrå
Standard deviation (S.D.)	Spredning
Urine	Urin
Year	År

CHAPTER 10

10.1. Statistical appendix

Stud. stat. Søren Henckel

Average
The mean, sample mean or $\bar{x}$ is defined by $\bar{x} := \frac{1}{n} \Sigma_1^n x_i$
If $x_1, \ldots, x_n$ are identically idenpendent normal distributed random variables with parameters (μ, σ^2), we know that $\bar{x}$ has a normal distribution with parameters $(\mu, \sigma^2/n)$

b
The regression coefficient b in $y = a + bx$

Correlation
A measure of the linear relationship between 2 random variables X and Y. A high degree of correlation indicates that X is well suited for predicting Y and vice versa i.e. we can make a well founded regression of Y on X

C.V.
Coefficient of variation defined by C.V.: = S.D./$\bar{x}$
C.V. is the standard deviation relative to the mean therefore also called the relative standard deviation

D
Difference between two sample means i.e. $D := \bar{x}_1 - \bar{x}_2$

D.F.
Degrees of freedom is in general denoting the decrease in number of parameters you want to test. In a regression analysis we begin with n free varying variables and fit a k-dimensional plane to the n observatios thereby leaving n–k D.F. to the residual squaresum

f-test
A f-test is made by comparing the observed value of f (Fisher's f) with the relevant $f_{1-\alpha}$ fractile for suitable degrees of freedom and significance level α. The 1-α fractile in the f-distribution is defined by the integral equation $\int_0^{f_{1-\alpha}} g(x)\,dx = 1-\alpha$, where g(x) is the probability density for the relevant f-distribution. The f-test is significant on level α if $f > f_{1-\alpha}$, and is used to test if two independent estimates of two variances might be considered as estimates of the same true value of a common variance, i.e. the f-test tests the hypothesis $H_1 : \sigma_1^2 = \sigma_2^2 = \sigma^2$

Intercept
The constant term (a) in the regression equation $Y = a + \Sigma_1^k b_i X_i$

Linear function
A function of the form: $y = a + bx$ or in general $y = a + \Sigma_1^k b_i x_i$ is called a linear function

n
n is always used to indicate the number of observations in question

Mean
See average above

Proportionality
A function of the form: $y = bx$ or in general $y = \sum_1^k b_i x_i$ says that y is proportional to x (or in general to $x_1, \dots x_k$)

Quadratic function
A function of the form: $y = a + bx + cx^2$ is called quadratic

Regression analysis
A common name for several different statistical methods all examining the linear dependence between Y and the set $(X_1, X_2, \dots, X_k)$

Regression coefficients
The coefficients $b_1, \dots b_k$ in the regression equation $Y = a + \sum_1^k b_i X_i$

Regression models
We work with 3 different regression models, which are

1: $Y = a + \sum_1^k b_i X_i$ with $Var(Y) = \sigma^2$

2: $Y = \sum_1^k b_i X_i$ with $Var(Y) = \sigma^2$

3: $Y = \sum_1^k b_i X_i$ with $Var(Y) = (\sigma \cdot E(Y))^2$ with is equivalent to $C.V. = \sigma^2$

Relative standard deviation
See C.V. above

Residual
The difference between an observed value and the estimated value, i.e. residual: $= y - \hat{y}$

S.D.
Standard deviation defined by S.D.: $= \sqrt{SSD/(n-1)}$

S.E.
Standard error of mean defined by S.E.: $= S.D./\sqrt{n} = \sqrt{SSD/(n\,(n-1))}$

SSD
Sum of squares of deviations from the mean defined by SSD: $= \sum_1^n (x_i - \bar{x})^2$

s_b
Estimated standard deviation on the regression coefficients

s_I
Estimated standard deviation on the intercept

$s_{\hat{y}}$
Estimated standard deviation on the estimated values of Y

S.D. of regression coefficients
See s_b above

S.D. of residuals
See $s_{\hat{y}}$ above

Sample mean
See average above

Significance
A statistical test is said to be significant if the observed teststatistic has a value which lies in the tail of the distribution i.e. a rather extreme value. The more extreme the observation is the more significant the test is and vice versa for common values of the teststatistic. The degree of significance is expressed in terms of a significance level $1\text{-}\alpha$ where α normally takes one of the values 0.95, 0.99 and 0.999 corresponding to 5%, 1% and 0.1% significance level often denoted as *-, **- and ***-significance. We write $f > f_{1-\alpha}$ for level α significance of the f-statistic

t-test
A t-test is made by comparing the observed value of t (Student's t) with the relevant $t_{1-\alpha/2}$ fractile for suitable degrees of freedom and significance level α. The $1\text{-}\alpha/2$ fractile in the t-distribution is defined by the integral equation $\int_{-\infty}^{t_{1-\alpha/2}} g(x)dx = 1-\alpha/2$, where g(x) is the probability density for the relevant t-distribution. The t-test is significant on level α if $|t| > t_{1-\alpha/2}$ ($|t|$ is the modulus of t) and is used for testing hypotheses of the form:

H_1: $\mu_1 = \mu_2$ where μ_1 and μ_2 are the theoretical sample means
H_2: $b_i = 0$ where b_i is a single regression coefficient, i.e.
H_2 is the hypothesis of independence between Y and X_i

$\bar{x}$
See average above

$\hat{y}$
An estimate of some true but unobservable value of the random variable Y

10.2. References

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Digestibility of nutrients and gross energy.	Fordøjelighed af næringsstoffer og brutto energi.

	Abbreviations	Forkortelser
Age:	Age	Alder
LW:	Live weight	Legemsvægt
DMI:	Dry matter intake	Tørstof, optaget
OMI:	Organic matter intake	Organisk stof, optaget
NI:	Nitrogen intake	Kvælstof, optaget
EEI:	Crude fat intake (Ether extract)	Råfedt, optaget (Æter ekstrakt)
CFI:	Crude fibre intake	Træstof, optaget
NFEI:	Nitrogen free extract intake	Ekstraktstoffer, optaget
CI:	Carbon intake	Kulstof, optaget
GEI:	Gross energy intake	Brutto energi, optaget
DMD:	Dry matter digested	Tørstof, fordøjet
OMD:	Organic matter digested	Organisk stof, fordøjet
ND:	Nitrogen digested	Kvælstof, fordøjet
EED:	Crude fat digested (Ether extract)	Råfedt, fordøjet (Æter ekstrakt)
CFD:	Crude fibre digested	Træstof, fordøjet
NFED:	Nitrogen free extract digested	Kvælstoffri ekstraktstoffer, fordøjet
CD:	Carbon digested	Kulstof, fordøjet
GED:	Gross energy digested	Brutto energi, fordøjet

BYG OG SKUMMETMÆLK (BARLEY AND SKIMMILK) SERIE C.

Svin (Pig) nr. 1

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
I	83	20.7	705	648	21.8	17.1	20.4	462	301	2947	623	585	18.9	14.3	6.7	433	267	2597
II	97	26.7	905	839	28.5	21.2	27.8	607	395	3881	794	752	24.3	17.8	8.9	568	349	3406
III	111	33.4	1062	992	32.7	25.6	32.6	721	466	4571	931	886	28.0	22.3	9.6	670	411	3997
IV	125	41.1	1234	1155	36.2	25.9	37.3	858	540	5303	1087	1036	31.3	23.3	8.7	801	476	4664
V	139	49.8	1501	1409	41.3	31.9	50.6	1060	660	6453	1303	1246	35.4	28.4	8.1	981	576	5583
VI	153	59.8	1763	1660	46.6	37.7	70.2	1252	781	7621	1541	1477	40.2	33.5	20.7	1162	684	6655
VII	167	70.5	1936	1830	49.3	40.6	72.4	1402	859	8385	1708	1641	43.1	36.6	21.7	1307	760	7385
VIII	181	82.1	2190	2075	52.8	43.5	76.1	1619	970	9426	1945	1867	46.1	39.8	20.9	1511	863	8348

Svin (Pig) nr. 2

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
I	85	20.9	705	648	21.8	17.1	20.4	462	301	2947	609	574	18.1	13.6	4.8	431	262	2541
II	99	26.6	905	839	28.5	21.2	27.8	607	395	3881	788	747	23.9	16.7	9.9	566	346	3371
III	113	32.5	1062	992	32.7	25.6	32.6	721	466	4571	929	885	28.0	22.7	9.0	669	411	3994
IV	127	38.3	1234	1155	36.2	25.9	37.3	858	540	5303	1082	1034	31.4	22.4	9.7	798	475	4650
V	141	46.6	1501	1409	41.3	31.9	50.6	1060	660	6453	1296	1242	35.0	26.5	7.0	981	573	5559
VI	155	55.2	1763	1660	46.6	37.7	70.2	1252	781	7621	1482	1428	39.0	31.1	7.5	1137	659	6399
VII	169	64.3	1936	1830	49.3	40.6	72.4	1402	859	8385	1666	1606	42.1	35.3	12.0	1289	741	7189
VIII	183	74.5	2190	2075	52.8	43.5	76.1	1619	970	9426	1874	1811	44.1	38.0	4.5	1486	833	8042

Svin (Pig) nr. 3

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
I	82	20.5	705	648	21.8	17.1	20.4	462	301	2947	593	561	17.9	12.8	1.6	422	254	2468
II	96	25.4	905	839	28.5	21.2	27.8	607	395	3881	762	724	23.5	16.4	1.0	554	333	3255
III	110	31.3	1062	992	32.7	25.6	32.6	721	466	4571	901	860	26.8	20.1	3.9	660	400	3855
IV	124	39.1	1234	1155	36.2	25.9	37.3	858	540	5303	1051	1005	30.7	19.9	0.2	785	460	4498
V	138	46.8	1501	1409	41.3	31.9	50.6	1060	660	6453	1308	1249	35.0	25.7	9.7	987	577	5598
VI	152	54.1	1763	1660	46.6	37.7	70.2	1252	781	7621	1513	1453	39.9	31.8	12.8	1150	671	6513
VII	166	64.6	1936	1830	49.3	40.6	72.4	1402	859	8385	1695	1630	42.7	34.1	21.1	1302	753	7306
VIII	180	75.4	2190	2075	52.8	43.5	76.1	1619	970	9426	1930	1856	45.8	38.2	19.7	1505	855	8299

BYG OG SKUMMETMÆLK (BARLEY AND SKIMMILK) SERIE D.

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
Svin (Pig) nr. 1																		
I	85	24.8	773	709	23.7	20.5	22.2	510	342	3289	668	626	20.4	16.8	3.9	470	295	2843
II	99	30.9	968	888	29.5	21.1	32.3	642	418	4144	840	788	25.6	18.0	8.0	593	364	3599
III	113	37.8	1159	1065	35.1	23.8	31.6	780	504	4943	1007	949	30.6	20.4	4.9	721	443	4309
IV	127	46.1	1400	1292	39.7	29.5	48.3	959	608	5997	1213	1141	34.6	23.9	12.0	882	528	5185
V	141	55.3	1695	1572	44.8	37.5	55.9	1187	735	7239	1475	1396	39.2	30.9	11.8	1095	641	6283
VI	155	65.4	1951	1817	49.2	44.1	72.3	1383	858	8401	1673	1593	42.1	37.1	17.1	1266	738	7186
VII	169	76.5	2216	2073	54.6	48.7	81.5	1583	964	9530	1924	1836	47.1	42.1	20.9	1460	836	8243
VIII	183	88.1	2464	2309	58.7	57.7	94.5	1773	1082	10675	2142	2047	50.0	49.7	26.9	1642	942	9198
Svin (Pig) nr. 2																		
I	85	24.3	773	709	23.7	20.5	22.2	510	342	3289	677	635	20.2	15.6	7.8	478	299	2873
II	99	29.8	968	888	29.5	21.1	32.3	642	418	4144	847	794	25.3	17.6	9.4	600	367	3638
III	113	36.1	1159	1065	35.1	23.8	31.6	780	504	4943	1004	946	30.3	20.4	4.2	721	442	4305
IV	127	43.9	1400	1292	39.7	29.5	48.3	959	608	5997	1226	1156	34.7	24.2	14.8	893	535	5259
V	141	54.2	1695	1572	44.8	37.5	55.9	1187	735	7239	1487	1405	38.9	29.3	15.5	1104	646	6332
VI	155	64.3	1951	1817	49.2	44.1	72.3	1383	858	8401	1705	1620	42.1	37.9	20.7	1288	753	7336
VII	169	75.1	2216	2073	54.6	48.7	81.5	1583	964	9530	1928	1847	46.9	41.4	24.0	1469	840	8276
VIII	183	86.7	2464	2309	58.7	57.7	94.5	1773	1082	10675	2119	2035	49.0	49.7	26.3	1637	933	9108
Svin (Pig) nr. 3																		
I	87	25.1	773	709	23.7	20.5	22.2	510	342	3289	654	620	19.9	17.4	3.1	467	291	2798
II	101	30.3	968	888	29.5	21.1	32.3	642	418	4144	827	781	25.3	18.1	7.5	588	361	3568
III	115	37.3	1159	1065	35.1	23.8	31.6	780	504	4943	994	939	30.0	20.1	1.9	719	438	4267
IV	129	44.4	1400	1292	39.7	29.5	48.3	959	608	5997	1200	1135	34.0	24.6	10.0	881	524	5150
V	143	52.1	1695	1572	44.8	37.5	55.9	1187	735	7239	1459	1387	38.1	29.2	7.0	1100	637	6248
VI	157	62.0	1951	1817	49.2	44.1	72.3	1383	858	8401	1694	1612	42.1	36.4	19.3	1284	749	7295
VII	171	72.2	2216	2073	54.6	48.7	81.5	1583	964	9530	1936	1853	46.4	42.6	25.0	1476	844	8308
VIII	185	81.4	2464	2309	58.7	57.7	94.5	1773	1082	10675	2102	2019	50.1	46.7	22.2	1621	927	9046

BYG OG SKUMMETMÆLK (BARLEY AND SKIMMILK) SERIE E.

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
Svin (Pig) nr. 1																		
I	80	24.0	760	712	21.5	18.3	26.4	531	333	3278	668	637	18.5	15.5	8.6	496	293	2867
II	94	30.0	946	890	26.6	21.1	34.3	667	420	4085	829	793	22.9	16.4	11.2	621	368	3549
III	108	38.4	1115	1052	30.8	22.7	37.5	800	496	4837	967	928	26.1	16.1	7.0	741	430	4154
IV	122	45.6	1378	1302	34.3	27.2	48.7	1011	609	6012	1185	1140	28.0	21.0	10.7	934	524	5129
V	136	54.6	1657	1571	40.1	34.5	60.2	1225	734	7261	1431	1379	33.0	25.4	12.0	1135	630	6203
VI	150	64.3	1896	1801	43.7	38.3	73.2	1417	851	8272	1644	1587	36.1	27.1	20.0	1314	736	7091
VII	164	74.8	2161	2056	46.5	45.7	90.1	1629	975	9457	1859	1796	37.4	34.6	25.4	1503	835	8039
VIII	178	85.5	2432	2316	50.5	47.1	99.2	1855	1097	10612	2093	2029	40.0	39.7	22.1	1717	940	9024
Svin (Pig) nr. 2																		
I	76	20.0	760	712	21.5	18.3	26.4	531	333	3278	648	618	16.7	6.9	7.9	497	282	2742
II	90	26.1	946	890	26.6	21.1	34.3	667	420	4085	824	785	22.0	9.0	11.2	626	363	3501
III	104	33.0	1115	1052	30.8	22.7	37.5	800	496	4837	970	929	25.3	7.6	10.6	752	430	4150
IV	132	46.9	1378	1302	34.3	27.2	48.7	1011	609	6012	1177	1132	26.9	7.8	11.8	944	515	5064
V	146	54.7	1657	1571	40.1	34.5	60.2	1225	734	7261	1416	1362	32.1	16.9	10.7	1133	623	6126
VI	160	64.3	1896	1801	43.7	38.3	73.2	1417	851	8272	1650	1589	35.7	20.0	22.1	1324	738	7112
VII	174	74.3	2161	2056	46.5	45.7	90.1	1629	975	9457	1843	1782	36.3	36.6	20.1	1498	829	7996
VIII	190	85.1	2432	2316	50.5	47.1	99.2	1855	1097	10612	2069	2001	39.0	21.1	19.6	1716	928	8901
Svin (Pig) nr. 3																		
I	84	26.7	760	712	21.5	18.3	26.4	531	333	3278	655	625	18.2	13.9	4.9	491	287	2805
II	98	32.4	946	890	26.6	21.1	34.3	667	420	4085	818	793	22.4	15.0	9.9	627	362	3493
III	112	38.6	1115	1052	30.8	22.7	37.5	800	496	4837	968	931	26.4	16.5	9.1	740	430	4171
IV	126	45.1	1378	1302	34.3	27.2	48.7	1011	609	6012	1196	1150	28.6	20.7	13.5	938	528	5176
V	140	54.4	1657	1571	40.1	34.5	60.2	1225	734	7261	1368	1327	31.8	17.6	-	1111	600	5897
VI	154	61.8	1896	1801	43.7	38.3	73.2	1417	851	8272	1636	1584	36.2	29.3	27.5	1305	734	7072
VII	168	71.1	2161	2056	46.5	45.7	90.1	1629	975	9457	1822	1768	36.6	32.5	24.4	1482	822	7871
VIII	182	81.6	2432	2316	50.5	47.1	99.2	1855	1097	10612	2081	2022	39.8	41.9	26.3	1705	939	8999

BYG OG SKUMMETMÆLK (BARLEY AND SKIMMILK) SERIE F.

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
Svin (Pig) nr. 1																		
I	106	28.3	757	705	23.9	19.3	26.5	507	339	3299	651	620	20.2	14.6	6.8	470	293	2835
II	120	33.1	939	885	29.3	22.9	34.4	645	418	4139	794	767	23.9	15.9	8.2	593	354	3481
III	134	39.1	1116	1050	35.0	26.0	36.8	769	501	4876	964	926	29.2	18.4	8.5	717	433	4185
IV	148	46.9	1383	1305	39.8	31.3	54.8	971	625	6074	1174	1133	32.4	21.6	16.0	893	532	5126
V	162	55.2	1649	1563	44.4	35.0	65.0	1185	743	7208	1442	1391	36.8	25.8	27.9	1107	650	6269
VI	176	63.6	1900	1798	48.3	41.1	84.2	1371	850	8289	1604	1551	38.9	34.7	24.2	1249	720	6971
VII	190	75.4	2195	2086	54.3	46.2	86.5	1614	985	9580	1857	1796	44.1	34.7	9.9	1476	832	8036
VIII	204	88.4	2444	2325	56.5	52.0	112.1	1807	1097	10682	2112	2047	46.0	40.0	41.4	1678	946	9184
Svin (Pig) nr. 2																		
I	85	26.4	757	705	23.9	19.3	26.5	507	339	3299	654	620	20.1	14.6	7.4	470	294	2838
II	99	31.1	939	885	29.3	22.9	34.4	645	418	4139	814	780	24.7	16.9	10.4	599	362	3557
III	113	37.0	1116	1050	35.0	26.0	36.8	769	501	4876	980	938	29.9	22.2	10.0	719	441	4257
IV	127	44.8	1383	1305	39.8	31.3	54.8	971	625	6074	1208	1158	33.5	25.2	21.0	903	547	5266
V	141	53.8	1649	1563	44.4	35.0	65.0	1185	743	7208	1458	1401	37.7	27.5	26.8	1111	655	6329
VI	155	64.1	1900	1798	48.3	41.1	84.2	1371	850	8289	1639	1580	40.2	34.3	32.0	1267	734	7100
VII	169	75.0	2195	2086	54.3	46.2	86.5	1614	985	9580	1872	1809	44.9	35.6	20.4	1472	837	8091
VIII	183	86.2	2444	2325	56.5	52.0	112.1	1807	1097	10682	2110	2044	46.6	41.3	39.5	1672	946	9163
Svin (Pig) nr. 3																		
I	85	23.0	757	705	23.9	19.3	26.5	507	339	3299	628	602	19.4	14.1	3.6	461	284	2741
II	99	28.8	939	885	29.3	22.9	34.4	645	418	4139	772	744	22.6	10.1	2.9	589	342	3344
III	113	33.3	1116	1050	35.0	26.0	36.8	769	501	4876	936	899	27.7	11.0	3.6	711	418	4019
IV	127	40.6	1383	1305	39.8	31.3	54.8	971	625	6074	1178	1132	32.8	22.7	13.0	891	532	5126
V	141	49.5	1649	1563	44.4	35.0	65.0	1185	743	7208	1389	1345	35.7	22.3	16.9	1083	626	6028
VI	155	58.2	1900	1798	48.3	41.1	84.2	1371	850	8289	1642	1585	40.4	30.9	36.5	1266	736	7110
VII	169	69.4	2195	2086	54.3	46.2	86.5	1614	985	9580	1844	1787	44.1	31.0	10.7	1470	825	7954
VIII	183	82.2	2444	2325	56.5	52.0	112.1	1807	1097	10682	2107	2041	47.0	40.0	38.5	1669	944	9134

BYG OG PROTEINBLANDING (BARLEY AND PROTEINMIXTURE) SERIE C.

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
Svin (Pig) nr. 4																		
I	85	21.1	660	608	26.3	20.7	33.6	390	292	2889	545	516	21.5	16.4	14.9	351	243	2380
II	99	26.6	864	794	34.5	26.4	49.6	503	385	3797	711	674	28.2	20.8	23.7	453	320	3136
III	113	32.4	1014	942	39.2	31.0	54.4	612	455	4486	853	814	32.3	28.0	27.1	557	389	3779
IV	127	39.6	1183	1105	42.9	31.7	55.7	749	529	5227	995	953	35.6	26.6	20.0	684	447	4397
V	141	48.0	1451	1360	47.9	37.0	67.2	956	649	6383	1236	1185	39.9	31.1	27.9	876	557	5430
VI	155	54.9	1716	1614	53.9	41.8	87.5	1148	770	7561	1444	1391	44.6	35.7	33.0	1044	652	6357
VII	169	64.9	1893	1783	55.9	46.5	89.9	1297	849	8339	1614	1553	46.7	39.6	34.4	1188	726	7087
VIII	183	75.0	2146	2028	59.5	49.4	93.8	1513	959	9364	1825	1757	49.3	43.9	27.3	1377	818	7935
Svin (Pig) nr. 5																		
I	89	21.9	660	608	26.3	20.7	33.6	390	292	2889	537	511	21.1	17.7	9.2	352	241	2364
II	103	26.4	864	794	34.5	26.4	49.6	503	385	3797	705	671	28.4	22.9	20.8	450	319	3125
III	117	32.6	1014	942	39.2	31.0	54.4	612	455	4486	828	798	31.8	28.6	22.2	549	378	3710
IV	131	39.0	1183	1105	42.9	31.7	55.7	749	529	5227	984	950	35.4	26.5	22.4	680	446	4383
V	145	44.7	1451	1360	47.9	37.0	67.2	956	649	6383	1209	1166	39.2	32.8	18.5	869	549	5355
VI	159	50.9	1716	1614	53.9	41.8	87.5	1148	770	7561	1425	1377	44.2	36.0	29.2	1036	645	6299
VII	173	59.9	1893	1783	55.9	46.5	89.9	1297	849	8339	1570	1519	45.2	40.7	23.7	1173	710	6932
VIII	187	69.2	2146	2028	59.5	49.4	93.8	1513	959	9364	1795	1739	48.6	43.1	17.0	1375	806	7827
Svin (Pig) nr. 6																		
I	84	21.1	660	608	26.3	20.7	33.6	390	292	2889	541	513	21.3	17.6	13.2	349	241	2362
II	98	26.7	864	794	34.5	26.4	49.6	503	385	3797	713	674	28.0	22.2	23.4	454	320	3138
III	112	34.4	1014	942	39.2	31.0	54.4	612	455	4486	823	787	32.1	27.4	16.0	543	372	3652
IV	126	41.5	1183	1105	42.9	31.7	55.7	749	529	5227	988	940	35.2	25.0	14.5	680	442	4338
V	140	50.9	1451	1360	47.9	37.0	67.2	956	649	6383	1247	1189	40.6	32.3	23.6	879	560	5463
VI	154	59.0	1716	1614	53.9	41.8	87.5	1148	770	7561	1460	1400	45.6	37.1	33.5	1044	657	6409
VII	168	69.8	1893	1783	55.9	46.5	89.9	1297	849	8339	1620	1556	47.6	41.2	27.6	1190	727	7110
VIII	182	80.3	2146	2028	59.5	49.4	93.8	1513	959	9364	1825	1758	49.9	43.7	18.5	1384	816	7933

BYG OG PROTEINBLANDING (BARLEY AND PROTEINMIXTURE) SERIE D.

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
Svin (Pig) nr. 7																		
I	92	23.9	725	673	27.2	26.3	34.2	437	334	3231	596	564	21.9	21.7	11.7	394	278	2659
II	106	30.4	916	842	34.4	28.1	46.6	552	412	4087	751	710	27.8	23.7	16.5	495	341	3365
III	120	37.0	1104	1016	41.4	31.3	47.6	678	495	4887	902	858	33.6	25.7	12.7	609	410	3947
IV	134	45.9	1346	1248	46.0	36.8	66.9	857	600	5951	1095	1044	36.7	29.4	17.8	768	489	4839
V	148	54.8	1617	1510	50.2	44.8	72.0	1079	719	7143	1356	1300	40.9	37.3	22.6	984	605	5987
VI	162	65.4	1883	1767	54.7	52.1	89.5	1282	846	8331	1561	1501	43.6	44.4	22.5	1161	704	6879
VII	176	76.3	2150	2017	60.0	57.1	99.5	1480	951	9457	1804	1731	48.9	46.2	33.6	1341	798	7900
VIII	190	88.7	2399	2252	64.3	65.6	112.7	1668	1068	10584	1964	1895	50.0	49.6	26.1	1502	875	8634
Svin (Pig) nr. 8																		
I	92	22.9	725	673	27.2	26.3	34.2	437	334	3231	585	554	21.7	22.4	8.2	388	273	2611
II	106	27.9	916	842	34.4	28.1	46.6	552	412	4087	754	714	28.5	24.4	16.9	495	343	3399
III	120	33.8	1104	1016	41.4	31.3	47.6	678	495	4887	897	856	33.6	26.1	13.0	606	408	3928
IV	134	42.4	1346	1248	46.0	36.8	66.9	857	600	5951	1099	1051	37.4	30.6	19.8	767	495	4890
V	148	50.8	1617	1510	50.2	44.8	72.0	1079	719	7143	1333	1284	40.3	35.7	18.3	977	596	5909
VI	162	60.4	1883	1767	54.7	52.1	89.5	1282	846	8331	1601	1538	45.2	42.5	38.3	1174	724	7081
VII	176	70.7	2150	2017	60.0	57.1	99.5	1480	951	9457	1826	1753	49.2	46.7	41.6	1353	810	8014
VIII	190	82.9	2399	2252	64.3	65.6	112.7	1668	1068	10584	2017	1943	52.2	54.9	40.5	1517	899	8892
Svin (Pig) nr. 9																		
I	94	25.5	725	673	27.2	26.3	34.2	437	334	3231	596	565	22.2	22.3	10.8	393	278	2671
II	108	30.0	916	842	34.4	28.1	46.6	552	412	4087	760	717	28.7	25.3	14.1	498	345	3412
III	122	35.4	1104	1016	41.4	31.3	47.6	678	495	4887	902	861	34.1	26.3	13.2	608	412	3963
IV	136	43.3	1346	1248	46.0	36.8	66.9	857	600	5951	1139	1085	38.9	32.4	27.4	782	512	5072
V	150	53.4	1617	1510	50.2	44.8	72.0	1079	719	7143	1368	1312	42.3	39.2	22.5	986	613	6075
VI	164	62.7	1883	1767	54.7	52.1	89.5	1282	846	8331	1574	1517	45.2	46.1	24.6	1162	713	6985
VII	178	71.6	2150	2017	60.0	57.1	99.5	1480	951	9457	1821	1751	49.9	49.8	33.4	1351	808	8021
VIII	192	84.8	2399	2252	64.3	65.6	112.7	1668	1068	10584	2009	1936	52.7	56.9	34.8	1510	897	8879

BYG OG PROTEINBLANDING (BARLEY AND PROTEINMIXTURE) SERIE E.

Svin (Pig) nr. 7

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
I	87	22.8	738	683	25.6	26.7	38.0	459	326	3246	620	586	20.9	21.5	17.2	417	276	2716
II	101	29.1	922	855	31.8	31.7	48.1	577	411	4049	743	708	25.4	25.7	12.9	511	333	3245
III	115	36.5	1089	1012	37.0	34.5	52.2	695	488	4801	878	841	28.9	26.3	14.5	620	394	3842
IV	129	45.3	1352	1260	40.2	39.6	65.3	904	599	5969	1094	1049	31.2	32.6	15.5	806	486	4806
V	143	53.2	1632	1529	45.2	47.1	75.1	1124	729	7197	1347	1296	34.8	33.7	23.6	1021	604	5908
VI	157	63.0	1873	1764	48.6	49.6	89.5	1321	842	8216	1548	1493	37.1	34.3	27.6	1199	697	6738
VII	171	73.8	2140	2016	51.8	58.5	106.8	1527	966	9401	1753	1694	39.4	47.1	26.5	1374	786	7642
VIII	185	84.0	2408	2275	55.6	59.4	116.5	1752	1086	10556	1985	1922	41.8	50.3	33.7	1576	897	8606

Svin (Pig) nr. 8

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
I	83	20.7	738	683	25.6	26.7	38.0	459	326	3246	604	573	19.9	14.7	15.2	418	267	2623
II	97	26.1	922	855	31.8	31.7	48.1	577	411	4049	734	698	24.0	15.7	12.6	520	327	3181
III	111	30.9	1089	1012	37.0	34.5	52.2	695	488	4801	874	842	28.4	18.3	11.4	635	394	3833
IV	139	44.2	1352	1260	40.2	39.6	65.3	904	599	5969	1065	1023	29.7	13.6	12.0	812	469	4633
V	153	51.4	1632	1529	45.2	47.1	75.1	1124	729	7197	1350	1299	35.3	31.8	20.6	1026	604	5913
VI	167	59.7	1873	1764	48.6	49.6	89.5	1321	842	8216	1548	1495	36.8	26.6	28.9	1209	696	6721
VII	181	70.0	2140	2016	51.8	58.5	106.8	1527	966	9401	1749	1688	37.1	32.2	29.2	1395	783	7576
VIII	195	81.1	2408	2275	55.6	59.4	116.5	1752	1086	10556	2006	1936	41.5	31.2	37.8	1607	902	8673

Svin (Pig) nr. 9

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
I	91	27.2	738	683	25.6	26.7	38.0	459	326	3246	602	571	19.9	18.3	14.1	424	267	2627
II	105	32.1	922	855	31.8	31.7	48.1	577	411	4049	759	722	24.9	21.4	19.8	526	340	3311
III	119	37.8	1089	1012	37.0	34.5	52.2	695	488	4801	892	852	29.2	26.4	16.4	628	403	3912
IV	133	45.6	1352	1260	40.2	39.6	65.3	904	599	5969	1133	1081	32.6	32.9	23.5	821	502	4984
V	147	51.7	1632	1529	45.2	47.1	75.1	1124	729	7197	1363	1311	36.0	38.7	25.3	1021	611	5977
VI	161	59.7	1873	1764	48.6	49.6	89.5	1321	842	8216	1554	1501	38.2	41.0	24.3	1197	700	6785
VII	175	69.0	2140	2016	51.8	58.5	106.8	1527	966	9401	1763	1708	39.6	49.2	33.1	1378	792	7691
VIII	189	78.7	2408	2275	55.6	59.4	116.5	1752	1086	10556	2006	1942	42.6	46.5	36.4	1592	905	8708

BYG OG PROTEINBLANDING (BARLEY AND PROTEINMIXTURE) SERIE F.

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
Svin (Pig) nr. 7																		
I	113	26.6	728	673	27.1	28.5	38.4	437	333	3260	598	572	21.9	25.5	16.1	394	279	2687
II	127	32.3	918	852	33.7	35.8	49.1	557	410	4111	729	703	25.7	27.9	17.6	497	329	3260
III	141	37.6	1087	1009	39.6	32.8	54.4	667	492	4832	874	842	31.4	24.3	19.4	594	401	3889
IV	155	44.0	1360	1268	44.7	47.3	72.7	869	619	6041	1096	1055	34.9	38.2	25.6	774	503	4858
V	169	52.5	1624	1525	49.3	51.1	83.4	1082	734	7185	1338	1293	38.8	41.3	34.6	974	609	5903
VI	183	61.7	1871	1758	53.2	56.9	101.4	1267	840	8255	1533	1482	41.0	49.0	39.8	1137	690	6740
VII	197	70.5	2170	2048	59.2	62.3	103.8	1512	976	9543	1814	1750	46.2	49.6	39.4	1373	816	7908
VIII	211	82.2	2419	2285	61.0	68.4	127.4	1708	1088	10634	2067	1989	49.8	58.7	60.5	1558	931	9032
Svin (Pig) nr. 8																		
I	92	23.9	728	673	27.1	28.5	38.4	437	333	3260	600	573	21.8	22.9	16.9	398	279	2694
II	106	28.8	918	852	33.7	35.8	49.1	557	410	4111	755	722	26.9	30.8	22.4	501	340	3386
III	120	34.5	1087	1009	39.6	32.8	54.4	667	492	4832	905	865	33.0	24.8	21.9	605	414	4026
IV	134	41.4	1360	1268	44.7	47.3	72.7	869	619	6041	1121	1074	35.9	38.5	25.9	785	513	4968
V	148	48.8	1624	1525	49.3	51.1	83.4	1082	734	7185	1361	1311	39.5	42.2	37.7	985	619	6011
VI	162	58.3	1871	1758	53.2	56.9	101.4	1267	840	8255	1580	1519	43.6	47.8	44.1	1155	712	6954
VII	176	68.7	2170	2048	59.2	62.3	103.8	1512	976	9543	1818	1756	47.1	53.4	37.9	1370	818	7964
VIII	190	79.2	2419	2285	61.0	68.4	127.4	1708	1088	10634	2058	1983	48.8	59.8	55.6	1563	927	9008
Svin (Pig) nr. 9																		
I	92	23.3	728	673	27.1	28.5	38.4	437	333	3260	588	563	21.3	18.9	15.3	396	272	2619
II	106	28.1	918	852	33.7	35.8	49.1	557	410	4111	732	703	26.3	20.1	19.1	500	326	3238
III	120	33.2	1087	1009	39.6	32.8	54.4	667	492	4832	897	860	31.6	18.9	24.1	610	408	3964
IV	134	40.9	1360	1268	44.7	47.3	72.7	869	619	6041	1115	1070	35.2	29.4	31.3	790	510	4914
V	148	50.0	1624	1525	49.3	51.1	83.4	1082	734	7185	1344	1296	38.8	37.3	35.7	981	609	5916
VI	162	59.4	1871	1758	53.2	56.9	101.4	1267	840	8255	1512	1461	39.2	36.1	36.8	1143	679	6593
VII	176	69.5	2170	2048	59.2	62.3	103.8	1512	976	9543	1823	1760	45.6	37.8	43.5	1394	817	7922
VIII	190	76.0	2419	2285	61.0	68.4	127.4	1708	1088	10634	2048	1974	47.5	44.8	63.4	1569	919	8903

MAIS OG SKUMMETMÆLK (MAIZE AND SKIMMILK) SERIE C.

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
Svin (Pig) nr. 7																		
I	90	19.8	689	634	20.6	27.8	9.9	453	293	2899	611	578	17.7	23.3	3.5	426	262	2575
II	104	25.1	882	820	27.0	34.3	13.6	595	383	3788	790	750	23.8	30.0	5.0	558	344	3386
III	118	31.4	1043	974	31.0	42.6	16.5	708	454	4517	948	903	27.7	38.0	8.3	670	415	4108
IV	132	38.3	1212	1133	34.0	47.6	19.7	841	532	5225	1106	1053	30.5	42.4	9.2	799	488	4772
V	146	46.2	1457	1366	37.5	60.4	25.2	1032	643	6297	1343	1279	33.9	54.0	14.9	985	594	5788
VI	160	53.4	1706	1611	41.1	70.5	32.6	1236	758	7447	1573	1506	36.9	65.2	20.5	1176	700	6844
VII	174	63.9	1884	1782	44.5	80.2	33.3	1374	836	8158	1763	1696	40.2	73.4	25.5	1329	786	7620
VIII	188	74.4	2134	2020	47.4	89.0	41.9	1574	947	9253	1990	1914	42.3	78.4	27.9	1526	886	8596
Svin (Pig) nr. 8																		
I	92	19.7	689	634	20.6	27.8	9.9	453	293	2899	614	578	17.8	22.4	3.6	426	262	2579
II	106	25.5	882	820	27.0	34.3	13.6	595	383	3788	795	752	23.5	27.3	6.1	563	345	3398
III	120	31.2	1043	974	31.0	42.6	16.5	708	454	4517	934	889	27.0	37.6	6.4	663	407	4040
IV	134	37.8	1212	1133	34.0	47.6	19.7	841	532	5225	1099	1045	29.9	42.2	8.8	795	485	4744
V	148	45.2	1457	1366	37.5	60.4	25.2	1032	643	6297	1327	1265	33.0	48.9	13.2	983	587	5716
VI	162	51.8	1706	1611	41.1	70.5	32.6	1236	758	7447	1516	1462	35.2	60.1	13.8	1154	676	6602
VII	176	61.5	1884	1782	44.5	80.2	33.3	1374	836	8158	1690	1627	38.6	67.8	13.8	1287	753	7289
VIII	190	72.0	2134	2020	47.4	89.0	41.9	1574	947	9253	1875	1811	38.9	71.6	15.4	1463	836	8099
Svin (Pig) nr. 9																		
I	89	19.2	689	634	20.6	27.8	9.9	453	293	2899	617	581	18.0	24.0	3.6	426	265	2597
II	103	24.6	882	820	27.0	34.3	13.6	595	383	3788	795	753	23.7	27.8	5.6	563	346	3409
III	117	30.9	1043	974	31.0	42.6	16.5	708	454	4517	936	892	27.1	36.1	7.2	667	409	4057
IV	131	37.5	1212	1133	34.0	47.6	19.7	841	532	5225	1092	1041	30.0	40.8	7.9	793	483	4719
V	145	43.5	1457	1366	37.5	60.4	25.2	1032	643	6297	1310	1253	32.7	49.2	11.4	974	583	5651
VI	159	51.1	1706	1611	41.1	70.5	32.6	1236	758	7447	1553	1492	36.3	59.4	18.3	1173	693	6762
VII	173	59.6	1884	1782	44.5	80.2	33.3	1374	836	8158	1711	1643	39.3	70.7	15.4	1294	762	7385
VIII	187	69.3	2134	2020	47.4	89.0	41.9	1574	947	9253	1931	1857	41.3	75.7	22.1	1483	861	8362

MAIS OG SKUMMETMÆLK (MAIZE AND SKIMMILK) SERIE E.

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
Svin (Pig) nr. 4																		
I	82	24.1	716	669	21.8	30.2	9.8	489	315	3139	648	619	19.7	27.1	4.0	461	287	2854
II	96	30.1	882	830	27.1	36.3	13.8	608	395	3886	806	767	24.5	31.0	7.1	573	363	3550
III	110	37.2	1044	990	31.6	41.7	15.2	735	471	4635	959	923	28.5	34.0	7.8	703	435	4254
IV	124	44.9	1290	1220	35.7	56.3	19.2	920	580	5753	1168	1124	31.6	48.6	7.2	870	528	5209
V	138	55.2	1533	1453	41.8	68.4	23.6	1097	692	6849	1376	1328	36.6	58.2	9.3	1029	621	6110
VI	152	63.4	1768	1685	45.4	76.2	27.7	1296	805	7887	1628	1574	40.4	64.1	14.0	1241	743	7239
VII	166	73.8	2014	1921	49.2	92.7	37.2	1484	922	9054	1841	1783	43.5	78.9	22.0	1410	846	8246
VIII	180	85.3	2239	2130	52.9	98.6	37.1	1659	1025	10009	2072	2002	46.5	85.7	25.4	1595	951	9232
Svin (Pig) nr. 5																		
I	80	20.8	716	669	21.8	30.2	9.8	489	315	3139	635	604	18.1	20.0	3.9	462	279	2762
II	94	26.6	882	830	27.1	36.3	13.8	608	395	3886	784	749	22.9	20.2	6.5	577	350	3399
III	108	31.9	1044	990	31.6	41.7	15.2	735	471	4635	938	901	26.9	27.0	6.1	699	423	4123
IV	136	46.5	1290	1220	35.7	56.3	19.2	920	580	5753	1152	1103	30.2	39.4	7.0	866	515	5080
V	150	54.6	1533	1453	41.8	68.4	23.6	1097	692	6849	1385	1328	36.1	47.5	10.4	1043	623	6126
VI	164	63.7	1768	1685	45.4	76.2	27.7	1296	805	7887	1637	1576	40.3	57.1	17.0	1248	744	7254
VII	178	73.4	2014	1921	49.2	92.7	37.2	1484	922	9054	1839	1775	42.7	71.0	23.0	1414	840	8196
VIII	190	80.9	2239	2130	52.9	98.6	37.1	1659	1025	10009	2007	1938	43.8	77.6	19.6	1562	918	8876
Svin (Pig) nr. 6																		
I	86	26.8	716	669	21.8	30.2	9.8	489	315	3139	656	623	19.6	25.7	4.6	465	290	2879
II	100	31.6	882	830	27.1	36.3	13.8	608	395	3886	801	764	24.4	29.2	6.1	574	359	3508
III	114	38.4	1044	990	31.6	41.7	15.2	735	471	4635	954	919	28.2	33.6	7.7	701	432	4224
IV	128	46.3	1290	1220	35.7	56.3	19.2	920	580	5753	1194	1146	31.5	48.8	11.9	887	540	5317
V	142	53.5	1533	1453	41.8	68.4	23.6	1097	692	6849	1420	1363	37.5	60.7	13.5	1052	643	6319
VI	156	63.1	1768	1685	45.4	76.2	27.7	1296	805	7887	1615	1564	38.8	60.0	16.6	1243	737	7162
VII	170	73.1	2014	1921	49.2	92.7	37.2	1484	922	9054	1841	1784	42.1	71.0	24.8	1425	844	8227
VIII	184	82.5	2239	2130	52.9	98.6	37.1	1659	1025	10009	2063	1994	45.1	83.6	25.1	1554	947	9166

MAIS OG PROTEINBLANDING (MAIZE AND PROTEINMIXTURE) SERIE C.

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
Svin (Pig) nr. 10.																		
I	92	19.7	640	591	25.1	31.4	23.1	380	284	2841	531	506	20.4	26.8	9.5	343	238	2364
II	106	25.3	841	775	33.1	39.5	35.4	491	372	3704	696	663	26.9	31.8	18.5	442	311	3072
III	120	32.5	995	924	37.5	48.0	38.3	599	444	4432	840	805	31.0	42.8	20.0	544	378	3767
IV	134	40.5	1159	1083	40.7	53.4	38.1	732	521	5149	995	954	34.4	44.3	22.9	668	450	4397
V	148	47.2	1405	1316	44.2	65.5	41.8	927	631	6227	1191	1147	36.9	57.8	15.2	837	540	5278
VI	162	55.8	1660	1564	48.4	74.6	49.9	1132	748	7387	1460	1406	42.1	68.3	28.2	1041	662	6489
VII	176	65.1	1841	1735	51.1	86.1	50.8	1268	826	8112	1651	1586	45.3	79.2	31.1	1182	745	7280
VIII	190	76.6	2089	1973	54.1	94.9	59.6	1469	936	9190	1870	1800	47.8	87.1	35.8	1367	843	8220
Svin (Pig) nr.11																		
I	96	20.3	640	591	25.1	31.4	23.1	380	284	2841	540	515	20.8	27.4	12.7	345	242	2405
II	110	25.3	841	775	33.1	39.5	35.4	491	372	3704	715	681	28.0	34.3	24.3	445	322	3172
III	124	31.3	995	924	37.5	48.0	38.3	599	444	4432	857	821	31.9	43.8	25.8	548	387	3843
IV	138	38.1	1159	1083	40.7	53.4	38.1	732	521	5149	1011	970	35.0	48.4	24.6	674	459	4505
V	152	45.9	1405	1316	44.2	65.5	41.8	927	631	6227	1202	1154	36.9	45.6	25.7	847	543	5283
VI	166	53.5	1660	1564	48.4	74.6	49.9	1132	748	7387	1483	1428	41.7	67.0	34.2	1061	672	6599
VII	180	62.5	1841	1735	51.1	86.1	50.8	1268	826	8112	1627	1571	43.5	73.1	32.7	1182	734	7146
VIII	194	72.8	2089	1973	54.1	94.9	59.6	1469	936	9190	1875	1810	46.1	82.4	40.9	1386	846	8236
Svin (Pig) nr. 12																		
I	91	19.6	640	591	25.1	31.4	23.1	380	284	2841	547	519	21.3	27.0	13.4	346	245	2424
II	105	24.8	841	775	33.1	39.5	35.4	491	372	3704	720	682	28.2	34.9	21.9	447	322	3182
III	119	31.2	995	924	37.5	48.0	38.3	599	444	4432	851	813	32.2	44.1	22.1	542	383	3801
IV	133	37.4	1159	1083	40.7	53.4	38.1	732	521	5149	980	944	34.1	45.2	18.4	663	445	4359
V	147	44.9	1405	1316	44.2	65.5	41.8	927	631	6227	1218	1169	37.3	54.4	20.5	855	549	5368
VI	161	52.5	1660	1564	48.4	74.6	49.9	1132	748	7387	1463	1410	41.6	66.2	30.2	1049	663	6500
VII	175	62.1	1841	1735	51.1	86.1	50.8	1268	826	8112	1641	1575	44.5	74.7	28.9	1183	737	7189
VIII	189	71.9	2089	1973	54.1	94.9	59.6	1469	936	9190	1855	1789	46.8	83.5	33.2	1367	836	8140

MAIS OG PROTEINBLANDING (MAIZE AND PROTEINMIXTURE) SERIE E.

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
Svin (Pig) nr. 10																		
I	89	26.2	695	640	25.9	38.6	21.4	416	308	3106	591	561	21.6	34.0	11.3	379	265	2655
II	103	31.0	855	794	32.3	46.9	27.6	518	386	3850	726	693	26.9	40.5	15.9	469	331	3274
III	117	37.2	1020	950	37.7	53.5	29.9	631	463	4599	872	837	31.5	47.4	17.3	576	402	3949
IV	131	44.2	1264	1179	41.6	68.7	35.8	813	571	5710	1093	1048	34.8	62.1	20.9	746	498	4953
V	145	52.1	1507	1411	46.9	81.0	38.5	996	681	6785	1307	1254	38.9	68.3	20.6	920	594	5867
VI	159	61.0	1745	1647	50.2	87.5	44.0	1200	796	7831	1553	1497	42.5	75.8	27.3	1127	712	6959
VII	173	70.9	1993	1882	54.5	105.5	53.9	1382	913	8998	1746	1690	45.1	85.0	35.1	1288	804	7854
VIII	187	81.7	2214	2089	58.0	110.9	54.4	1556	1014	9953	1955	1888	48.0	92.2	32.9	1458	901	8755
Svin (Pig) nr. 11																		
I	87	20.7	695	640	25.9	38.6	21.4	416	308	3106	592	559	21.2	26.9	12.5	385	263	2629
II	101	25.7	855	794	32.3	46.9	27.6	518	386	3850	713	679	26.0	29.5	14.4	473	323	3186
III	115	28.2	1020	950	37.7	53.5	29.9	631	463	4599	849	817	29.7	34.8	14.6	582	388	3794
IV	143	42.9	1264	1179	41.6	68.7	35.8	813	571	5710	1069	1027	33.2	51.3	20.8	746	486	4804
V	157	51.0	1507	1411	46.9	81.0	38.5	996	681	6785	1302	1247	38.3	62.1	22.0	921	587	5791
VI	171	59.8	1745	1647	50.2	87.5	44.0	1200	796	7831	1529	1473	40.7	64.1	28.2	1125	697	6776
VII	185	68.6	1993	1882	54.5	105.5	53.9	1382	913	8998	1722	1663	43.5	82.1	33.8	1275	789	7693
VIII	197	79.9	2214	2089	58.0	110.9	54.4	1556	1014	9953	1924	1854	46.1	84.1	31.9	1444	882	8570
Svin (Pig) nr. 12																		
I	93	25.7	695	640	25.9	38.6	21.4	416	308	3106	597	566	21.6	32.5	14.0	382	267	2676
II	107	31.0	855	794	32.3	46.9	27.6	518	386	3850	755	718	27.8	41.4	20.0	483	344	3411
III	121	38.1	1020	950	37.7	53.5	29.9	631	463	4599	890	852	32.2	48.4	20.2	583	410	4036
IV	135	44.9	1264	1179	41.6	68.7	35.8	813	571	5710	1115	1066	35.3	60.7	25.4	758	507	5036
V	149	52.7	1507	1411	46.9	81.0	38.5	996	681	6785	1328	1274	39.4	70.4	24.3	931	601	5941
VI	163	61.5	1745	1647	50.2	87.5	44.0	1200	796	7831	1549	1497	42.1	69.2	29.6	1134	713	6934
VII	177	70.7	1993	1882	54.5	105.5	53.9	1382	913	8998	1760	1703	45.5	88.7	35.3	1294	811	7932
VIII	191	80.3	2214	2089	58.0	110.9	54.4	1556	1014	9953	1989	1915	48.6	97.6	37.3	1472	917	8923

MILO OG SKUMMETMÆLK (SORGHUM AND SKIMMILK) SERIE D.

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
Svin (Pig) nr. 4																		
I	87	22.8	778	717	24.4	27.1	13.8	516	345	3355	685	651	20.0	22.6	8.6	487	305	2958
II	101	28.4	975	899	30.4	31.1	15.2	655	425	4195	869	825	25.5	27.2	8.7	621	382	3748
III	115	36.1	1158	1065	36.0	35.9	15.3	778	504	4966	1028	974	29.9	29.5	9.2	738	453	4408
IV	129	44.5	1427	1321	41.5	41.5	21.9	991	630	6164	1275	1210	32.7	34.2	13.2	950	567	5500
V	143	52.5	1687	1571	45.7	54.5	25.4	1194	746	7260	1487	1427	36.6	42.7	14.5	1131	665	6409
VI	157	63.2	1955	1830	52.9	63.3	32.7	1394	857	8468	1745	1677	42.7	54.8	21.0	1325	771	7566
VII	171	75.6	2214	2082	57.2	73.7	39.0	1597	969	9634	1986	1914	46.2	64.9	26.6	1519	874	8626
VIII	185	86.3	2509	2366	61.6	88.2	46.4	1834	1125	11001	2265	2187	50.7	75.4	33.9	1749	1020	9934
Svin (Pig) nr. 5																		
I	89	23.7	778	717	24.4	27.1	13.8	516	345	3355	694	657	20.6	17.3	9.4	495	308	2989
II	103	29.1	975	899	30.4	31.1	15.2	655	425	4195	889	840	26.8	24.0	5.8	634	391	3835
III	117	36.0	1158	1065	36.0	35.9	15.3	778	504	4966	1040	989	30.8	29.4	10.3	745	461	4494
IV	131	45.2	1427	1321	41.5	41.5	21.9	991	630	6164	1266	1209	36.5	28.6	12.7	932	566	5494
V	145	53.5	1687	1571	45.7	54.5	25.4	1194	746	7260	1519	1451	37.7	38.3	17.8	1149	678	6535
VI	159	62.5	1955	1830	52.9	63.3	32.7	1394	857	8468	1760	1691	43.7	44.6	22.1	1342	778	7617
VII	173	74.4	2214	2082	57.2	73.7	39.0	1597	969	9364	1987	1912	46.9	48.2	24.8	1531	877	8591
VIII	187	84.5	2509	2366	61.6	88.2	46.4	1834	1125	11001	2268	2188	50.0	63.7	33.7	1766	1020	9904
Svin (Pig) nr. 6																		
I	89	24.4	778	717	24.4	27.1	13.8	516	345	3355	697	660	20.9	20.5	9.5	492	309	2997
II	103	29.9	975	899	30.4	31.1	15.2	655	425	4195	885	839	26.8	26.1	5.6	632	391	3828
III	117	36.0	1158	1065	36.0	35.9	15.3	778	504	4966	1049	994	31.7	30.5	9.9	744	464	4539
IV	131	44.7	1427	1321	41.5	41.5	21.9	991	630	6164	1292	1227	35.9	34.7	14.7	946	577	5600
V	145	52.4	1687	1571	45.7	54.5	25.4	1194	746	7260	1534	1463	39.4	42.8	18.2	1145	686	6618
VI	159	62.1	1955	1830	52.9	63.3	32.7	1394	857	8468	1772	1700	45.1	48.1	23.2	1338	785	7694
VII	173	72.9	2214	2082	57.2	73.7	39.0	1597	969	9634	2013	1938	48.9	60.6	28.0	1530	887	8770
VIII	187	83.7	Ingen målinger (No measurements)															

MILO OG SKUMMETMÆLK (SORGHUM AND SKIMMILK) SERIE F.

Svin (Pig) nr. 4

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
I	108	26.1	728	682	23.1	24.2	13.9	498	328	3185	651	622	19.2	16.0	7.4	478	293	2821
II	122	30.6	895	841	27.9	28.9	14.5	620	397	3915	810	777	23.3	20.9	9.7	597	360	3510
III	136	37.0	1080	1016	33.5	33.5	17.2	752	484	4704	983	944	28.2	24.4	12.4	727	441	4244
IV	150	44.0	1323	1249	37.9	41.7	22.8	943	593	5790	1211	1162	32.2	32.7	15.5	908	543	5245
V	164	52.1	1563	1481	41.9	48.7	28.8	1136	702	6841	1421	1369	34.0	32.5	21.7	1097	637	6137
VI	178	61.5	1799	1702	45.7	57.4	39.8	1311	797	7852	1639	1576	36.8	39.3	32.1	1267	724	7049
VII	192	71.3	2055	1949	49.7	66.6	42.5	1521	917	8932	1856	1790	39.3	42.4	30.3	1463	823	7926
VIII	206	81.3	2299	2185	53.3	74.9	46.4	1721	1028	9987	2064	1998	41.3	44.0	33.0	1653	917	8759

Svin (Pig) nr. 5

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
I	89	25.2	728	682	23.1	24.2	13.9	498	328	3185	657	629	19.8	19.4	8.1	476	298	2864
II	103	29.7	895	841	27.9	28.9	14.5	620	397	3915	817	783	23.8	22.5	10.5	597	363	3541
III	117	35.9	1080	1016	33.5	33.5	17.2	752	484	4704	984	944	28.6	25.0	12.1	724	442	4250
IV	131	43.8	1323	1249	37.9	41.7	22.8	943	593	5790	1207	1155	31.6	27.5	15.5	909	539	5198
V	145	50.8	1563	1481	41.9	48.7	28.8	1136	702	6841	1444	1386	35.5	36.9	22.6	1100	648	6252
VI	159	61.1	1799	1702	45.7	57.4	39.8	1311	797	7852	1623	1562	36.3	42.1	28.7	1256	715	6961
VII	173	70.9	2055	1949	49.7	66.6	42.5	1521	917	8932	1874	1806	40.6	51.1	31.5	1461	832	8016
VIII	187	81.1	2299	2185	53.3	74.9	46.6	1721	1028	9987	2090	2021	42.8	56.3	33.5	1653	931	8935

Svin (Pig) nr. 6

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
I	87	22.0	728	682	23.1	24.2	13.9	498	328	3185	645	617	18.8	17.1	6.7	474	291	2796
II	101	26.0	895	841	27.9	28.9	14.5	620	397	3915	810	774	23.0	19.0	9.9	597	359	3499
III	115	30.9	1080	1016	33.5	33.5	17.2	752	484	4704	967	924	26.9	18.1	10.8	723	431	4139
IV	129	36.0	1323	1249	37.9	41.7	22.8	943	593	5790	1143	1094	28.4	19.4	9.8	883	508	4883
V	143	42.2	1563	1481	41.9	48.7	28.8	1136	702	6841	1378	1326	31.8	25.6	15.9	1081	615	5917
VI	157	50.3	1799	1702	45.7	57.4	39.8	1311	797	7852	1627	1566	35.6	36.5	31.8	1267	718	6989
VII	171	58.6	2055	1949	49.7	66.6	42.5	1521	917	8932	1840	1773	38.1	43.2	27.9	1455	815	7835
VIII	185	68.6	2299	2185	53.3	74.9	46.4	1721	1028	9987	2059	1992	40.2	47.1	31.3	1653	916	8777

MILO OG PROTEINBLANDING (SORGHUM AND PROTEINMIXTURE) SERIE D.

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
Svin (Pig) nr. 10																		
I	94	23.6	733	677	27.9	32.9	25.8	444	337	3297	600	574	20.3	20.3	15.6	411	279	2678
II	108	29.7	925	854	35.3	38.1	29.5	565	419	4138	778	742	27.5	29.8	17.9	530	355	3467
III	122	36.2	1102	1016	42.3	43.4	31.3	677	495	4910	928	886	33.6	32.1	19.8	624	423	4145
IV	136	44.7	1373	1277	47.7	48.8	40.5	889	622	6118	1188	1140	38.3	35.5	29.3	836	543	5289
V	150	54.5	1614	1510	51.2	61.8	41.5	1087	730	7164	1398	1343	40.1	44.6	23.1	1025	635	6151
VI	164	65.5	1886	1779	58.4	71.3	49.9	1293	846	8398	1652	1601	46.7	54.2	37.9	1217	744	7326
VII	178	76.9	2148	2025	62.6	82.1	57.0	1494	957	9561	1881	1824	50.0	63.1	38.8	1409	842	8354
VIII	192	89.3	2442	2309	67.2	96.1	64.6	1728	1111	10910	2151	2095	53.7	70.4	47.1	1642	987	9625
Svin (Pig) nr. 11																		
I	96	21.3	733	677	27.9	32.9	25.8	444	337	3297	618	587	21.6	23.1	15.7	413	287	2768
II	110	27.0	925	854	35.3	38.1	29.5	565	419	4138	788	747	28.5	29.5	16.2	530	359	3512
III	124	33.3	1102	1016	42.3	43.4	31.3	677	495	4910	939	896	34.4	34.2	19.6	627	428	4204
IV	138	41.1	1373	1277	47.7	48.8	40.5	889	622	6118	1209	1154	39.1	38.6	29.2	842	552	5383
V	152	49.4	1614	1510	51.2	61.8	41.5	1087	730	7164	1418	1360	40.3	40.1	26.5	1041	644	6252
VI	166	59.1	1886	1779	58.4	71.3	49.9	1293	846	8398	1678	1623	47.7	50.6	37.0	1238	757	7455
VII	180	71.3	2148	2025	62.6	82.1	57.0	1494	957	9561	1908	1844	50.9	61.2	41.0	1423	854	8475
VIII	194	82.0	2442	2309	67.2	96.1	64.6	1728	1111	10910	2173	2107	54.4	69.4	46.6	1651	994	9692
Svin (Pig) nr. 12																		
I	96	25.2	733	677	27.9	32.9	25.8	444	337	3297	638	607	23.2	28.6	19.0	414	298	2880
II	110	30.4	925	854	35.3	38.1	29.5	565	419	4138	804	764	29.3	32.8	19.8	528	368	3606
III	124	36.5	1102	1016	42.3	43.4	31.3	677	495	4910	948	905	34.9	37.1	21.5	628	433	4246
IV	138	44.4	1373	1277	47.7	48.8	40.5	889	622	6118	1212	1161	40.0	42.2	30.9	838	556	5420
V	152	52.9	1614	1510	51.2	61.8	41.5	1087	730	7164	1426	1367	41.1	49.9	26.1	1034	650	6313
VI	166	60.3	1886	1779	58.4	71.3	49.9	1293	846	8398	1680	1623	48.2	57.5	36.0	1229	758	7466
VII	180	70.9	2148	2025	62.6	82.1	57.0	1494	957	9561	1912	1845	51.3	64.7	40.4	1419	854	8486
VIII	194	81.9	2442	2309	67.2	96.1	64.6	1728	1111	10910	2176	2112	54.9	77.3	47.1	1644	997	9715

MILO OG PROTEINBLANDING (SORGHUM AND PROTEINMIXTURE) SERIE F.

Svin (Pig) nr. 10

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
I	115	26.3	702	651	26.3	33.4	25.8	427	322	3146	591	565	20.4	25.4	14.3	398	274	2627
II	129	31.3	874	809	32.3	41.8	29.2	532	390	3887	730	698	24.1	26.5	17.6	499	326	3203
III	143	37.1	1051	975	38.1	40.3	34.8	650	475	4660	879	838	28.3	19.9	20.1	609	396	3832
IV	157	44.1	1300	1212	42.9	57.7	40.7	841	587	5757	1101	1054	32.2	29.9	24.9	794	496	4800
V	171	51.9	1538	1442	46.7	64.8	47.2	1033	694	6818	1327	1277	35.2	33.1	32.8	986	598	5808
VI	185	60.0	1770	1662	50.7	73.2	57.0	1207	787	7818	1517	1463	36.3	37.1	39.5	1152	671	6586
VII	199	70.4	2030	1910	54.5	82.7	59.8	1418	907	8895	1745	1682	38.5	38.8	40.4	1353	775	7489
VIII	213	79.2	2274	2145	57.7	91.3	61.7	1621	1019	9939	1977	1904	42.7	52.1	31.1	1544	882	8486

Svin (Pig) nr. 11

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
I	96	24.5	702	651	26.3	33.4	25.8	427	322	3146	592	563	20.5	24.6	14.7	396	273	2619
II	110	29.4	874	809	32.3	41.8	29.2	532	390	3887	763	723	25.7	29.7	21.7	507	341	3362
III	124	36.1	1051	975	38.1	40.3	34.8	650	475	4660	912	865	30.1	22.6	24.1	618	411	3976
IV	138	42.5	1300	1212	42.9	57.7	40.7	841	587	5757	1125	1075	33.1	38.7	28.5	796	508	4916
V	152	51.6	1538	1442	46.7	64.8	47.2	1033	694	6818	1349	1292	35.6	44.2	35.4	984	607	5886
VI	166	60.8	1770	1662	50.7	73.2	57.0	1207	787	7818	1549	1486	38.4	51.1	44.2	1143	686	6736
VII	180	70.6	2030	1910	54.5	82.7	59.8	1418	907	8895	1773	1705	39.9	59.5	43.3	1344	789	7623
VIII	194	81.0	2274	2145	57.7	91.3	61.7	1621	1019	9939	2010	1935	42.9	66.4	43.6	1547	895	8621

Svin (Pig) nr. 12

PER. NO.	AGE DAY	LW kg	DMI g	OMI g	NI g	EEI g	CFI g	NFEI g	CI g	GEI kcal	DMD g	OMD g	ND g	EED g	CFD g	NFED g	CD g	GED kcal
I	94	22.2	702	651	26.3	33.4	25.8	427	322	3146	580	556	20.2	23.1	13.4	393	268	2568
II	108	27.0	874	809	32.3	41.8	29.2	532	390	3887	766	725	26.7	28.2	22.6	504	341	3348
III	122	33.3	1051	975	38.1	40.3	34.8	650	475	4660	915	869	31.0	21.3	25.3	616	413	3984
IV	136	39.2	1300	1212	42.9	57.7	40.7	841	587	5757	1120	1070	33.3	36.7	28.6	792	504	4860
V	150	46.9	1538	1442	46.7	64.8	47.2	1033	694	6818	1325	1276	35.1	39.1	34.4	978	594	5762
VI	164	55.1	1770	1662	50.7	73.2	57.0	1207	787	7818	1522	1469	37.1	47.6	42.2	1139	673	6589
VII	178	64.4	2030	1910	54.5	82.7	59.8	1418	907	8895	1764	1701	40.2	50.5	42.7	1347	785	7577
VIII	192	73.8	2274	2145	57.7	91.3	61.7	1621	1019	9939	1961	1897	40.7	61.4	40.7	1530	875	8392

Main Tables II

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Kvælstof- og kulstof balancer.
Omsættelig energi og varmeproduktion.
Protein- og fedtaflejring.

Abbreviations / Forkortelser

	Abbreviations	Forkortelser
Age:	Age	Alder
LW:	Live weight	Legemsvægt
CO_2:	CO_2-production	CO_2-produktion og O_2-optagelse.
O_2:	O_2-consumption	O_2-optagelse
ND:	Nitrogen digested	Kvælstof, fordøjet
NU:	Nitrogen in urine	Kvælstof i urin
NBAL:	Nitrogen balance	Kvælstof-balance
CBAL:	Carbon balance	Kulstof-balance
GEI:	Gross energy intake	Brutto energi, optaget
ME:	Metabolizable energy	Omsættelig energi
HP(RQ):	Heat production (RQ-method)	Varmeproduktion (RQ-metode)
EBAL(RQ):	Energy balance (RQ-method)	Energi-balance (RQ-metode)
HP(NC):	Heatproduction (CN-method)	Varmeproduktion (CN-metode)
PROT GAIN:	Protein gain	Protein-aflejring
FAT GAIN:	Fat gain	Fedt-aflejring
ENERGY GAIN:	Energy gain (CN-method)	Energi-aflejring (CN-metode)

BYG OG SKUMMETMÆLK (BARLEY AND SKIMMILK) SERIE C.

PER. NO.	AGE DAY	LW kg	CO2 l	O2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Svin (Pig) nr. 1																
I	83	20.7	432	417	18.9	6.6	12.3	27.2	2947	2509	2121	388	2229	438	-158	280
II	97	26.7	521	500	24.3	7.7	16.6	62.0	3881	3319	2547	772	2628	593	98	691
III	111	33.4	567	551	28.0	10.2	17.8	98.7	4571	3881	2796	1085	2742	634	505	1139
IV	125	41.1	645	584	31.3	11.6	19.7	120.0	5303	4540	3015	1525	3145	701	694	1395
V	139	49.8	669	654	35.4	13.6	21.8	204.5	6453	5456	3312	2144	3024	777	1655	2432
VI	153	59.8	767	691	40.2	15.5	24.7	257.5	7621	6488	3570	2918	3413	881	2194	3075
VII	167	70.5	840	720	43.1	20.3	22.8	295.0	8385	7194	3763	3431	3645	812	2737	3549
VIII	181	82.1	953	873	46.1	21.7	24.4	330.9	9426	8142	4488	3654	4156	868	3118	3986
Svin (Pig) nr. 2																
I	85	20.9	415	423	18.1	6.3	11.8	33.4	2947	2482	2124	358	2123	421	- 62	359
II	99	26.6	467	451	23.9	9.0	14.9	89.5	3881	3297	2291	1006	2257	531	509	1040
III	113	32.5	520	496	28.0	12.6	15.4	124.8	4571	3881	2524	1357	2407	550	924	1474
IV	127	38.3	589	507	31.4	15.8	15.7	147.1	5303	4520	2644	1876	2771	558	1191	1749
V	141	46.6	664	635	35.0	17.2	17.8	204.3	6453	5405	3227	2178	2957	634	1814	2448
VI	155	55.2	718	642	39.0	20.0	19.0	260.0	7621	6244	3315	2929	3110	678	2456	3134
VII	169	64.3	815	684	42.1	22.7	19.4	290.9	8385	7011	3590	3421	3497	693	2821	3514
VIII	183	74.5	920	823	44.1	27.0	17.1	319.7	9426	7825	4247	3578	3943	609	3273	3882
Svin (Pig) nr. 3																
I	82	20.5	411	426	17.9	6.6	11.3	26.9	2947	2399	2131	268	2118	404	-123	281
II	96	25.4	496	512	23.5	8.4	15.0	59.4	3881	3160	2563	597	2494	536	130	666
III	110	31.3	552	566	26.8	11.3	15.5	92.7	4571	3738	2835	903	2662	552	524	1076
IV	124	39.1	673	705	30.7	13.1	17.6	86.8	5303	4367	3514	853	3372	629	366	995
V	138	46.8	709	676	35.0	14.5	20.4	185.5	6453	5444	3443	2001	3241	728	1475	2203
VI	152	54.1	808	709	39.9	19.8	20.1	221.9	7621	6340	3683	2657	3685	716	1939	2655
VII	166	64.6	Ingen respirationsmålinger						(No respiration measurements)							
VIII	180	75.4	970	852	45.8	25.2	20.6	315.7	9426	8076	4422	3654	4261	733	3082	3815

BYG OG SKUMMETMÆLK (BARLEY AND SKIMMILK) SERIE D.

PER. NO.	AGE DAY	LW kg	CO_2 l	O_2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Svin (Pig) nr. 1																
I	85	24.8	466	-	20.4	6.0	14.4	37.3	3289	2765	-	-	2370	514	-119	395
II	99	30.9	531	-	25.6	9.0	16.5	68.7	4144	3496	-	-	2723	589	184	773
III	113	37.8	589	593	30.6	11.2	19.4	113.7	4943	4186	2983	1203	2867	691	628	1319
IV	127	46.1	710	669	34.6	13.5	21.2	132.4	5997	5028	3419	1609	3485	754	789	1543
V	141	55.3	784	757	39.2	17.1	22.1	203.8	7239	6101	3843	2258	3679	788	1634	2422
VI	155	65.4	879	756	42.1	19.8	22.3	249.0	8401	7004	3949	3055	4022	795	2187	2982
VII	169	76.5	962	849	47.1	24.7	22.4	299.1	9530	8064	4402	3662	4463	798	2803	3601
VIII	183	88.1	1042	940	50.0	28.5	21.5	360.1	10675	9035	4843	4192	4674	766	3595	4361
Svin (Pig) nr. 2																
I	85	24.3	419	-	20.2	7.8	12.4	66.3	3289	2778	-	-	2014	443	321	764
II	99	29.8	506	-	25.3	9.2	16.1	86.1	4144	3530	-	-	2538	573	419	992
III	113	36.1	567	557	30.3	13.2	17.1	125.2	4943	4171	2815	1356	2698	610	863	1473
IV	127	43.9	672	626	34.7	15.0	19.6	163.6	5997	5109	3205	1904	3172	699	1238	1937
V	141	54.2	752	709	38.9	17.9	21.1	224.9	7239	6160	3617	2543	3472	751	1937	2688
VI	155	64.3	826	685	42.1	20.0	22.1	293.3	8401	7191	3610	3581	3660	787	2744	3531
VII	169	75.1	923	798	46.9	24.6	22.3	326.0	9530	8076	4158	3918	4140	795	3141	3936
VIII	183	86.7	1007	868	49.0	28.2	20.8	371.3	10675	8949	4524	4425	4445	740	3764	4504
Svin (Pig) nr. 3																
I	87	25.1	456	-	19.9	7.9	12.0	37.6	3289	2708	-	-	2298	429	-19	410
II	101	30.3	521	526	25.3	10.9	14.4	70.4	4144	3460	2643	817	2654	512	294	806
III	115	37.3	581	582	30.0	13.2	16.8	115.1	4943	4140	2928	1212	2792	597	751	1348
IV	129	44.4	706	658	34.0	16.1	17.9	133.0	5997	4998	3368	1630	3434	638	926	1564
V	143	52.1	794	764	38.1	19.5	18.6	192.3	7239	6049	3878	2171	3754	664	1631	2295
VI	157	62.0	879	770	42.1	22.1	20.0	257.7	8401	7092	4000	3092	3993	711	2388	3099
VII	171	72.2	990	879	46.4	26.7	19.7	289.6	9530	8064	4548	3516	4567	702	2795	3497
VIII	185	81.4	1070	949	50.1	29.8	20.3	329.5	10675	8851	4910	3941	4864	722	3265	3987

BYG OG SKUMMETMÆLK (BARLEY AND SKIMMILK) SERIE E.

PER. NO.	AGE DAY	LW kg	CO2 l	O2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Svin (Pig) nr. 1																
I	80	24.0	495	445	18.5	6.4	12.1	20.3	3278	2785	2305	480	2589	430	-234	196
II	94	30.0	505	468	22.9	8.1	14.8	87.7	4085	3446	2404	1042	2428	526	492	1018
III	108	38.4	598	550	26.1	10.7	15.5	99.4	4837	4040	2829	1211	2879	551	610	1161
IV	122	45.6	679	588	28.0	12.8	15.1	147.7	6012	4998	3070	1928	3237	539	1222	1761
V	136	54.6	796	746	33.0	14.0	18.9	196.5	7261	6038	3819	2219	3692	675	1671	2346
VI	150	64.3	916	823	36.1	17.3	18.9	228.6	8272	6908	4256	2652	4164	673	2071	2744
VII	164	74.8	964	835	37.4	18.8	18.6	300.8	9457	7813	4358	3455	4173	662	2978	3640
VIII	178	85.5	1084	953	40.0	21.5	18.5	337.3	10612	8819	4954	3865	4728	659	3432	4091
Svin (Pig) nr. 2																
I	76	20.0	451	400	16.7	6.2	10.5	33.0	3278	2667	2079	588	2307	375	- 15	360
II	90	26.1	506	467	22.0	8.0	14.0	82.6	4085	3403	2401	1002	2447	498	458	956
III	104	33.0	580	538	25.3	9.9	15.4	109.4	4837	4030	2762	1268	2747	549	734	1283
IV	132	46.9		Ingen respirationsmålinger					(No respiration measurements)							
V	146	54.7	763	685	32.1	14.4	17.7	205.1	7261	5962	3543	2419	3504	632	1826	2458
VI	160	64.3	828	744	35.7	15.7	19.7	279.2	8272	6927	3847	3080	3561	709	2657	3366
VII	174	74.3	982	873	36.3	18.7	17.6	283.2	9457	7766	4526	3240	4338	629	2799	3428
VIII	190	85.1	1095	1025	39.0	20.6	18.3	320.2	10612	8696	5247	3449	4815	653	3228	3881
Svin (Pig) nr. 3																
I	84	26.7	429	400	18.2	8.4	9.8	49.4	3278	2729	2049	680	2162	350	217	567
II	98	32.4	497	466	22.4	9.5	12.9	86.3	4085	3389	2384	1005	2380	459	550	1009
III	112	38.6	580	511	26.4	13.4	13.0	110.0	4837	4051	2652	1399	2748	465	838	1303
IV	126	45.1	649	540	28.6	16.2	12.4	168.6	6012	5021	2843	2178	2990	441	1590	2031
V	140	54.4	718	637	31.8	17.5	14.3	208.5	7261	5705	3299	2406	3189	511	2005	2516
VI	154	61.8	841	710	36.2	20.6	15.6	267.5	8272	6899	3724	3175	3658	556	2685	3241
VII	168	71.1	904	752	36.6	22.0	14.5	318.2	9457	7659	3960	3699	3784	518	3357	3875
VIII	182	81.6	1026	799	39.8	23.5	16.3	369.8	10612	8776	4286	4490	4270	582	3924	4506

BYG OG SKUMMETMÆLK (BARLEY AND SKIMMILK) SERIE F.

PER. NO.	AGE DAY	LW kg	CO2 l	O2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Svin (Pig) nr. 1																
I	106	28.3	469	500	20.2	9.0	11.2	33.0	3299	2751	2483	268	2395	398	- 42	356
II	120	33.1	551	525	23.9	11.3	12.6	48.8	4139	3360	2675	685	2815	450	95	545
III	134	39.1	591	574	29.2	12.0	17.2	106.0	4876	4071	2911	1160	2838	614	619	1233
IV	148	46.9	696	666	32.4	15.3	17.2	146.2	6074	4969	3388	1581	3237	611	1121	1732
V	162	55.2	744	694	36.8	17.0	19.8	237.5	7208	6133	3552	2581	3283	706	2144	2850
VI	176	63.6	821	706	38.9	19.1	19.8	262.6	8289	6771	3688	3083	3610	703	2458	3161
VII	190	75.4	924	774	44.1	20.9	23.2	319.2	9580	7829	4071	3758	3983	825	3021	3846
VIII	204	88.4	985	821	46.0	23.6	22.3	397.7	10682	8960	4322	4638	4137	796	4027	4823
Svin (Pig) nr. 2																
I	85	26.4	470	505	20.1	9.7	10.4	32.1	3299	2737	2502	235	2388	370	- 21	349
II	99	31.1	534	512	24.7	11.7	13.0	65.3	4139	3447	2603	844	2699	462	286	748
III	113	37.0	562	545	29.9	13.0	16.9	128.2	4876	4118	2762	1356	2609	604	905	1509
IV	127	44.8	693	668	33.5	18.4	15.1	159.7	6074	5098	3388	1710	3188	538	1372	1910
V	141	53.8	777	751	37.7	17.4	20.3	223.5	7208	6158	3811	2347	3485	724	1949	2673
VI	155	64.1	855	766	40.2	22.4	17.8	256.1	8289	6877	3955	2922	3787	636	2454	3090
VII	169	75.0	968	851	44.9	23.3	21.7	298.9	9580	7870	4419	3451	4269	772	2829	3601
VIII	183	86.2	1027	875	46.6	25.6	21.0	373.4	10682	8922	4578	4344	4394	748	3780	4528
Svin (Pig) nr. 3																
I	85	23.0	445	440	19.4	9.6	9.8	36.3	3299	2649	2221	428	2246	349	54	403
II	99	28.8	495	467	22.6	12.3	10.3	65.6	4139	3214	2382	833	2450	368	396	764
III	113	33.3	527	460	27.7	13.4	14.3	124.1	4876	3896	2392	1504	2425	511	960	1471
IV	127	40.6	619	572	32.8	15.6	17.2	188.6	6074	5006	2932	2074	2749	614	1643	2257
V	141	49.5	706	622	35.7	17.8	17.8	232.0	7208	5888	3226	2662	3096	635	2157	2792
VI	155	58.2	801	689	40.4	20.4	20.0	289.4	8289	6898	3596	3302	3406	711	2781	3492
VII	169	69.4	896	739	44.1	22.6	21.5	326.6	9580	7747	3900	3847	3801	767	3179	3946
VIII	183	82.2	1000	828	47.0	25.0	22.0	389.3	10682	8887	4365	4522	4166	783	3938	4721

BYG OG PROTEINBLANDING (BARLEY AND PROTEINMIXTURE) SERIE C.

PER. NO.	AGE DAY	LW kg	CO2 l	O2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Svin (Pig) nr. 4																
I	85	21.1	381	384	21.5	9.7	11.8	31.7	2889	2282	1928	354	1944	421	- 83	338
II	99	26.6	454	482	28.2	11.9	16.4	69.5	3797	3030	2391	639	2244	583	203	786
III	113	32.4	546	527	32.3	14.4	17.9	86.1	4486	3682	2672	1010	2698	639	345	984
IV	127	39.6	589	593	35.6	16.4	19.3	118.8	5227	4236	2976	1260	2854	686	696	1382
V	141	48.0	665	637	39.9	16.1	23.8	188.8	6383	5265	3238	2027	3036	848	1381	2229
VI	155	54.9	751	658	44.6	21.5	23.1	233.4	7561	6151	3414	2737	3366	821	1964	2785
VII	169	64.9	823	725	46.7	24.5	22.2	268.4	8339	6908	3755	3153	3686	789	2433	3222
VIII	183	75.0	937	826	49.3	27.1	22.2	294.7	9364	7716	4279	3437	4169	791	2756	3547
Svin (Pig) nr. 5																
I	89	21.9	415	431	21.1	9.8	11.2	13.2	2889	2274	2150	124	2162	401	-289	112
II	103	26.4	450	458	28.4	13.7	14.8	71.7	3797	2999	2291	708	2179	526	294	820
III	117	32.6	506	487	31.8	17.0	14.8	97.7	4486	3579	2466	1113	2438	528	613	1141
IV	131	39.0	569	542	35.4	19.8	15.6	129.0	5227	4226	2750	1476	2700	556	970	1526
V	145	44.7	602	532	39.2	23.2	16.1	212.2	6383	5190	2746	2444	2636	572	1982	2554
VI	159	50.9	713	600	44.2	24.7	19.5	245.4	7561	6075	3140	2935	3126	696	2253	2949
VII	173	59.9	792	677	45.2	24.7	20.5	271.5	8339	6740	3533	3207	3472	730	2538	3268
VIII	187	69.2	865	742	48.6	28.5	20.1	321.1	9364	7610	3866	3744	3726	714	3170	3884
Svin (Pig) nr. 6																
I	84	21.1	413	404	21.3	8.9	12.4	14.3	2889	2276	2044	232	2157	442	-323	119
II	98	26.7	468	500	28.0	11.1	16.8	63.4	3797	3035	2479	556	2329	599	107	706
III	112	34.4	543	552	32.1	12.9	19.2	72.6	4486	3533	2768	765	2723	683	127	810
IV	126	41.5	603	622	35.2	14.9	20.3	107.7	5227	4190	3107	1083	2951	724	515	1239
V	140	50.9	646	617	40.6	16.7	23.9	200.6	6383	5288	3137	2151	2913	850	1525	2375
VI	154	59.0	749	688	45.6	18.5	27.1	240.0	7561	6221	3532	2689	3374	964	1883	2847
VII	168	69.8	863	785	47.6	23.0	24.5	247.2	8339	6896	4037	2859	3947	874	2075	2949
VIII	182	80.3	909	822	49.9	27.1	22.8	305.9	9364	7749	4230	3519	4064	812	2873	3685

BYG OG PROTEINBLANDING (BARLEY AND PROTEINMIXTURE) SERIE D.

PER. NO.	AGE DAY	LW kg	CO_2 l	O_2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Svin (Pig) nr. 7																
I	92	23.9	410	-	21.9	7.9	14.0	51.0	3231	2577	-	-	2010	499	68	567
II	106	30.4	491	466	27.8	10.6	17.3	69.5	4087	3271	2376	895	2491	616	164	780
III	120	37.0	573	544	33.6	12.8	20.9	91.4	4887	3887	2773	1114	2852	744	291	1035
IV	134	45.9	690	638	36.7	15.7	21.0	106.3	5951	4682	3273	1409	3463	747	472	1219
V	148	54.8	733	648	40.9	17.8	23.1	196.9	7143	5809	3360	2449	3475	823	1511	2334
VI	162	65.4	861	731	43.6	22.6	21.0	223.5	8331	6706	3827	2879	4034	749	1923	2672
VII	176	76.3	980	856	48.9	25.2	23.7	254.2	9457	7695	4449	3246	4656	845	2194	3039
VIII	190	88.7	1085	930	50.0	29.4	20.6	268.4	10584	8469	4855	3614	5240	735	2494	3229
Svin (Pig) nr. 8																
I	92	22.9	388	-	21.7	10.1	11.6	57.2	3231	2520	-	-	1866	414	240	654
II	106	27.9	491	465	28.5	13.2	15.3	70.3	4087	3294	2368	926	2494	543	257	800
III	120	33.8	568	544	33.6	16.7	16.9	91.1	4887	3856	2761	1095	2806	601	449	1050
IV	134	42.4	674	646	37.4	19.3	18.2	119.9	5951	4705	3278	1427	3304	648	753	1401
V	148	50.8	741	660	40.3	20.3	20.0	184.4	7143	5729	3412	2317	3538	711	1480	2191
VI	162	60.4	837	717	45.2	24.5	20.7	257.0	8331	6872	3741	3131	3785	739	2348	3087
VII	176	70.7	921	788	49.2	25.6	23.6	298.6	9457	7790	4115	3675	4200	841	2749	3590
VIII	190	82.9	1011	855	52.2	30.4	21.9	333.7	10584	8670	4476	4194	4637	780	3253	4033
Svin (Pig) nr. 9																
I	94	25.5	450	-	22.2	11.1	11.1	27.6	3231	2566	-	-	2275	396	-105	291
II	108	30.0	564	584	28.7	13.7	15.1	30.6	4087	3290	2915	375	2981	537	-228	309
III	122	35.4	627	655	34.1	16.9	17.3	63.4	4887	3879	3261	618	3174	616	89	705
IV	136	43.3	680	624	38.9	18.7	20.2	132.2	5951	4921	3201	1720	3377	720	824	1544
V	150	53.4	751	702	42.3	22.0	20.2	194.2	7143	5883	3583	2300	3571	720	1592	2312
VI	164	62.7	820	726	45.2	26.6	18.6	258.1	8331	6761	3753	3008	3650	663	2448	3111
VII	178	71.6	967	872	49.9	29.0	20.8	270.3	9457	7779	4490	3289	4526	743	2510	3253
VIII	192	84.8	1107	916	52.7	33.2	19.5	281.7	10584	8645	4822	3823	5246	696	2703	3399

BYG OG PROTEINBLANDING (BARLEY AND PROTEINMIXTURE) SERIE E.

PER. NO.	AGE DAY	LW kg	CO2 l	O2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Svin (Pig) nr. 7																
I	87	22.8	412	396	20.9	8.1	12.8	46.6	3246	2626	2013	613	2109	455	62	517
II	101	29.1	489	490	25.4	9.7	15.7	62.7	4049	3136	2467	669	2433	557	146	703
III	115	36.5	536	515	28.9	12.8	16.1	96.0	4801	3705	2616	1089	2590	574	541	1115
IV	129	45.3	600	524	31.2	15.3	15.8	150.8	5969	4650	2724	1926	2856	564	1230	1794
V	143	53.2	731	615	34.8	16.7	18.1	198.5	7197	5737	3231	2506	3361	645	1731	2376
VI	157	63.0	799	695	37.1	16.8	20.4	251.3	8216	6565	3622	2943	3546	726	2293	3019
VII	171	73.8	895	758	39.4	19.5	19.9	292.1	9401	7433	3976	3457	3905	709	2819	3528
VIII	185	84.0	990	838	41.8	20.7	21.1	345.0	10556	8385	4398	3987	4209	752	3424	4176
Svin (Pig) nr. 8																
I	83	20.7	420	409	19.9	8.4	11.5	33.2	3246	2526	2073	453	2167	409	- 50	359
II	97	26.1	483	489	24.0	9.6	14.5	59.5	4049	3073	2456	617	2403	515	155	670
III	111	30.9	544	511	28.4	12.4	16.0	91.8	4801	3707	2611	1096	2645	569	493	1062
IV	139	44.2	644	595	29.7	14.9	14.8	110.3	5969	4470	3052	1418	3172	528	770	1298
V	153	51.4	708	644	35.3	17.5	17.8	208.1	7197	5737	3314	2423	3242	636	1859	2495
VI	167	59.7	814	712	36.8	19.7	17.1	240.5	8216	6545	3701	2844	3645	610	2290	2900
VII	181	70.0	867	760	37.1	19.3	17.7	303.2	9401	7353	3951	3402	3680	632	3041	3673
VIII	195	81.1	1086	958	41.5	23.1	18.3	297.4	10556	8399	4974	3425	4800	653	2946	3399
Svin (Pig) nr. 9																
I	91	27.2	409	403	19.9	8.9	11.0	38.6	3246	2535	2036	499	2108	390	37	427
II	105	32.1	492	451	24.9	11.0	13.9	67.1	4049	3210	2318	892	2442	496	272	768
III	119	37.8	554	544	29.2	15.1	14.1	94.9	4801	3778	2746	1032	2667	501	610	1111
IV	133	45.6	618	584	32.6	18.3	14.3	157.7	5969	4798	2973	1825	2911	509	1378	1887
V	147	51.7	746	680	36.0	20.1	15.9	196.1	7197	5780	3495	2285	3424	566	1790	2356
VI	161	59.7	847	774	38.2	22.2	16.0	227.3	8216	6575	3977	2598	3833	569	2173	2742
VII	175	69.0	938	784	39.6	23.7	15.9	276.1	9401	7464	4123	3341	4117	566	2781	3347
VIII	189	78.7	972	837	42.6	26.3	16.3	361.8	10556	8460	4364	4096	4054	582	3824	4406

BYG OG PROTEINBLANDING (BARLEY AND PROTEINMIXTURE) SERIE F.

PER. NO.	AGE DAY	LW kg	CO2 l	O2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Svin (Pig) nr. 7																
I	113	26.6	456	486	21.9	10.7	11.2	26.2	3260	2581	2411	170	2308	398	-125	273
II	127	32.3	535	549	25.7	13.1	12.6	31.4	4111	3132	2745	387	2802	449	-119	330
III	141	37.6	572	572	31.4	17.1	14.3	80.9	4832	3739	2874	865	2802	510	427	937
IV	155	44.0	609	586	34.9	17.8	17.0	162.0	6041	4736	2970	1766	2809	606	1321	1927
V	169	52.5	705	667	38.8	20.7	18.2	213.4	7185	5707	3395	2312	3148	647	1912	2559
VI	183	61.7	842	742	41.0	23.3	17.7	220.4	8255	6517	3846	2671	3869	631	2017	2648
VII	197	70.5	896	764	46.2	25.9	20.3	313.3	9543	7664	3992	3672	3876	722	3066	3788
VIII	211	82.2	967	805	49.8	28.0	21.8	389.1	10634	8764	4233	4531	4045	776	3943	4719
Svin (Pig) nr. 8																
I	92	23.9	430	458	21.8	11.5	10.3	39.8	3260	2587	2270	317	2141	365	81	446
II	106	28.8	495	499	26.9	13.8	13.1	63.5	4111	3259	2503	756	2533	466	260	726
III	120	34.5	549	550	33.0	17.7	15.3	105.1	4832	3861	2760	1101	2630	546	685	1231
IV	134	41.4	605	596	35.9	17.5	18.4	175.6	6041	4810	3005	1805	2720	657	1433	2090
V	148	48.8	661	643	39.5	22.4	17.1	249.4	7185	5830	3247	2583	2820	608	2402	3010
VI	162	58.3	798	717	43.6	24.5	19.1	268.2	8255	6747	3695	3052	3512	680	2555	3235
VII	176	68.7	890	779	47.1	26.7	20.3	319.5	9543	7710	4042	3668	3847	724	3139	3863
VIII	190	79.2	960	809	48.8	30.1	18.7	390.5	10634	8738	4237	4501	3988	666	4084	4750
Svin (Pig) nr. 9																
I	92	23.3	451	484	21.3	10.0	11.3	22.5	3260	2517	2398	119	2292	404	-179	225
II	106	28.1	490	486	26.3	14.0	12.3	51.0	4111	3099	2447	652	2523	438	138	576
III	120	33.2	555	532	31.6	16.0	15.7	96.6	4832	3797	2700	1097	2673	559	565	1124
IV	134	40.9	629	620	35.2	17.3	17.9	157.5	6041	4735	3127	1608	2867	639	1229	1868
V	148	50.0	711	646	38.8	17.8	21.0	212.3	7185	5756	3326	2430	3224	748	1784	2532
VI	162	59.4	792	683	39.2	21.3	18.0	236.2	8255	6399	3561	2838	3555	640	2204	2844
VII	176	69.5	873	766	45.6	23.8	21.8	325.5	9543	7660	3975	3685	3729	777	3154	3931
VIII	190	76.0	887	731	47.5	25.9	21.6	421.8	10634	8654	3853	4801	3529	768	4357	5125

MAIS OG SKUMMETMÆLK (MAIZE AND SKIMMILK) SERIE C.

Svin (Pig) nr. 7

PER. NO.	AGE DAY	LW kg	CO_2 l	O_2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
I	90	19.8	408	415	17.7	6.7	10.9	37.1	2899	2501	2084	417	2092	390	19	409
II	104	25.1	473	484	23.8	9.2	14.6	82.1	3788	3286	2426	860	2337	521	428	949
III	118	31.4	551	526	27.7	11.1	16.6	108.7	4517	3990	2679	1311	2720	591	679	1270
IV	132	38.3	597	571	30.5	12.6	17.8	155.2	5225	4648	2906	1742	2807	635	1206	1841
V	146	46.2	618	576	33.9	15.7	18.2	247.8	6297	5638	2946	2692	2652	648	2338	2986
VI	160	53.4	731	631	36.9	16.7	20.2	292.6	7447	6678	3293	3385	3147	718	2813	3531
VII	174	63.9	801	672	40.2	19.5	20.7	337.5	8158	7448	3531	3917	3363	738	3347	4085
VIII	188	74.4	868	773	42.3	21.7	20.6	403.9	9253	8380	3999	4381	3471	735	4174	4909

Svin (Pig) nr. 8

PER. NO.	AGE DAY	LW kg	CO_2 l	O_2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
I	92	19.7	429	428	17.8	7.4	10.4	26.2	2899	2509	2158	351	2232	371	- 94	277
II	106	25.5	470	504	23.5	9.5	14.1	84.2	3788	3302	2498	804	2325	500	477	977
III	120	31.2	583	562	27.0	12.5	14.5	85.2	4517	3920	2852	1068	2933	518	469	987
IV	134	37.8	591	584	29.9	14.0	15.9	156.4	5225	4627	2947	1680	2763	567	1297	1864
V	148	45.2	630	592	33.0	16.3	16.7	235.2	6297	5560	3022	2538	2724	596	2240	2836
VI	162	51.8	783	692	35.2	18.8	16.3	240.4	7447	6458	3588	2870	3556	582	2320	2902
VII	176	61.5	828	709	38.6	19.5	19.1	292.2	8158	7186	3707	3479	3655	682	2849	3531
VIII	190	72.0	874	797	38.9	21.3	17.6	349.0	9253	7916	4099	3817	3675	626	3615	4241

Svin (Pig) nr. 9

PER. NO.	AGE DAY	LW kg	CO_2 l	O_2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
I	89	19.2	398	399	18.0	7.7	10.3	44.6	2899	2518	2009	509	2013	367	138	505
II	103	24.6	452	426	23.7	9.3	14.4	94.8	3788	3310	2176	1134	2202	514	594	1108
III	117	30.9	528	519	27.1	13.6	13.5	115.4	4517	3923	2621	1302	2556	479	888	1367
IV	131	37.5	564	555	30.0	15.9	14.1	166.3	5225	4577	2799	1778	2583	500	1494	1994
V	145	43.5	657	605	32.7	17.6	15.1	217.1	6297	5520	3102	2418	2901	538	2081	2619
VI	159	51.1	750	655	36.3	19.3	17.0	276.2	7447	6598	3404	3194	3255	604	2739	3343
VII	173	59.6	808	706	39.3	22.6	16.8	308.6	8158	7173	3667	3506	3429	597	3147	3744
VIII	187	69.3	915	799	41.3	23.9	17.3	351.9	9253	8157	4153	4004	3879	618	3660	4278

MAIS OG SKUMMETMÆLK (MAIZE AND SKIMMILK) SERIE E.

PER. NO.	AGE DAY	LW kg	CO2 l	O2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Svin (Pig) nr. 4																
I	82	24.1	449	432	19.7	8.4	11.3	38.3	3139	2757	2197	560	2335	401	21	422
II	96	30.1	517	519	24.5	9.6	14.9	75.8	3886	3430	2613	817	2560	531	339	870
III	110	37.2	596	570	28.5	12.0	16.5	104.4	4635	4115	2902	1213	2899	587	629	1216
IV	124	44.9	691	624	31.6	15.9	15.7	145.3	5753	5067	3219	1848	3340	558	1169	1727
V	138	55.2	789	724	36.6	19.3	17.3	181.7	6849	5911	3718	2193	3741	614	1556	2170
VI	152	63.4	854	788	40.4	20.1	20.4	269.7	7887	7036	4042	2994	3788	726	2522	3248
VII	166	73.8	914	816	43.5	23.7	19.9	336.5	9054	8034	4217	3817	3957	708	3369	4077
VIII	180	85.3	1017	856	46.5	25.8	20.8	380.8	10009	8959	4493	4466	4338	740	3881	4621
Svin (Pig) nr. 5																
I	80	20.8	418	391	18.1	7.2	11.0	46.2	3139	2683	2003	680	2162	391	130	521
II	94	26.6	534	520	22.9	9.6	13.3	55.3	3886	3290	2637	653	2668	474	148	622
III	108	31.9	577	535	26.9	12.6	14.3	103.4	4635	3988	2743	1245	2773	510	705	1215
IV	136	46.5	702	674	30.2	15.6	14.6	121.5	5753	4903	3426	1477	3466	519	918	1437
V	150	54.6	788	715	36.1	18.4	17.7	186.0	6849	5947	3684	2263	3725	629	1593	2222
VI	164	63.7	823	774	40.3	20.9	19.4	283.4	7887	7025	3950	3075	3604	692	2729	3421
VII	178	73.4	919	834	42.7	21.8	20.9	326.0	9054	7972	4296	3676	4031	744	3197	3941
VIII	190	80.9	1050	1004	43.8	24.7	19.0	332.0	10009	8600	5106	3494	4576	677	3347	4024
Svin (Pig) nr. 6																
I	86	26.8	445	421	19.6	8.3	11.4	42.1	3139	2788	2150	638	2319	405	64	469
II	100	31.6	512	496	24.4	10.0	14.4	76.7	3886	3404	2518	886	2519	514	371	885
III	114	38.4	574	523	28.2	14.3	13.8	115.2	4635	4093	2690	1403	2730	492	871	1363
IV	128	46.3	653	570	31.5	15.3	16.2	180.1	5753	5165	2965	2200	3008	577	1580	2157
V	142	53.5	719	677	37.5	19.5	18.0	243.2	6849	6166	3452	2714	3236	640	2290	2930
VI	156	63.1	790	716	38.8	21.1	17.7	298.5	7887	6972	3686	3286	3356	630	2986	3616
VII	170	73.1	847	789	42.1	24.6	17.5	370.5	9054	7974	4032	3942	3465	623	3886	4509
VIII	184	82.5	976	859	45.1	26.3	18.8	402.3	10009	8915	4454	4461	4018	670	4227	4897

MAIS OG PROTEINBLANDING (MAIZE AND PROTEINMIXTURE) SERIE C.

PER. NO.	AGE DAY	LW kg	CO2 l	O2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Svin (Pig) nr. 10																
I	92	19.7	394	429	20.4	8.1	12.3	21.9	2841	2285	2119	166	2065	439	-219	220
II	106	25.3	459	439	26.9	10.8	16.1	56.9	3704	2974	2233	741	2344	573	57	630
III	120	32.5	522	529	31.0	13.7	17.3	88.1	4432	3630	2652	978	2619	617	394	1011
IV	134	40.5	606	593	34.4	15.9	18.4	111.5	5149	4237	2997	1240	2941	657	639	1296
V	148	47.2	643	590	36.9	18.9	18.0	183.3	6227	5127	3026	2101	2942	640	1545	2185
VI	162	55.8	737	642	42.1	20.1	22.0	252.6	7387	6318	3337	2981	3291	785	2242	3027
VII	176	65.1	794	701	45.3	24.4	20.9	299.2	8112	7051	3628	3423	3442	746	2863	3609
VIII	190	76.6	872	746	47.8	27.0	20.8	353.8	9190	7965	3891	4074	3679	741	3545	4286
Svin (Pig) nr. 11																
I	96	20.3	404	403	20.8	9.5	11.3	20.4	2841	2313	2029	284	2113	402	-202	200
II	110	25.3	447	443	28.0	12.2	15.8	74.7	3704	3062	2232	830	2210	562	290	852
III	124	31.3	524	493	31.9	15.5	16.5	92.9	4432	3698	2513	1185	2624	586	488	1074
IV	138	38.1	594	601	35.0	18.8	16.2	127.5	5149	4332	3009	1323	2829	577	926	1503
V	152	45.9	682	623	36.9	19.9	17.0	162.8	6227	5095	3199	1896	3157	606	1332	1938
VI	166	53.5	758	682	41.7	20.8	20.9	252.0	7387	6403	3516	2887	3378	746	2279	3025
VII	180	62.5	859	814	43.5	24.1	19.4	253.5	8112	6918	4144	2774	3868	691	2359	3050
VIII	194	72.8	892	857	46.1	26.3	19.9	347.1	9190	8051	4346	3705	3843	707	3501	4208
Svin (Pig) nr. 12																
I	91	19.6	405	396	21.3	10.5	10.8	20.0	2841	2334	2002	332	2135	383	-184	199
II	105	24.8	429	436	28.2	13.0	15.1	83.1	3704	3063	2181	882	2104	539	420	959
III	119	31.2	518	505	32.2	16.8	15.4	94.4	4432	3668	2550	1118	2570	547	551	1098
IV	133	37.4	599	615	34.1	18.3	15.8	112.3	5149	4195	3070	1125	2877	561	757	1318
V	147	44.9	662	607	37.3	19.2	18.2	181.9	6227	5187	3114	2073	3018	648	1521	2169
VI	161	52.5	741	663	41.6	21.2	20.4	250.7	7387	6302	3422	2880	3292	727	2283	3010
VII	175	62.1	821	763	44.5	22.7	21.8	278.1	8112	6971	3902	3069	3627	775	2569	3344
VIII	189	71.9	886	843	46.8	26.5	20.3	341.5	9190	7895	4284	3611	3759	723	3413	4136

MAIS OG PROTEINBLANDING (MAIZE AND PROTEINMIXTURE) SERIE E.

Svin (Pig) nr. 10

PER. NO.	AGE DAY	LW kg	CO2 l	O2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
I	89	26.2	451	466	21.6	9.8	11.8	13.2	3106	2578	2329	249	2469	420	-311	109
II	103	31.0	527	529	26.9	11.8	15.0	39.9	3850	3166	2661	505	2736	535	-105	430
III	117	37.2	604	620	31.5	15.0	16.5	66.3	4599	3831	3100	731	3086	589	156	745
IV	131	44.2	685	685	34.8	16.9	17.9	119.1	5710	4796	3446	1350	3404	639	753	1392
V	145	52.1	770	748	38.9	19.4	19.5	166.0	6785	5659	3788	1871	3693	696	1270	1966
VI	159	61.0	813	779	42.5	23.0	19.5	257.5	7831	6735	3954	2781	3636	694	2405	3099
VII	173	70.9	911	805	45.1	24.0	21.1	295.8	8998	7596	4171	3425	4029	752	2815	3567
VIII	187	81.7	963	884	48.0	27.0	21.0	362.8	9953	8491	4534	3957	4094	747	3650	4397

Svin (Pig) nr. 11

PER. NO.	AGE DAY	LW kg	CO2 l	O2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
I	87	20.7	379	363	21.2	9.8	11.4	50.7	3106	2535	1844	691	1960	405	170	575
II	101	25.7	482	468	26.0	12.2	13.8	54.5	3850	3052	2370	682	2437	492	123	615
III	115	28.2	550	517	29.7	15.0	14.7	80.8	4599	3635	2637	998	2702	523	410	933
IV	143	42.9	651	625	33.2	18.1	15.1	122.0	5710	4647	3171	1476	3205	538	904	1442
V	157	51.0	742	667	38.3	20.1	18.3	171.7	6785	5590	3440	2150	3547	650	1393	2043
VI	171	59.8	840	770	40.7	21.6	19.0	225.1	7831	6553	3954	2599	3853	677	2033	2700
VII	185	68.6	882	794	43.5	26.6	16.9	291.7	8998	7390	4090	3300	3855	602	2933	3535
VIII	197	79.9	964	855	46.1	27.4	18.7	341.2	9953	8334	4423	3911	4195	667	3472	4139

Svin (Pig) nr. 12

PER. NO.	AGE DAY	LW kg	CO2 l	O2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
I	93	25.7	430	422	21.6	9.2	12.4	29.9	3106	2592	2134	458	2280	441	-129	312
II	107	31.0	507	520	27.8	11.7	16.1	63.5	3850	3292	2602	690	2580	572	140	712
III	121	38.1	566	562	32.2	14.9	17.3	95.3	4599	3889	2831	1058	2788	616	485	1101
IV	135	44.9	656	647	35.3	17.6	17.7	143.3	5710	4876	3264	1612	3183	629	1064	1693
V	149	52.7	699	655	39.4	21.3	18.1	212.6	6785	5739	3341	2398	3188	645	1906	2551
VI	163	61.5	746	650	42.1	24.4	17.7	296.3	7831	6692	3373	3319	3104	631	2957	3588
VII	177	70.7	851	757	45.5	28.6	16.9	335.8	8998	7719	3907	3812	3637	603	3479	4082
VIII	191	80.3	891	782	48.6	31.4	17.2	416.3	9953	8619	4047	4572	3541	612	4466	5078

MILO OG SKUMMETMÆLK (SORGHUM AND SKIMMILK) SERIE D.

PER. NO.	AGE DAY	LW kg	CO2 l	O2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Svin (Pig) nr. 4																
I	87	22.8	444	-	20.0	8.6	11.4	57.5	3355	2875	-	-	2215	408	252	660
II	101	28.4	524	528	25.5	9.2	16.3	89.9	4195	3632	2657	975	2594	582	456	1038
III	115	36.1	578	544	29.9	12.4	17.5	131.7	4966	4298	2779	1519	2747	623	928	1551
IV	129	44.5	678	612	32.7	14.9	17.8	189.0	6164	5335	3159	2176	3077	633	1625	2258
V	143	52.5	758	706	36.6	16.3	20.3	242.7	7260	6242	3616	2626	3330	722	2190	2912
VI	157	63.2	874	752	42.7	20.2	22.5	284.5	8468	7469	3927	3542	4049	803	2617	3420
VII	171	75.6	957	823	46.2	24.4	21.8	343.3	9634	8405	4295	4110	4254	777	3374	4151
VIII	185	86.3	1031	854	50.7	27.7	23.0	445.5	11001	9674	4499	5175	4262	820	4592	5412
Svin (Pig) nr. 5																
I	89	23.7	395	-	20.6	8.1	12.5	87.8	3355	2911	-	-	1882	446	583	1029
II	103	29.1	520	504	26.8	11.0	15.8	99.1	4195	3716	2556	1160	2561	564	591	1155
III	117	36.0	597	588	30.8	12.4	18.5	125.0	4966	4345	2972	1373	2882	657	806	1463
IV	131	45.2	720	655	36.5	15.5	21.0	164.2	6164	5321	3374	1947	3385	747	1189	1936
V	145	53.5	778	724	37.7	18.0	19.6	241.2	7260	6342	3707	2635	3445	700	2197	2897
VI	159	62.5	921	835	43.7	20.7	23.1	263.9	8468	7451	4303	3148	4289	822	2340	3162
VII	173	74.4	1026	874	46.9	24.1	22.8	301.4	9634	8376	4576	3800	4747	812	2817	3629
VIII	187	84.5	1157	977	50.0	26.3	23.7	378.0	11001	9711	5127	4584	5138	844	3729	4573
Svin (Pig) nr. 6																
I	89	24.4	496	-	20.9	9.8	11.2	33.1	3355	2897	-	-	2539	398	- 40	358
II	103	29.9	527	520	26.8	12.2	14.6	96.1	4195	3724	2625	1099	2601	519	604	1123
III	117	36.0	588	538	31.7	14.2	17.5	135.7	4966	4390	2766	1624	2789	624	977	1601
IV	131	44.7	699	631	35.9	18.1	17.7	186.7	6164	5439	3252	2187	3209	632	1598	2230
V	145	52.4	774	695	39.4	20.3	19.1	252.5	7260	6450	3587	2863	3410	681	2359	3040
VI	159	62.1	859	791	45.1	24.2	20.9	305.1	8468	7501	4054	3447	3819	744	2938	3682
VII	173	72.9	978	812	48.9	28.9	20.1	344.3	9634	8651	4272	4379	4480	714	3457	4171
VIII	187	83.7	Ingen respirationsmålinger (No respiration measurements)													

MILO OG SKUMMETMÆLK (SORGHUM AND SKIMMILK) SERIE F.

PER. NO.	AGE DAY	LW kg	CO2 l	O2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Svin (Pig) nr. 4																
I	108	26.1	424	430	19.2	9.9	9.3	55.1	3185	2718	2157	561	2078	331	309	640
II	122	30.6	518	499	23.3	11.9	11.4	70.5	3915	3382	2534	848	2562	405	415	820
III	136	37.0	580	523	28.2	13.3	15.0	118.6	4704	4112	2699	1413	2712	533	867	1400
IV	150	44.0	670	627	32.2	16.6	15.6	167.4	5790	5077	3204	1873	3075	555	1447	2002
V	164	52.1	721	652	34.0	16.6	17.4	235.5	6841	5972	3362	2610	3136	618	2218	2836
VI	178	61.5	793	678	36.8	19.0	17.8	279.4	7852	6869	3546	3323	3491	634	2744	3378
VII	192	71.3	913	756	39.3	21.4	18.0	313.0	8932	7683	3987	3696	3889	640	3154	3794
VIII	206	81.3	967	802	41.3	22.6	18.7	378.4	9987	8531	4229	4302	3929	665	3937	4602
Svin (Pig) nr. 5																
I	89	25.2	491	496	19.8	9.7	10.1	24.2	3185	2770	2493	277	2516	360	-106	254
II	103	29.7	558	570	23.8	12.2	11.6	53.9	3915	3421	2856	565	2807	414	200	614
III	117	35.9	603	585	28.6	14.4	14.2	106.5	4704	4107	2964	1143	2852	506	749	1255
IV	131	43.8	721	677	31.6	15.9	15.8	136.5	5790	5039	3459	1580	3422	561	1056	1617
V	145	50.8	774	728	35.5	18.1	17.4	216.5	6841	6085	3717	2368	3484	620	1981	2601
VI	159	61.1	845	748	36.3	19.7	16.6	244.4	7852	6761	3878	2883	3810	591	2360	2951
VII	173	70.9	990	853	40.6	23.1	17.5	282.4	8932	7808	4453	3355	4391	625	2792	3417
VIII	187	81.1	1121	956	42.8	25.4	17.4	311.0	9987	8710	5005	3705	4938	621	3151	3772
Svin (Pig) nr. 6																
I	87	22.0	418	404	18.8	8.3	10.5	58.6	3185	2713	2052	661	2036	372	305	677
II	101	26.0	483	468	23.0	10.3	12.7	90.0	3915	3393	2374	1019	2337	454	602	1056
III	115	30.9	539	499	26.9	12.0	15.0	130.8	4704	4008	2559	1449	2457	533	1018	1551
IV	129	36.0	622	581	28.4	12.9	15.5	160.8	5790	4757	2975	1782	2836	553	1368	1921
V	143	42.2	697	662	31.8	15.6	16.2	226.9	6841	5756	3374	2382	3021	575	2160	2735
VI	157	50.3	787	694	35.6	16.5	19.1	279.9	7852	6827	3603	3224	3448	680	2699	3379
VII	171	58.6	900	747	38.1	18.1	20.0	316.0	8932	7636	3942	3694	3815	713	3108	3821
VIII	185	68.6	999	835	40.2	20.4	19.8	363.4	9987	8610	4398	4212	4200	705	3705	4410

MILO OG PROTEINBLANDING (SORGHUM AND PROTEINMIXTURE) SERIE D.

PER. NO.	AGE DAY	LW kg	CO2 l	O2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Svin (Pig) nr. 10																
I	94	23.6	425	-	20.3	9.7	10.6	41.8	3297	2578	-	-	2110	377	91	468
II	108	29.7	517	507	27.5	12.7	14.8	68.8	4138	3340	2562	778	2556	528	256	784
III	122	36.2	586	586	33.6	15.1	18.6	96.4	4910	4014	2947	1067	2906	661	447	1108
IV	136	44.7	673	603	38.3	18.3	20.0	169.8	6118	5134	3113	2021	3123	712	1299	2011
V	150	54.5	757	669	40.1	20.3	19.8	214.0	7164	5953	3466	2487	3394	705	1854	2559
VI	164	65.5	858	750	46.7	25.8	20.9	267.1	8398	7094	3892	3202	3882	746	2466	3212
VII	178	76.9	969	839	50.0	28.0	22.0	301.9	9561	8110	4366	3744	4472	784	2854	3638
VIII	192	89.3	1106	885	53.7	32.1	21.6	372.6	10910	9382	4703	4679	4867	769	3746	4515
Svin (Pig) nr. 11																
I	96	21.3	390	-	21.6	9.6	12.1	69.8	3297	2689	-	-	1881	429	379	808
II	110	27.0	505	491	28.5	13.6	14.9	76.6	4138	3382	2485	897	2503	531	348	879
III	124	33.3	578	560	34.4	16.1	18.3	106.4	4910	4054	2836	1218	2821	653	580	1233
IV	138	41.1	701	670	39.1	18.8	20.4	160.2	6118	5205	3404	1801	3314	726	1165	1891
V	152	49.4	756	650	40.3	17.7	22.6	223.7	7164	6137	3395	2742	3471	807	1859	2666
VI	166	59.1	837	686	47.7	25.0	22.7	291.5	8398	7235	3620	3615	3729	807	2699	3506
VII	180	71.3	969	865	50.9	28.7	22.3	315.7	9561	8277	4466	3811	4469	794	3014	3808
VIII	194	82.0	1059	942	54.4	32.1	22.3	403.8	10910	9446	4867	4579	4547	794	4105	4899
Svin (Pig) nr. 12																
I	96	25.2	454	-	23.2	11.8	11.4	45.1	3297	2802	-	-	2295	406	101	507
II	110	30.4	543	540	29.3	14.6	14.7	65.4	4138	3469	2718	751	2727	523	219	742
III	124	36.5	623	623	34.9	18.0	16.9	86.3	4910	4081	3130	951	3090	604	387	991
IV	138	44.4	715	692	40.0	21.4	18.6	155.5	6118	5234	3502	1732	3394	661	1179	1840
V	152	52.9	786	686	41.1	21.4	19.8	212.5	7164	6135	3564	2571	3594	704	1837	2541
VI	166	60.3	853	720	48.2	28.0	20.2	284.7	8398	7243	3767	3481	3815	720	2713	3433
VII	180	70.9	1002	906	51.3	30.8	20.4	300.2	9561	8265	4661	3604	4640	728	2897	3625
VIII	194	81.9	1055	976	54.9	36.5	18.4	410.5	10910	9420	4987	4433	4421	654	4345	4999

MILO OG PROTEINBLANDING (SORGHUM AND PROTEINMIXTURE) SERIE F.

PER. NO.	AGE DAY	LW kg	CO2 l	O2 l	ND g	NU g	NBAL g	CBAL g	GEI kcal	ME kcal	HP (RQ) kcal	EBAL (RQ) kcal	HP (NC) kcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Svin (Pig) nr. 10																
I	115	26.3	454	496	20.4	9.0	11.5	22.4	3146	2530	2450	80	2305	409	-184	225
II	129	31.3	502	520	24.1	10.2	14.0	47.9	3887	3099	2598	501	2570	498	31	529
III	143	37.1	554	546	28.3	12.1	16.2	87.9	4660	3701	2759	942	2688	577	436	1013
IV	157	44.1	594	588	32.2	14.5	17.7	164.1	5757	4651	2965	1686	2701	629	1321	1950
V	171	51.9	680	693	35.2	15.9	19.3	218.9	6818	5667	3472	2195	3045	686	1936	2622
VI	185	60.0	823	731	36.3	16.9	19.4	214.6	7818	6424	3790	2634	3853	692	1879	2571
VII	199	70.4	900	800	38.5	17.5	21.0	275.9	8895	7313	4148	3165	3993	748	2572	3320
VIII	213	79.2	978	766	42.7	21.4	21.2	338.1	9939	8300	4104	4196	4210	756	3334	4090
Svin (Pig) nr. 11																
I	96	24.5	425	480	20.5	9.1	11.4	36.1	3146	2524	2353	171	2129	405	- 10	395
II	110	29.4	499	511	25.7	10.3	15.4	63.5	3887	3251	2560	691	2536	549	166	715
III	124	36.1	550	547	30.1	12.9	17.2	104.0	4660	3839	2757	1082	2629	612	598	1210
IV	138	42.5	630	614	33.1	15.4	17.7	156.8	5757	4770	3108	1662	2910	630	1230	1860
V	152	51.6	738	676	35.6	16.8	18.8	195.7	6818	5730	3262	2468	3393	669	1668	2337
VI	166	60.8	846	715	38.4	17.9	20.5	217.0	7818	6577	3753	2824	3983	729	1865	2594
VII	180	70.6	899	782	39.9	21.6	18.2	288.0	8895	7441	4071	3370	3957	649	2835	3484
VIII	194	81.0	996	808	42.9	22.5	20.5	343.3	9939	8416	4287	4139	4259	728	3429	4157
Svin (Pig) nr. 12																
I	94	22.2	456	456	20.2	9.8	10.4	14.5	3146	2460	2296	164	2328	371	-239	132
II	108	27.0	471	474	26.7	12.6	14.1	75.5	3887	3205	2380	825	2334	501	370	871
III	122	33.3	534	527	31.0	15.1	16.0	111.7	4660	3836	2656	1180	2526	568	742	1310
IV	136	39.2	623	587	33.3	16.8	16.5	153.7	5757	4687	2993	1694	2859	588	1240	1828
V	150	46.9	721	663	35.1	18.7	16.4	189.8	6818	5558	3189	2369	3282	586	1690	2276
VI	164	55.1	818	693	37.1	19.0	18.2	217.8	7818	6383	3634	2749	3769	648	1966	2614
VII	178	64.4	905	800	40.2	22.9	17.4	277.5	8895	7373	4146	3227	4016	618	2739	3357
VIII	192	73.8	976	810	40.7	22.5	18.2	330.2	9939	8185	4271	3914	4179	648	3358	4006