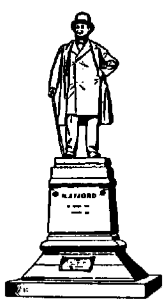
498. Beretning fra Statens Husdyrbrugs forsøg

Grete Thorbek

Studies on Protein and Energy Metabolism in Growing Calves

Studier over protein- og energiomsætningen hos voksende kalve



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Forord

De forsøgsresultater, der offentliggøres med nærværende beretning, har stor interesse for danske husdyrbrugsforskere, men i høj grad også for udenlandske kolleger, hvorfor beretningen publiceres på engelsk. Et tilsvarende arbejde, der omhandler protein- og fedtaflejringen hos voksende svin, er publiceret i 1975 (Grete Thorbek: Studies on Energy Metabolism in Growing Pigs).

Forsøgene med kalve er udført for at øge vort kendskab til omsætningen af protein og energi hos unge voksende dyr, hvorfor resultaterne er af stor betydning, såvel for alle der udfører vækstforsøg med kalve, som for opdrættere.

I beretningen er tillige inkluderet en beskrivelse af den teknik, der benyttes ved anvendelse af afdelingens respirationsanlæg. Disse anlæg, der har været en forudsætning for forsøgenes gennemførelse, er opbygget i årene 1959–63 og 1967–69.

De publicerede forsøg er således resultatet af mange års arbejde, udført af en lang række medarbejdere med tilknytning til den sektion ved afdelingen, som til 30. april 1980 blev ledet af forsøgsleder, dr.h.c. Grete Thorbek.

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CONTENTS

I Introduction

At the National Institute of Animal Science, Copenhagen, an open-air circulation respiration unit for pigs was built and calibrated from 1959 to 1963. After a preliminary investigation concerning techniques applied to balance experiments with pigs a serie of experiments from 1964 to 1966 was carried out with growing pigs fed different feed compounds in order to measure their protein and energy metabolism.

Based on the results obtained with this respiration unit and the techniques applied it was approved to build a similar unit for cattle. The construction took place from 1967 to 1969 with a unit consisting of two independent chambers each capable of housing cattle from 50 to 800 kg live weight, including milking cows. The chambers are 280 × 170 × 200 cm high with a moveable feeding trough of 80 × 57 × 45 cm high and devices for collecting faeces and urine separately. The unit is automatized with monitored air condition and needs very little attention. The unit works in accordance with the open-air circulation principle and is described in detail by Thorbek and Neergaard (1970).

Simultaneously with the construction of the respiration unit the stable was equipped with eight metabolic crates for male calves from 50 to 300 kg live weight. The crates are adjustable to secure a quantitative collection of faeces and urine and they were used in a preliminary experiment to establish a feeding plan (concentrates + hay) securing fast growth with a maximum nitrogen retention.

The first investigation was planned to measure digestibility, metabolizability, gas exchange and heat production together with protein and fat gain in growing calves from 100 to 300 kg live weight fed different diets on different levels. Three experimental series were carried out from 1970 to 1972. The concentrate mixture used in all series was in accordance with the feeding plan established in the preliminary experiment but different sources of roughage normally used in Denmark were applied for each series. The calves were fed alternately on high or low feeding level in order to estimate the maintenance requirement and the efficiency of utilization of metabolizable energy for growth.

II Methods and materials

2.1. Outline of experimental plan

After construction and calibration of an open-air circulation respiration unit for cattle (Thorbek & Neergaard, 1970), 3 experimental series with bull calves were planned in order to measure the protein- and energy metabolism during the growth period from 100–275 kg live weight. Twenty four Holstein-Friesian bull calves were distributed in series F 1970, G 1971 and H 1972 with 8 calves in each series. All calves received the same mixture of concentrates being fed on high or low levels. The roughage supply was clover-grass hay in series F, dried molassed sugar beet pulp + barley straw in series G and clover-grass pellets + barley straw in series H. Within each series 7 or 8 balance periods for each of the 8 calves were carried out as shown in Table 1. Initial mean age and mean live weight of the calves varied from 137–185 days and from 117–173 kg, respectively.

Table 1. Survey of experiments
Tabel 1. Forsøgsoversigt

Ser. no.	Year	Calves no.	Initial age (days)		Initial weight (kg)		Balance periods	
			Mean	SD	Mean	SD	High level of concentrates	Low level of concentrates
F	1970	1–8	185	12	173	7	I–II–III–IV–V	VI–VII–VIII
G	1971	1–8	171	7	160	6	I–III–IV–VI	II–V–VII
H	1972	1–8	137	24	117	13	I–III–V–VII	II–IV–VI–VIII

Each balance period consisted of a 7 days quantitative collection of faeces and urine combined with a 24-hour respiration experiment in the middle of the collection period. The calves in series F were fed constantly on high levels of concentrates for the first 5 balance periods and on low levels for the final periods. The preliminary periods before each period of collection were 7 days in series. F. In series G and H with alternating feeding levels the preliminary periods varied from 2–6 weeks, with the largest intervals when the calves were shifted from a low to a high feeding level.

2.2. Experimental animals

Series F: 8 Holstein-Friesian bull calves were raised with their dams on pasture without supplement until 2 months of age. They were then delivered to the laboratory and started on milk replacer which was substituted, gradually, by concentrates (barley + oats + soybean meal + linseed meal), hay, minerals and vitamins to bring them into the ruminant phase as soon as possible. After 2 months they were treated against parasites with 6 g Thibenzole. The calves were then trained in the respiration chambers and, at an age of about 6 months were placed on experiment.

Series G: 8 Holstein-Friesian bull calves were raised at the farm for a period of 1 month being fed individually with milk replacer, having access to concentrates. They were then delivered to the laboratory and fed for 2 months with milk replacer, concentrates, hay, minerals and vitamins, treated with Thibenzole and trained in the respiration chambers. After 2 months the milk replacer and hay were substituted gradually by dried molassed sugar beet pulp and barley straw, and the experiment was started when the calves were nearly 6 months old.

Series H: 8 Holstein-Friesian bull calves were kept on the farm and fed individually with milk replacer, concentrates and hay until delivery at an age of 2–4 months. At the laboratory the calves were fed for 3 weeks on the same ration as on the farm, and then the milk replacer and hay were substituted gradually by clover-grass pellets and barley straw. The calves were treated with Thibenzole and trained in the respiration chambers. After 6 weeks at the laboratory the experiment started with the calves being 3.5.–5.5. months old.

2.2.1. Journal of animals

Series F: Calf 2, without showing any sign of clinical illness, refused to eat the stipulated amounts of feed in period I, II and V. Consequently no measurement were carried out with this calf in these periods. Calf 5 showed no abnormalities in periods I to V but suddenly died of bloat just prior to period VI. For technical reason no respiration experiment was carried out with calf 7 in period VII.

Series G: No disturbances occured, so all balance periods were carried out as planned.

Series H: Because of feed refusals measurements for calf 3 period III were not used. Calves 1, 3 and 4 showed variable degrees of bloat in period VII on the high feeding level, consequently, these results were not used.

2.2.2. Bloat

In series F on clover-grass hay there was a slight tendency to bloat. However, in series H where the calves received clover-grass pellets as roughage there was a pronounced tendency to bloat. In series G, where the roughage was dried sugar beet pulp no disturbances were observed.

2.3. Feeding plan

2.3.1. Preliminary investigations. Series A and E

In preliminary experiments with growing calves to check the respiration unit, values were obtained on maximum feed intakes and corresponding weight gains at different live weights. The calves were fed a concentrate mixture consisting of barley, oats, linseed meal and soybean meal and a constant amount of hay. No feed residues occured in these experiments, but it was concluded from the time taken to consume the rations that they must have been near an ad lib. level. This was indicated also by the high rate of live weight gain. Nitrogen retention measured during these experiments produced levels indicating that the protein- and energy requirements had been met. Based on these experiments a feeding plan for calves on high level of concentrates in series F, G and H was designed as indicated in Table 2.

Table 2. Feed components applied at different live weight groups for calves on high level of concentrates in series F, G and H

Tabel 2. Foderkomponenter anvendt i de forskellige vægtklasser for kalve på høj kraft-foderblanding i serie F, G og H

Live weight kg	Barley g	Oats g	Linseed-exp. g	Soybean meal g
100	0	1000	250	340
120	350	1000	250	420
140	700	1000	250	500
160	1050	1000	250	600
180	1400	1000	250	700
200	1850	1000	250	700
220	2200	1000	250	700
240	2600	1000	250	650
260	3000	1000	250	600

The feeding plan is characterized by a constant amount of oats, expelled linseed meal and hay with an increasing amount of barley in order to satisfy the energy requirement. The protein requirement was provided by varying the supply of soybean meal.

2.3.2. Series F 1970. Concentrates + clover-grass hay

The calves were kept on a high level of concentrates in balance periods I–V (Table 3) in accordance with the estimated feeding plan (Table 2) with a daily supply of 600 g clover-grass hay. In period VI the intake of barley and oats was reduced to about 65% of maximum intake and in period VII and VIII the feeding was further reduced to about 40% of maximum intake while the intake of linseed meal and soybean meal was kept constant together with a constant intake of roughages.

Table 3. Feeding plan. Series F 1970
Tabel 3. Foderplan. Serie F 1970

Per. no.	Live weight Mean kg	Level of concen-trates	Barley g	Oats g	Soy-bean meal g	Lin-seed exp. g	Clover-grass hay g	$CaCO_3$ g
I	173	High	1400	1000	700	250	600	50
II	189	High	1800	1000	700	250	600	55
III	207	High	2100	1000	700	250	600	60
IV	224	High	2600	1000	670	250	600	65
V	242	High	3100	1000	620	250	600	70
VI	254	Medium	2000	600	600	250	600	50
VII	257	Low	1200	400	600	250	600	45
VIII	261	Low	1200	400	600	250	600	45

Daily supplement: 15 g trace mineral mixture + 5 g Tranox, Super
(5000 i.u A + 500 i.u D_2 + 5 mg tocopherol per g)

2.3.3. Series G 1971. Concentrates + dried sugar beet pulp + straw

The calves were fed with the same mixture of concentrates as in series F consisting of barley, oats, linseed meal and soybean meal at two levels, high or low (Table 4).

Table 4. Feeding plan. Series G 1971
Tabel 4. Foderplan. Serie G 1971

Per. no.	Live weight Mean kg.	Level of concen-trates	Barley g	Oats g	Soy-bean meal g	Lin-seed exp. g	Dried sugar beet pulp g	Barley straw g	$CaCO_3$ g	Na_2HPO_4 g
I	160	High	800	1200	600	400	400	300	25	0
II	158	Low	300	500	250	150	400	300	20	50
III	190	High	1300	1000	700	500	500	400	38	0
IV	229	High	1600	1000	500	500	500	400	40	0
V	232	Low	1000	700	100	100	500	400	35	50
VI	268	High	1700	1400	700	200	500	400	40	0
VII	264	Low	1300	700	100	100	500	400	35	40

Daily supplement: 15 g trace mineral mixture + 5 g Tranox, Super
(5000 i.u A + 500 i.u D_2 + 5 mg tocopherol per g)

The roughage supply consisted of 400 g dried molassed sugar beet pulp and 300 g barley straw in periods I and II. It was then kept constant at 500 g and 400 g, respectively, in the following 5 periods. In the periods in which the low level of concentrates was supplied the rations were calculated to be near the maintenance level, based on the function $ME_m = 106$ kcal $ME/kg^{0.75}$.

2.3.4. Series H 1972. Concentrates + clover-grass pellets + straw

The composition of the concentrate mixture used in this series was the same as that used in series F and G on both the high and low levels as shown in Table 5.

Table 5. Feeding plan. Series H 1972
Tabel 5. Foderplan. Serie H 1972

Per. no.	Live weight Mean kg	Level of concentrates	Barley g	Oats g	Soybean meal g	Linseed exp. g	Clover-grass pellets g	Barley straw g	$CaCO_3$ g	Na_2HPO_4 g
I	117	High	400	700	400	300	400	300	25	20
II	118	Low	300	500	200	100	400	300	25	50
III	154	High	800	1200	600	400	400	300	30	0
IV	155	Low	450	650	200	100	400	300	35	75
V	192	High	1000	800	500	300	400	600	40	30
VI	191	Low	500	400	200	100	400	600	45	90
VII	226	High	1500	1300	500	300	400	600	50	30
VIII	224	Low	700	500	200	100	400	600	50	100

Daily supplement: 15 g trace mineral mixture + 5 g Tranox, Super
(5000 i.u A + 500 i.u D_2 + 5 mg tocopherol per g)

The roughage supply consisted of 400 g clover-grass pellets in all periods plus 300 g barley straw in periods I to IV, increasing to 600 g straw in the following 4 periods. With a tendency to produce bloat the amount of clover-grass pellets was not increased. On the low level of concentrates the feed intake was calculated to be near the maintenance requirement for the different live weight groups.

2.3.5. Supply of minerals, vitamins and water

All feedstuffs were analyzed for calcium and phosphorus before each series and the intake of Ca and P was adjusted in accordance with requirements reference by adding $CaCO_3$ and/or Na_2HPO_4 as indicated in Table 3, 4 and 5. In addition all calves received a daily supply of 15 g of a trace mineral mixture, (Table 6).

Vitamin requirements were met by the daily provision of 5 g Tranox, Super containing 5000 i.u.A + 500 i.u. D_2 + 5 mg tokoferol pr. g. Water intake was given ad lib. and was measured daily by water meters.

Table 6. Composition of trace mineral mixture
Tabel 6. Sammensætning af mikromineralblanding

50.00 %	NaCl
30.00 %	KCl
13.33 %	$MgCO_3$
5.00 %	$FeSO_4$
0.83 %	$MnSO_4$
0.33 %	$CuSO_4$
0.17 %	$CoCl_2$
0.17 %	KJ
0.17 %	ZnO

2.4. Techniques applied in the balance experiments

Each balance experiment consisted of a preliminary period of 1–4 weeks, depending on the feeding level in the foregoing period, followed by a collection period of 7 days, with a 24-hours respiration experiment in the middle of the period.

The different feedstuffs were weighed out individually in paper bags for each balance experiment and aliquote samples were taken for chemical analyses. The animals were fed twice a day at 7 a.m. and 3 p.m.

The animals were kept in metabolic crates. The floor was covered with rubber, with a receptacle below and a box behind for collecting urine and faeces. When standing, the calf was kept in a position to secure a quantitative sampling of urine by means of moveable pipes. The front part with the feeding trough was moveable allowing the crates to be used by calves from 50 to 300 kg live weight.

The faeces and urine were collected at 08.00, 12.00 and 16.00 and stored in closed boxes at 5–7°C. Each morning at 8 a.m. the previous 24-hour faecal and urine output of each calf was mixed and a 20% sample of the faeces and a 5% sample of the urine taken and stored at 5–7°C. A teaspoonful of mercuric iodide was added to the urine sample to prevent bacterial growth. No preservative was added to the faeces.

After 7 days of collection the samples of faeces were mixed carefully after being passed through a mincer. Part of the sample was freeze dried, milled, and used for all the chemical analyses except nitrogen which was carried out on the fresh sample together with a dry matter determination for the recalculation. The bottles containing urine were shaken vigorously and a sample was filtered through glass wool and taken for chemical analyses. The 7 days' collection of faeces and urine was 1 day later than the corresponding feeding period.

2.5. Chemical composition of feedstuffs

Samples of each feedstuff in series F, G and H were analysed for each balance period. The mean values of the chemical components are shown in Table 7.

Table 7. Chemical composition of feedstuffs applied in series F, G and H. Mean values
Tabel 7. Kemisk sammensætning affodermidler anvendt i serie F, G og H. Gennemsnit

Feedstuffs	n	Dry matter %	Crude protein %	Crude fat %	N-free extr. %	Crude fibre %	Ash %	Gross energy kcal/kg
Barley	23	86.6	11.0	2.6	66.4	4.5	2.2	3868
Oats	23	87.1	11.8	5.5	57.1	10.3	2.4	4092
Soybean meal	23	86.7	44.6	2.0	28.3	5.9	5.9	4089
Linseed expeller	23	91.8	32.3	9.5	35.4	9.4	5.3	4563
Clover-grass hay	8	85.1	7.9	2.8	40.9	28.2	5.4	3843
Sugar beet pulp	7	90.0	9.7	1.9	56.8	13.6	7.9	3656
Clover-grass pellets	8	88.4	13.9	4.2	36.7	24.6	9.0	3968
Barley straw	15	89.0	3.7	1.8	37.8	41.7	4.0	4024

All chemical analyses in feedstuffs, faeces and urine were done by the methods described by Weidner & Jakobsen (1962) except for the carbon content which was measured by means of a Wösthoff instrument as described by Neergaard, Petersen & Thorbek (1969). The Stoldt method with HCl-hydrolysis was preferred for crude fat determination. A comparison between the ether-extract method (EE) and the Stoldt method (HCl + EE) (Thorbek & Henckel, 1977) has shown that the (HCl + EE) method gives higher values then the EE method, even for feedstuffs, but that no constant ratio between the two methods could be found.

2.6. Analytical accuracy

In order to estimate the analytical accuracy (repeatability) in the determination of nitrogen, carbon and energy in feed, faeces and urine, the method described by Rasch, Ludvigsen & Thorbek (1958) and discussed by Thorbek (1975) has been applied, using the daily routine work with duplicate analyses to estimate the standard deviation (SD) and the coefficient of variation, CV% (SD × 100/mean value). The results obtained are presented in Table 8.

The determinations of nitrogen, carbon and energy in the feedstuffs are carried out with an accuracy considered to be satisfactory. For nitrogen the CV values were approximately 0.6% except for barley straw with its low nitrogen content. The lower accuracy obtained by the nitrogen determination in faeces (CV about 1.3%) is caused by the heterogeneity of the samples being fresh in order to avoid ammonia loss, which can occur even by freeze-drying. Keeping in mind that the nitrogen loss in faeces constitutes only about 25% of the total intake of nitrogen, the accuracy is considered to be satisfactory for balance experiments and comparable with the accuracy obtained by nitrogen determination in feedstuffs. For carbon and energy the accuracy was high with mean CV of 0.27% and 0.20%, respectively, for both feedstuffs and for faeces, where the determinations were carried out in the freeze-dried and milled samples. With the very low concentration of carbon and energy in urine the CV values are higher than for feedstuffs and faeces. However, the accuracy of the carbon and energy balances will not be appreciable influenced as the carbon and energy losses in urine are no more than 2–3% of the intake.

Table 8. Precision (repeatability) of duplicate analyses in the determination of nitrogen, carbon and energy in feedstuffs, faeces and urine. Series F, G and H
Tabel 8. Analytisk nøjagtighed ved dobbeltbestemmelser af kvælstof, kulstof og energi i fodermidler, gødning og urin. Serie F, G og H

Materials	Series	Nitrogen		Carbon		Energy	
		Dupl. anal.	CV	Dupl. anal.	CV	Dupl. anal.	CV
	no.	n	(%)	n	(%)	n	(%)
Barley	F–G–H	23	0.72	21	0.32	26	0.22
Oats	F–G–H	22	0.71	17	0.21	25	0.22
Soybean meal	F–G–H	22	0.66	25	0.26	28	0.17
Linseed expeller	F–G–H	22	0.63	21	0.25	28	0.18
Clover-grass hay	F	10	0.73	9	0.29	11	0.15
Sugar beet pulp	G	6	0.56	7	0.39	8	0.16
Clover-grass pellets	H	9	0.62	7	0.18	7	0.22
Barley straw	G–H	13	1.56	15	0.23	16	0.24
Faeces	F	61	1.14	52	0.30	59	0.20
Faeces	G	56	1.35	48	0.22	55	0.21
Faeces	H	65	1.52	55	0.27	63	0.26
Urine	F	60	0.98	54	1.58	61	0.57
Urine	G	56	0.89	53	1.04	56	0.80
Urine	H	64	1.17	69	1.51	65	0.97

2.7. Techniques applied in the respiration experiments

The gas exchange of the calves was measured over a 24-hour period by means of an open-air circulation respiration unit with two chambers (A and B, 10 m^3 each) as described by Thorbek & Neergaard (1970). The heat production, HE(CN), was calculated by means of the carbon- and nitrogen balances measured over a 7-days period of collections with the respiration experiment placed in the middle of the period. The accepted set of constants and factors proposed by Brouwer (1965) have been used for all calculations.

The air volume was determined with a Barton cell measuring the differential pressure over an orifice (Hartmann & Braun, Frankfurt). The meter body works within a differential pressure of 500 mm WG corresponding to a flow from 0–20 m^3/h, transmitting a mA signal proportional to the flow, together with signals for temperature and pressure to an analogue computer, where the signals are partly transformed into a continous registration and partly integrated to indicate on a counter the volume of air at STP conditions (0°Cand760 mm). Most of the experiments in the present investigation have been carried out with an airflow of 4–6 m^3/h. The gas meters have been operating with an accuracy below 0.5%.

Aliquote samples of the outgoing air are collected in 4 litres cylindric glas, 233® containers which are then used for determining the composition of the air. Both CO_2 and CH_4 are measured by the infrared principle, using Uras instruments (Hartmann & Braun, Frankfurt), working in the range from 0–1.5% and 0–0.02%, respectively. For 0_2-determination a Magnos paramagnetic instrument, working in the range from 19.0–21.0% was used. In the first two series, F and G, we were not able to obtain the same accuracy below 0.5% in the O_2-determinations as for the CO_2-measurements. For that reason the O_2-measurements are not included in the present investigation.

Calibration of the respiration unit was carried out frequently by means of carbon dioxide as described by Thorbek (1969a). During the experimental time 30 calibrations were carried out with chamber A and 26 with chamber B and the results are shown in Tables 9 and 10.

The mean difference between in- and outgoing CO_2 was 0.68 ±1.25 litres for chamber A and 0.78 ±1.73 litres for chamber B. A t-test showed that there was no systematic error connected with the measurements from the two chambers:

Chamber A: Difference 0.68 ±1.25 l, $t_D = 0.54 < t_{.05} = 2.05$, n = 30
Chamber B: Difference 0.78 ±1.73 l, $t_D = 0.45 < t_{.05} = 2.06$, n = 26

The analytical accuracy (repeatability) obtained in the CO_2-determinations by means of the Uras instrument is evaluated according to the same principle as described for the chemical analyses (Rasch et al., 1958). Using the duplicate CO_2-analyses in series G and H the following results were found.

Series G: Mean: 0.761% CO_2, SD = 0.0040, CV = 0.53%, n = 107
Series H: Mean: 0.665% CO_2, SD = 0.0022, CV = 0.33%, n = 128

The accuracy of the Uras instrument is considered to be high and in accordance with the accuracy obtained for the carbon analyses in the feedstuffs (cf. Table 8) realizing that the loss of carbon through CO_2 is about 50% of the carbon intake.

Table 9. Calibration experiments with CO_2. Cattle chamber A
Tabel 9. Kalibreringsforsøg med kulsyre. Kvægkammer A

Series no.	Date	CO_2 exp. no.	Registration of CO_2 (in) litres	Registration of CO_2 (out) litres	Difference between registration of CO_2 litres	Difference between registration of CO_2 %
F	06.02.70	4	189.1	188.1	+ 1.0	+ 0.5
F	19.02.70	5	322.9	329.1	− 6.2	− 1.9
F	06.03.70	6	459.8	466.8	− 7.0	− 1.5
F	02.06.70	9	1138.8	1142.7	− 3.9	− 0.3
G	22.10.70	10	248.2	244.3	+ 3.9	+ 1.6
G	06.11.70	11	270.9	269.2	+ 1.7	+ 0.6
G	12.11.70	12	393.8	394.0	− 0.2	− 0.1
G	05.01.71	14	325.1	322.6	+ 2.5	+ 0.8
G	11.01.71	15	282.4	284.5	− 2.1	− 0.7
G	12.01.71	16	453.3	453.7	− 0.4	− 0.1
G	14.01.71	17	480.9	479.6	+ 1.3	+ 0.3
G	18.01.71	18	488.0	480.8	+ 7.2	+ 1.5
G	04.03.71	20	552.5	549.0	+ 3.5	+ 0.6
G	30.03.71	21	394.0	401.8	− 7.8	− 2.0
G	01.04.71	22	433.9	445.6	−11.7	− 2.7
G	26.05.71	23	607.3	609.3	− 2.0	− 0.3
G	27.05.71	24	538.4	538.2	+ 0.2	0.0
G	15.06.71	25	581.5	580.9	+ 0.6	+ 0.1
G	18.06.71	26	591.5	568.4	+23.1	+ 3.9
H	11.11.71	29	677.2	677.4	− 0.2	0.0
H	29.11.71	30	817.4	811.5	+ 5.9	+ 0.7
H	30.11.71	31	834.2	846.9	−12.7	− 1.5
H	01.12.71	32	845.1	839.0	+ 6.1	+ 0.7
H	03.01.72	34	781.9	776.3	+ 5.6	+ 0.7
H	04.01.72	35	922.7	915.6	+ 7.1	+ 0.8
H	14.02.72	36	645.2	646.8	− 1.6	− 0.3
H	15.02.72	37	807.9	810.8	− 2.9	− 0.4
H	21.02.72	38	701.7	704.1	− 2.4	− 0.3
H	02.03.72	39	537.5	527.8	+ 9.7	+ 1.8
H	03.03.72	40	609.5	607.3	+ 2.2	+ 0.4

Table 10. Calibration experiments with CO_2. Cattle chamber B
Tabel 10. Kalibreringsforsøg med kulsyre. Kvægkammer B

Series no.	Date	CO_2 exp. no.	Registration of CO_2 (in) litres	Registration of CO_2 (out) litres	Difference between registration of CO_2 litres	Difference between registration of CO_2 %
F	27.02.70	1	219.1	229.1	-10.0	- 4.6
F	07.03.70	2	366.0	364.6	+ 1.4	+ 0.4
F	17.06.70	5	490.8	480.7	+10.1	+ 2.1
F	18.06.70	6	584.6	584.1	+ 0.5	+ 0.1
F	19.06.70	7	486.0	479.4	+ 6.6	+ 1.4
G	21.10.70	12	257.6	271.0	-13.4	- 5.2
G	06.01.71	13	326.1	329.3	- 3.2	- 1.0
G	07.01.71	14	293.3	306.0	-12.7	- 4.3
G	20.01.71	15	450.7	460.0	- 9.3	- 2.1
G	03.03.71	16	487.6	482.6	+ 5.0	+ 1.0
G	02.04.71	17	516.6	514.8	+ 1.8	+ 0.3
G	24.05.71	18	600.0	582.5	+17.5	+ 2.9
G	25.05.71	19	606.8	586.8	+20.0	+ 3.3
H	11.11.71	22	689.3	684.8	+ 4.5	+ 0.7
H	29.11.71	23	837.8	826.0	+11.8	+ 1.4
H	30.11.71	24	808.6	814.6	- 6.0	- 0.7
H	01.12.71	25	751.1	745.8	+ 5.3	+ 0.7
H	03.01.72	27	742.4	746.4	- 4.0	- 0.5
H	04.01.72	28	760.4	770.4	-10.0	- 1.3
H	14.02.72	29	687.0	682.1	+ 4.9	+ 0.7
H	15.02.72	30	753.7	750.9	+ 2.8	+ 0.4
H	21.02.72	31	829.6	831.3	- 1.7	- 0.2
H	02.03.72	32	600.5	597.8	+ 2.7	+ 0.5
H	03.03.72	33	595.6	605.7	-10.1	- 1.7
H	28.03.72	34	516.5	518.2	- 1.7	- 0.3
H	29.03.72	35	498.3	490.7	+ 7.6	+ 1.5

III Intake of energy and protein

All individual measurements (n = 173) of the calves through the experimental periods are tabulated in the appendix with two sets of main tables. The first set (p. 85) includes age, live weight, intake and digested amounts of nutrients together with gross energy and digested energy. The second set (p. 95) includes CO_2 and CH_4 production, nitrogen balances, metabolizable energy, heat expenditure, protein-fat gain and total energy gain.

3.1. Series F. Concentrates + clover-grass hay

The calves were fed on concentrates and clover-grass hay according to the feeding plan (cf. Table 3, p. 11). They were kept continously on high feeding levels for 10 weeks and measured in 5 balance periods followed by 6 weeks on low levels and measured in 3 periods as shown in Table 11. A total of 57 individual measurements were made.

Table 11. Age, live weight, daily intake of energy and protein. Series F. Concentrates + clover-grass hay
Tabel 11. Alder, legemsvægt, daglig optagelse af energi og protein. Serie F. Kraftfoderblanding + kløvergræs hø

Period no.	Level of conc.	n	Age days	Live weight (kg) Mean	SE	Gross energy Mcal	Metab. energy Mcal	Crude protein intake g	dig. g	Dig. prot. in rel. to ME g/Mcal
I	H	7	185	173	2.6	15.46	9.93	692	533	54
II	H	7	199	189	2.8	17.18	11.31	756	589	52
III	H	8	213	207	2.6	18.53	12.26	801	621	51
IV	H	8	227	224	2.5	20.39	13.59	803	625	46
V	H	7	241	242	2.8	22.21	15.38	818	655	43
VI	M	7	256	254	3.0	15.99	10.45	617	494	47
VII	L	6	270	257	3.7	12.21	7.78	503	416	53
VIII	L	7	284	261	3.7	12.30	7.71	518	419	54

The mean daily intake of gross energy (GE) incerased from 15.5 Mcal in period I to 22.2 Mcal in period V while the metabolizable energy (ME) increased from 9.9 Mcal to 15.4 Mcal. At the same time the intake of crude protein increased from 692 to 818 g with an average apparent digestibility of 78%. The amount of digested crude protein in relation to metabolizable energy decreased from 54 to 43 g dig. protein/Mcal ME.

In period VI the intake of barley and oats was reduced to 65% with a further reduction in period VII and VIII to 40%. Intake of GE was reduced to 16 Mcal and 12.3 Mcal, respectively. With no reduction in the supply of soybean meal and linseed meal, the amount of digested protein in relation to ME increased from 47 to 54 g and the mean apparent digestibility of crude protein increased from 78% to 82%.

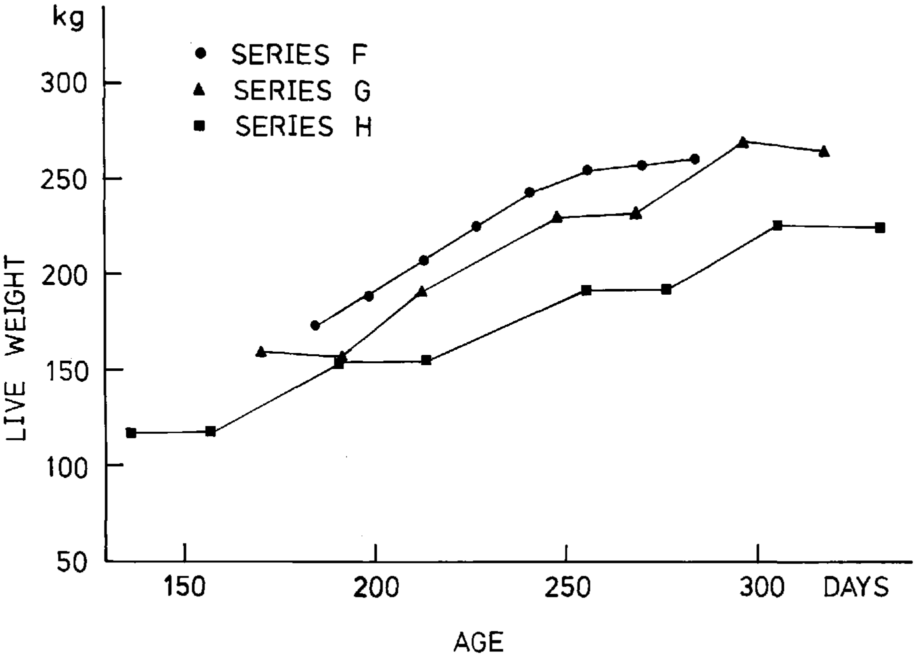

Figure 1
Live weight in relation to age in the respective balance periods (mean values).
Legemsvægt i relation til alder i de respektive balanceperioder (middelværdier).

The mean live weight of the calves through the 8 balance periods is demonstrated in Fig. 1. In period I to V on high level of grain mixture the mean live weight gain was 1250 g daily. A live weight gain of 4 kg or 286 g daily from period VII to VIII, where the calves were planned to be on maintenance level, indicates that the energy intake of 120 kcal ME/kg$^{0.75}$ must have been slightly above the energy requirement for maintenance.

3.2. Series G. Concentrates + dried sugar beet pulp + straw

The calves in series G received the same mixture of concentrates as the calves in series F but the roughage supply in series G consisted of dried molassed sugar beet pulp and barley straw. (cf. Table 4, p. 11). The calves were on a high feeding level in periods I, III, IV and VI, while a calculated maintenance level was provided in periods II, V and VII as demonstrated in Fig. 1. The mean intake of gross energy, metabolizable energy and protein in 7 periods with 56 individual measurements is shown in Table 12.

Table 12. Age, live weight, daily intake of energy and protein. Series G. Concentrates + dried sugar beet pulp + straw
Tabel 12. Alder, legemsvægt, daglig optagelse af energi og protein. Serie G. Kraftfoderblanding + Kosetter + halm

Period no.	Level of conc.	n	Age days	Live weight (kg) Mean	SE	Gross energy Mcal	Metab. energy Mcal	Crude protein intake g	dig. g	Dig. prot. in rel. to ME g/Mcal
I	H	8	171	160	2.2	15.04	9.71	684	542	56
II	L	8	192	158	2.6	7.57	4.48	306	226	50
III	H	8	213	190	1.9	17.68	11.31	812	643	57
IV	H	8	248	229	2.4	17.93	11.62	791	612	53
V	L	8	269	232	2.3	10.98	6.72	365	261	39
VI	H	8	297	268	2.1	19.71	12.80	855	671	52
VII	L	8	318	264	2.2	12.19	7.37	398	279	38

The apparent digestibility of crude protein on the high level of concentrates of about 79%, decreased to 72% on the low level as a result of the greater reduction of oil cakes than of grains combined with the constant intake of roughages. The calves were measured on high and low feeding levels in the 3 live weight classes of about 160, 230 and 265 kg. The intake of metabolizable energy at low levels was measured to be 101, 113 and 113 kcal ME/kg$^{0.75}$, respectively, for the weight groups in question. With a nearly constant live weight for each group the intake of metabolizable energy must have been near the maintenance requirement.

3.3. Series H. Concentrates + clover-grass pellets + straw

The calves in series H were fed the same mixture of concentrates as in series F and G (cf. Table 5, p. 12) but with clover-grass pellets and barley straw as roughage. The calves were kept on consecutive high or low levels as shown in Table 13 for a total of 60 individual measurements.

It was planned that the calves should be measured at a constant live weight on high and low feeding levels. By using long preliminary periods (4–6 weeks) when the calves shifted from the low to the high level this was obtained as demonstrated in Fig. 1. The calves were thereby measured at mean live weight of 118, 154, 191 and 225 kg with an intake of metabolizable energy on the low feeding level of 113, 108, 95 and 95 kcal ME/kg$^{0.75}$, respectively.

The apparent digestibility of crude protein on the high feeding level was about 76%, decreasing to 73% on the low level caused, as in series G, by the comparatively greater reduction of oil seed meals than of grains

Table 13. Age, live weight, daily intake of energy and protein. Series H. Concentrates + clover-grass pellets + straw

Tabel 13. Alder, legemsvægt, daglig optagelse af energi og protein. Serie H. Kraftfoderblanding + kløver-græs piller + halm

Period no.	Level of conc.	n	Age days	Live weight (kg) Mean	SE	Gross energy Mcal	Metab. energy Mcal	Crude protein intake g	dig. g	Dig. prot. in rel. to ME g/Mcal
I	H	8	137	117	4.6	10.12	5.81	538	421	72
II	L	8	158	118	5.4	7.20	3.99	275	198	50
III	H	7	191	154	5.1	15.13	9.33	736	582	62
IV	L	8	214	154	4.4	8.49	4.73	313	223	47
V	H	8	256	191	4.5	14.55	8.56	598	446	52
VI	L	8	277	191	4.1	8.85	4.84	445	356	74
VII	H	5	306	226	4.1	18.47	11.06	705	511	46
VIII	L	8	333	224	4.1	9.99	5.51	321	226	41

IV Gas exchange

All individual measurements of CO_2 and CH_4 production are tabulated in the appendix. O_2 consumption was measured, but caused by temporary technical difficulties in series F in obtaining the same accuracy in the O_2 determinations as for CO_2 and CH_4 the values are not tabulated.

4.1. CO_2 and CH_4 production in series F, G and H

Mean values of CO_2 and CH_4 production for each period in series F, G and H are shown in Table 14, 15 and 16, respectively, together with mean values of live weight and intake of organic matter being the pronounced determinants for the CO_2 production.

Table 14. CO_2- and CH_4-production in relation to live weight and intake of organic matter. Series F. Concentrates + clover-grass hay

Tabel 14. CO_2- og CH_4produktion i relation til legemsvægt og optagelse af organisk stof. Serie F. Kraftfoderblanding + kløver-græs hø

Period	Level of conc.		Live weight (kg)		Organic matter	CO_2 prod. (litres)		CH_4 prod. (litres)	
no.		n	Mean	SE	kg	Mean	SE	Mean	SE
I	H	7	173	2.6	3.21	1611	21.5	108	14.0
II	H	7	189	2.8	3.59	1821	32.9	101	11.3
III	H	8	207	2.6	3.86	1957	34.3	104	15.9
IV	H	8	224	2.5	4.26	2125	23.7	114	15.6
V	H	7	242	2.8	4.65	2350	28.0	126	24.2
VII	L	6	257	3.7	2.52	1552	21.2	138	2.4
VIII	L	7	261	3.7	2.56	1547	20.8	147	3.4

For CO_2 production the coefficient of variation (CV = SD/mean value) varied from 2.6% to 5.0% for all series indicating a relatively small variation between calves independent of whether the calves were fed on high or low feeding levels. For CH_4 production a much higher variation between calves was found. On high feeding level CV varied from 11% to 51% being reduced to 4–10% for calves on low feeding level.

Table 15. CO_2- and CH_4-production in relation to live weight and intake of organic matter. Series G. Concentrates + dried sugar beet pulp + straw

Tabel 15. CO_2- og CH_4produktion i relation til legemsvægt og optagelse af organisk stof. Serie G. Kraftfoderblanding + Kosetter + halm

Period no.	Level of conc.	n	Live weight (kg) Mean	SE	Organic matter kg	CO_2 prod. (litres) Mean	SE	CH_4 prod. (litres) Mean	SE
I	H	8	160	2.2	3.12	1519	19.4	65	3.5
III	H	8	190	1.9	3.69	1815	28.3	75	6.0
IV	H	8	229	2.4	3.75	1872	17.7	91	5.0
VI	H	8	268	2.1	4.13	2077	36.4	108	9.2
II	L	8	158	2.6	1.59	981	11.7	71	1.1
V	L	8	232	2.3	2.34	1368	12.4	116	4.2
VII	L	8	264	2.2	2.62	1537	16.3	127	3.2

The CO_2 production at 150 kg live weight was about 1500 litres for all series on high feeding level compared with 1000 litres on low feeding level. At 250 kg live weight the CO_2 production on high level varied from 2000 to 2400 litres in relation to the intake of organic matter. On low feeding level the CO_2 production was about 1500 litres at a live weight of 250 kg.

Table 16. CO_2- and CH_4-production in relation to live weight and intake of organic matter. Series H. Concentrates + clover-grass pellets + straw

Tabel 16. CO_2- og CH_4produktion i relation til legemsvægt og optagelse af organisk stof. Serie H. Kraftfoderblanding + kløver-græs piller + halm

Period no.	Level of conc.	n	Live weight (kg) Mean	SE	Organic matter kg	CO_2 prod. (litres) Mean	SE	CH_4 prod. (litres) Mean	SE
I	H	8	117	4.6	2.08	959	12.7	76	3.9
III	H	7	154	5.1	3.11	1425	17.4	52	10.6
V	H	8	191	4.5	3.03	1451	17.7	110	5.0
VII	H	5	226	4.1	3.88	1795	28.6	140	7.2
II	L	8	118	5.4	1.48	750	10.6	60	1.8
IV	L	8	154	4.4	1.76	1010	16.6	72	1.8
VI	L	8	191	4.1	1.85	1040	9.9	78	1.4
VIII	L	8	224	4.1	2.09	1176	14.1	88	1.8

CH_4 production ranged from 50 to 150 litres dependent on live weight, feeding level and source of reoughages. The CH_4 production in relation to CO_2 production was 5.7 and 9.2% in series F on high or low feeding levels, respectively. In series G, the corresponding values were 4.6 and 8.0%, while no difference between levels was found in series H where the CH_4 production was about 7.6% of the CO_2 production.

4.2. Prediction of CO_2 production in growing calves

In the present investigation a linear relationship between CO_2 production and metabolic live weight was indicated for the different series. By using all individual measurements, regressions of CO_2 production on metabolic live weight have been calculated for all calves on the high feeding level (n = 97) and on the low level (n = 76) with the following results:

(1) *High level:*		CO_2, litres	$= -237 + 37.9\ W,kg^{0.75}$
		s_I and s_b	$=$ 116 2.19
	RSD = ±178	(CV = 10.2%)	($r^2 = 0.759$) (n= 97)
(2) *Low level:*		CO_2, litres	$= -300 + 28.6\ W,kg^{0.75}$
		s_I and s_b	$=$ 81 1.46
	RSD = ±131	(CV = 10.4%)	($r^2 = 0.838$) (n = 76)

The difference between the two equations was highly significant ($P<0.001$), but with high RSD for both equations (CV about 10%), the use of the equations is problematic.

The CO_2 production is strongly influenced by the intake of organic matter and for that reason a new set of regressions of this relationship was calculated as:

(3) *High level:*		CO_2, litres	$= -180 + 0.54$ IOM, g
		s_I and s_b	$=$ 46 0.013
	RSD = ±81	(CV = 4.6%)	($r^2 = 0.950$) (n = 97)
(4) *Low level:*		CO_2, litres	$= -7.8 + 0.58$ IOM, g
		s_I and s_b	$=$ 37.6 0.017
	RSD = ±78	(CV = 6.2%)	($r^2 = 0.942$) (n = 76)

Compared with the first set of equations (1) and (2), the values for r^2 have increased considerably and the standard deviation of residual (RSD) is now 4.6% and 6.2% on high or low level, respectively, being acceptable. The difference between the two equations was highly significant ($P<0.001$).

Finally a regression on both metabolic live weight and intake of organic matter (IOM) have been calculated with the following resulta:

(5) *High level:*	CO_2, litres	=	$-202 + 1.82\ W,kg^{0.75} + 0.52\ IOM,g$
	s_I and s_b	=	53 2.14 0.027
RSD = ±81	(CV = 4.6%)		(r^2 = 0.951) (n = 97)
(6) *Low level:*	CO_2, litres	=	$-191 + 9.78\ W,kg^{0.75} + 0.42\ IOM,g$
	s_I and s_b	=	37 1.27 0.024
RSD = ±58	(CV = 4.6%)		(r^2 = 0.968) (n = 76)

By including metabolic live weight and organic matter in the regressions the equation for calves on the high feeding level was not improved but the equation for calves on low level, being near maintenance level, was slightly improved. The standard deviation of residuals decreased to 4.6% and r^2 increased to 0.968.

4.3. Discussion

Comparing the results obtained in measuring the CO_2 production and CH_4 production it is obvious that the variation between animals concerning their CH_4 production is much greater than for CO_2 production, confirming the results of Schiemann, Jentsch, Wittenburg and Hoffmann (1976). The CO_2 production depends mainly on the maintenance metabolism of the animals and their intake of feed, while the CH_4 production is strongly influenced by the fermentative processes in the rumen depending on the type of concentrates and roughages applied. This indicates that a greater variation for CH_4 production than for CO_2 production as found must be expected.

No significant differences in CO_2 production in relation to metabolic live weight were found between series F, G and H compared on the same levels of feed intake. By pooling the individual measurements and by regression of CO_2 production on metabolic live weight two equations (1) and (2) were obtained for the two feeding levels, but with CV-values of about 10% the use of the equations is problematic.

Regression of CO_2 production on intake of organic matter (IOM) improved the equation considerably (3) and (4). With CV = 4.6% and 6.2% on high or low level, respectively, the accuracy was now comparable to the one obtained in experiment with pigs (Thorbek, 1975). By including both metabolic live weight and intake of organic matter the equation on low feeding level (6) was further improved (CV = 4.6%). On high level no improvement was found and the regression coefficient for metabolic live weight was not significant.

The equations found indicate that for calves on high feeding level (near ad lib. feeding) the intake of organic matter can be used to predict the CO_2 production while on low feeding level (near maintenance level) metabolic live weight should be included in the equation.

By using all data concerning CH_4 production and live weight from calves on the low feeding level, where the coefficients of variation were between 4 and 10%, and plotting CH_4 production on live weight a linearity was indicated and the CH_4 production was found to be about 70 litres at 150 kg live weight increasing to about 120 litres at 250 kg live weight. A regression gave CH_4, litres = 0.49 W, kg but with CV = 18.4% and $r^2 = 0.746$ the use of the equation is problematic.

Caused by the great variation in CH_4 production between calves fed on the high feeding level no reliable regression of CH_4 production on live weight could be established ($r^2 = 0.19$). Nevertheless, plotting the data in the 3 series against live weight it can be demonstrated that CH_4 production was lowest in series G where the roughage consisted of dried sugar beet pulp + straw. The CH_4 production at a live weight of about 190 kg was in series G 75 litres compared with a production of 101 and 110 litres in series F and H, respectively, and the differences were highly significant.

4.4. Conclusions

1. Three experiments, each with eight growing bull calves (Holstein-Friesian) were made in which the same concentrate mixture was given on high feeding level or low level near maintenance. Three different sources of roughage were applied: clover-grass hay (Ser. F), dried molassed sugar beet pulp + barley straw (Ser. G) or clover-grass pellets + barley straw (Ser. H). Seven to eight balance periods, each consisting of 7 days' collection of faeces and urine with a 24 hours measurement of the gas exchange in the middle, were performed with each calf.
2. At 150 kg live weight the CO_2 production was about 1000 litres on maintenance level and 1500 litres on high feeding level. At 250 kg the respective values were 1500 litres and 2200 litres. The coefficients of variation were rather low, with CV-values between 2.6% and 5.0%.
3. The CH_4 production varied from 50 to 150 litres with great variation between animals. On high feeding level the coefficients of variation (CV) were between 11 and 51%, being reduced to 4–10% on low feeding level.
4. Om high feeding level the best fitting regression equations for prediction of CO_2 production was CO_2, litres = –180 + 0.54 IOM, g, based on intake of organic matter (IOM), while on feeding level near maintenance the metabolic live weight should be included in the equation as: CO_2, litres = –191 + 0.42 IOM, g + 9.78 W, $kg^{0.75}$.

V Metabolizable energy

All individual figures concerning measurements of gross energy (GE), digested energy (DE) and metabolizable energy (ME) are given in the appendix, togegher with figures for CH_4 production. The energy content in faeces (FE) has been determined individually but the figures are not tabulated, however, they can be calculated from the main tables according to FE = GE – DE. The energy losses in urine (UE) determined individually but not tabulated can be calculated from the main tables as: UE = DE – (ME + ECH_4). The energy loss (kcal) in CH_4 (ECH_4) is calculated from 9.45 × litres CH_4.

5.1. Energy losses in faeces, urine and methane

Mean values of energy losses in faeces, urine and methane in relation to GE for each period in series F, G and H are shown i Table 17, 18 and 19.

Table 17. Metabolizable energy (ME) and energy losses in faeces (FE), urine (UE) and methane (ECH_4) in relation to gross energy (GE). Series F. Concentrates + clover grass hay
Tabel 17. Omsættelig energi (ME) og energitab i gødning (FE), urin (UE) og metan (ECH_4) i relation til bruttoenergi (GE). Serie F. Kraftfoderblanding + kløver-græs hø

Period no.	Level of conc.	n	ME/GE (%) Mean	SE	FE/GE (%) Mean	SE	UE/GE (%) Mean	SE	ECH_4/GE (%) Mean	SE
I	H	7	64.2	1.1	25.1	0.5	4.0	0.1	6.6	0.8
II	H	7	65.8	1.1	24.5	1.0	4.1	0.1	5.6	0.6
III	H	8	66.2	0.8	24.7	0.5	3.8	0.1	5.3	0.8
IV	H	8	66.7	0.8	24.4	0.4	3.6	0.1	5.3	0.7
V	H	7	69.2	1.0	21.6	0.2	3.7	0.1	5.4	1.0
VII	L	6	63.8	0.3	19.7	0.5	5.9	0.2	10.7	0.2
VIII	L	7	62.7	0.2	20.4	0.4	5.7	0.2	11.3	0.3
I+II+III +IV+V	H	37	66.4	0.5	24.1	0.3	3.8	0.1	5.6	0.3
VII+VIII	L	13	63.2	0.2	20.1	0.3	5.8	0.1	11.0	0.2

The energy loss in faeces, being the main part of the loss, was 24.1±0.3% and 20.1±0.3% in series F on high or low feeding levels, respectively, and 30.5±0.4% and 32.4±0.3% in series H. In both series the differences between high or low feeding levels were highly significant. In series G no significant difference was found between levels, the energy loss in faeces being 26.8±0.3% and 26.4±0.3%, respectively.

Table 18. Metabolizable energy (ME) and energy losses in faeces (FE), urine (UE) and methane (ECH_4) in relation to gross energy (GE). Series G. Concentrates + dried sugar beet pulp + straw

Tabel 18. Omsættelig energi (ME) og energitab i gødning (FE), urin (UE) og metan (ECH_4) i relation til bruttoenergi (GE). Serie G. Kraftfoderblanding + Kosetter + halm

Period	Level of		ME/GE (%)		FE/GE (%)		UE/GE (%)		ECH_4/GE (%)	
no.	conc.	n	Mean	SE	Mean	SE	Mean	SE	Mean	SE
I	H	8	64.6	0.3	27.2	0.3	4.1	0.1	4.1	0.2
III	H	8	64.1	0.5	27.9	0.7	4.0	0.1	4.0	0.3
IV	H	8	64.8	0.3	26.3	0.3	4.1	0.1	4.8	0.3
VI	H	8	65.0	0.4	25.9	0.7	3.9	0.1	5.2	0.4
II	L	8	59.2	0.4	27.6	0.3	4.4	0.1	8.8	0.1
V	L	8	61.2	0.4	25.6	0.5	3.3	0.1	9.9	0.4
VII	L	8	60.5	0.6	26.0	0.5	3.7	0.2	9.9	0.2
I+III +IV+VI	H	32	64.6	0.2	26.8	0.3	4.0	0.1	4.5	0.2
II+V+VII	L	24	60.3	0.3	26.4	0.3	3.8	0.1	9.6	0.2

The energy loss in urine was 3.8±0.1% and 5.8±0.1% in series F on high and low levels, respectively, the difference being highly significant. No significant differences were found in series G where the respective energy losses in urine were 4.0±0.1% and 3.8±0.1% or in series H where the respective losses were 4.1±0.1% and 4.2±0.1%.

The energy loss in methane was 5.6±0.3% and 11.0±0.2% in series F on high or low feeding levels and 6.1±0.4% and 8.1±0.1% in series H, respectively, but the differences were not significant. In series G the energy loss in methane was 4.5±0.2% and 9.6±0.2%, respectively, and the difference was highly significant.

Table 19. Metabolizable energy (ME) and energy losses in faeces (FE), urine (UE) and methane (ECH_4) in relation to gross energy (GE). Series H. Concentrates + clover grass pellets + straw

Tabel 19. Omsættelig energi (ME) og energitab i gødning (FE), urin (UE) og metan (ECH_4) i relation til bruttoenergi (GE). Serie H. Kraftfoderblanding + kløver-græs piller + halm

Period no.	Level of conc.	n	ME/GE (%) Mean	SE	FE/GE (%) Mean	SE	UE/GE (%) Mean	SE	ECH_4/GE (%) Mean	SE
I	H	8	57.4	0.6	30.9	0.8	4.7	0.1	7.0	0.4
III	H	7	61.6	0.8	31.3	0.8	4.3	0.2	3.2	0.7
V	H	8	58.8	0.5	30.1	0.7	4.0	0.2	7.1	0.3
VII	H	5	59.9	0.5	29.9	0.8	3.1	0.3	7.2	0.4
II	L	8	55.5	0.5	32.4	0.4	4.2	0.1	7.8	0.2
IV	L	8	55.8	0.8	32.4	0.7	3.8	0.2	8.1	0.2
VI	L	8	54.7	0.3	32.7	0.5	4.3	0.2	8.3	0.1
VIII	L	8	55.2	0.9	31.9	0.8	4.6	0.4	8.3	0.1
I+III +V+VII	H	28	59.3	0.4	30.5	0.4	4.1	0.1	6.1	0.4
II+IV +VI+VIII	L	32	55.3	0.3	32.4	0.3	4.2	0.1	8.1	0.1

5.2. Digestibility of energy (DE/GE) in series F, G and H

The mean values of energy losses in faeces, shown in Tables 17, 18 and 19, indicate differences in digestibility of energy (reciprocal values of FE/GE) depending on the roughage applied. In series F, where the roughage was clover-grass hay, the digestibility of energy was 75.9±0.3% on the high level and 79.9±0.3% on the low feeding level decreasing to 69.5±0.4% and 67.6±0.3%, respectively, in series H where the roughage was clover-grass pellets + straw. With dried sugar beet pulp + straw the digestibility of energy was 73.2±0.3% on the high feeding level and 73.6±0.3% on the low level.

Using pooled data from all 3 series the differences between the series on high and low feeding level, respectively, have been calculated and the results are shown in Table 20. All differences, independent of feeding level, are highly significant with the greatest difference between clover-grass hay (series F) and clover-grass pellets + straw (series H).

Table 20. Digestibility of energy (DE/GE) in rations with clover-grass hay (series F), dried sugar beet pulp (series G) or clover-grass pellets (series H) on high or low feeding levels
Tabel 20. Fordøjelighed af energi (DE/GE) i rationer med kløver-græs hø (serie F), tørret sukkerroe pulp (serie G) eller kløver-græs piller (serie H) på højt eller lavt foderniveau

Level of conc.	DE/GE, %				DE/GE, %				Diff.	t
	Ser. no.	n	Mean	SE	Ser. no.	n	Mean	SE		
High	F	37	75.9	0.3	G	32	73.2	0.3	2.7	6.2***
Low	F	13	79.9	0.3	G	24	73.6	0.3	6.3	13.5***
High	F	37	75.9	0.3	H	28	69.5	0.4	6.4	12.8***
Low	F	13	79.9	0.3	H	32	67.6	0.3	12.3	24.3***
High	G	32	73.2	0.3	H	28	69.5	0.4	3.7	7.8***
Low	G	24	73.6	0.3	H	32	67.6	0.3	6.0	14.2***

5.3. Metabolizability (ME/GE) in series F, G and H

The metabolizability follows the same pattern as the digestibility of energy showing differences between roughages. The curves obtained by plotting mean values of metabolizable energy against gross energy for rations on high feeding level are presented in Fig. 2.

The highest metabolizability, 66.4±0.5% was found in series F with clover-grass hay, and the lowest, 59.3±0.4% in series H where the roughage was clover-grass pellets + straw. In series G, with dried sugar beet pulp, the metabolizability was 64.6±0.2%. Comparisons between the 3 series have been made on both the high and the low feeding level, with the results given in Table 21.

All differences in metabolizability are highly significant, independent of the feeding level.

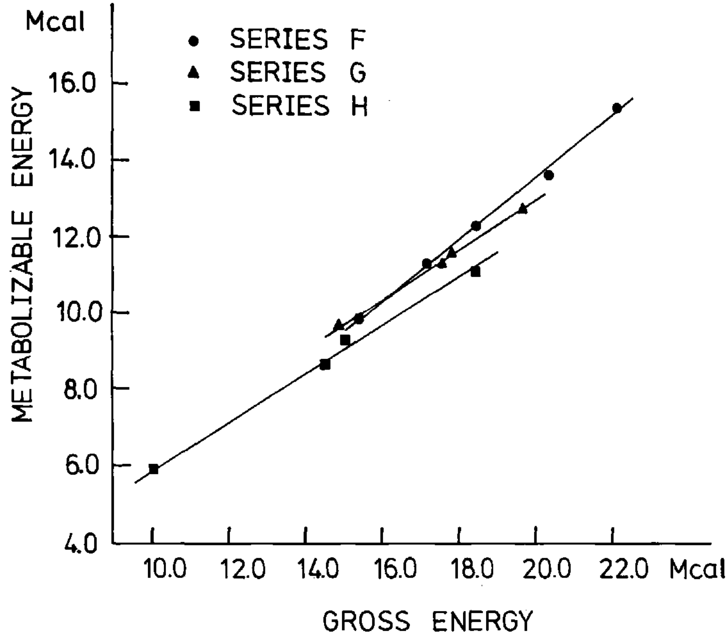

Figure 2
Metabolizable energy in relation to gross energy in series F, G and H on high feeding level (mean values).
Omsættelig energi i relation til brutto energi i serie F, G og H på højt foderniveau (middelværdier).

Table 21. Metabolizability (ME/GE) in rations with clover-grass hay (series F), dried sugar beet pulp (series G) or clover-grass pellets (series H) on high or low feeding levels
Tabel 21. Omsættelighed (ME/GE) i rationer med kløver-græs hø (serie F), tørret sukkerroe pulp (Kosetter) (serie G) eller kløver-græs piller (serie H) på højt eller lavt foderniveau

Level of conc.	ME/GE, %				ME/GE, %				Diff.	t
	Ser. no.	n	Mean	SE	Ser. no.	n	Mean	SE		
High	F	37	66.4	0.5	G	32	64.6	0.2	1.8	3.3**
Low	F	13	63.2	0.2	G	24	60.3	0.3	2.9	6.6***
High	F	37	66.4	0.5	H	28	59.3	0.4	7.1	10.5***
Low	F	13	63.2	0.2	H	32	55.3	0.3	7.9	15.2***
High	G	32	64.6	0.2	H	28	59.3	0.4	5.3	11.7***
Low	G	24	60.3	0.3	H	32	55.3	0.3	5.0	11.1***

5.4. Prediction of ME based on digested nutrients

From work with steers at Oskar-Kellner-Institut, Rostock an equation for prediction of ME in feed compounds for cattle mostly on high feeding level has been established (Schiemann, et al., 1971) as follows:

$$\text{ME, kcal} = (4.17\ x_1 + 7.46\ x_2 + 3.26\ x_3 + 3.53\ x_4) \pm 287\ (\pm 1.5\%)$$

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

In the present investigation with growing calves and with individual measurements of ME and the amount of digested nutrients, the data have been used to calculate similar equations for prediction of ME for feed compounds based on both high and low feeding levels. The following equations were found:

(1) *High level:* $\text{ME, kcal} = 4.04\ x_1 + 10.30\ x_2 - 0.01\ x_3 + 4.16\ x_4$

$s_b = 0.50 \quad 2.40 \quad 0.52 \quad 0.11$

RSD = ±307 (CV = 2.8%) (n = 97)

(2) *Low level:* $\text{ME, kcal} = 2.49\ x_1 + 15.57\ x_2 + 1.79\ x_3 + 3.76\ x_4$

$s_b = 0.36 \quad 1.71 \quad 0.38 \quad 0.09$

RSD = ±165 (CV = 2.6%) (n = 76)

The difference between the two levels of energy intake was highly significant ($F = 15.7$, $P < 0.001$). As digested organic matter is a summation of digested nutrients (crude protein + crude fat + crude fibre + NFE) regressions have been calculated to investigate the possibility of using the amount of digested organic matter for prediction of ME with the following results:

(3) *High level:* $\text{ME, kcal} = 4.07\ \text{DOM, g}$

$s_b = 0.013$

RSD = ±378 (CV = 3.4%) (n = 97)

(4) *Low level:* $\text{ME, kcal} = 3.77\ \text{DOM, g}$

$s_b = 0.011$

RSD = ±162 (CV = 2.6%) (N = 76)

The difference between the two equations was highly significant ($F = 187$, $P < 0.001$).

5.5. Discussion

The energy loss in urine varied in the present study from 3.1% (SE = ±0.31) to 4.7% (±0.07) of GE with calves fed on high feeding level and from 3.3% (±0.07) to 5.9% (±0.20) on maintenance level. Schiemann et al. (1976) found in a study with 56 calves and steers on high feeding level with different composition of the diets that the energy loss in urine varied from 3.0% to 9.0% depending on the intake of protein. A rather constant value of 4% energy loss in urine was found in the present investigation, where the protein intake on high feeding level was planned to be near the animals' requirement for maximal protein retention.

The energy loss in CH_4 in relation to GE was lowest on the high feeding level with variations from 3.2% (SE = ±0.68) to 7.2% (±0.36) being in accordance with results obtained by Schiemann et al. (1976) who found variations from 2.0% to 6.9% in calves fed different diets on high feeding level. In an experiment with steers fed a constant diet on high or medium level a mean energy loss in CH_4 of 4.2% was found on high level and 6.0% on medium level (Webster et al., 1974a). On maintenance level the energy loss in CH_4 varied from 7.8% (±0.25) to 11.3% (±0.26) of GE in our investigation corresponding to the results obtained by Blaxter and Clapperton (1965) in their experiments with sheep and cattle in which a variation from 6.2% to 10.8% was found at maintenance level.

In the present investigation the digestibility of energy varied from 68.7% (SE ±0.83) to 78.4% (±0.23) on high feeding level depending on the sources of roughage and the proportion between concentrates and roughages, which was not kept constant. The digestibility of energy on maintenance level varied from 67.3% (±0.46) to 80.3% (±0.49). As the proportions between concentrates and roughages were not constant on high and low feeding level the results cannot be used to compare digestibility of energi on different feeding levels. However, a comparison can be made between the series, where different sources of roughages have been applied (Table 20). The highest digestibility of energy was found in series F with clover-grass hay and the lowest in series H with clover-grass pellets + straw, and the differences were highly significant for both levels of feeding. In series G with dried sugar beet pulp the values of DE was intermediate, and the differences between F, G and G, H were highly significant on high feeding level as on maintenance level.

The symbols given by ARC (1965) where Q = ME/GE measured at production level and Q_m = ME/GE measured at maintenance level have been used in the following discussion. On high feeding leved Q varied in the present investigation from 57.4% (±0.57) to 69.2% (±0.98) and on maintenance level the variation was from 54.7% (±0.28) to 63.8% (±0.29). As found by Blaxter (1974) and discussed by van Es (1976, 1978), there seems to be a close relationship between Q_m and the proportion between cereal and roughage in the diet with a further influence of the efficiency of utilization of ME for maintenance as for production. The figures from the present investigation where a great variation between concentrates and roughages exists have been used for such an inspection. The proportions between concentrates and roughages for each period in series, F, G and H have been calculated (Tables 4, 5 and 6) and compared with the corresponding values of Q and Q_m (Tables 17, 18 and 19) and the results are shown in Table 22.

Table 22. Metabolizability (Q = ME/GE) in relation to proportion between concentrates (C) and roughages (R)

Tabel 22. Omsættelighed (Q = ME/GE) i relation til forholdet mellem kraftfoder (C) og grovfoder (R)

Series F				Series G				Series H			
Concentrates (C) + clover-grass hay (R)				Concentrates (C) + dried sugar beet pulp + straw (R)				Concentrates (C) + clover-grass pellets + straw (R)			
Per.	C/R	Q, % mean	Q, % SE	Per.	C/R	Q, % mean	Q, % SE	Per.	C/R	Q, % mean	Q, % SE
V	8.3	69.2	0.98	VI	4.4	65.0	0.42	III	4.3	61.6	0.83
IV	7.5	66.7	0.81	I	4.3	64.6	0.32	VII	3.6	59.9	0.54
III	6.8	66.2	0.85	IV	4.0	64.8	0.25	V	2.6	58.8	0.53
II	6.3	65.8	1.13	III	3.9	64.1	0.50	I	2.6	57.4	0.57
I	5.6	64.2	1.10								
				VII	2.4	60.5*	0.56	IV	2.0	55.8*	0.78
VII	4.1	63.8*	0.29	V	2.1	61.2*	0.42	II	1.6	55.5*	0.53
VIII	4.1	62.7*	0.19	II	1.7	59.2*	0.35	VIII	1.5	55.2*	0.88
								VI	1.2	54.7*	0.28

*) Q_m

A close relationship for each series between Q and the proportion between concentrates (C) and roughages (R) was found. In series F, where the roughage was clover-grass hay, the Q-values on high feeding level decreased from 69.2% to 64.2% with C/R values decreasing from 8.3 to 5.6. At maintenance level with C/R = 4.1 a mean Q_m-value of 63.2% (±0.22) was found which corresponds very well with figures given by Blaxter (1974) and Webster et al. (1974b). In series G where the roughage consisted of dried sugar beet pulp + straw the mean value of Q_m was 60.3% (±0.31). The difference between Q_m in series F (63.2%) and G (60.3%) was highly significant (Table 21) but this may be caused more by difference in the proportion of C/R (4.1 in series F and 2.1 in series G) than by different effect of the roughages. On high feeding level the Q-values for the two series corresponds fairly well when compared on the same ratio of C/R, which indicate an equal metabolizability between the two diets used in series F and G.

In series H where the roughage was clover-grass pellets and straw the value of Q_m decreased from 55.8% (±0.78) to 54.7% (±0.28) with a decreasing proportion of C/R from 2.0 to 1.2. The mean Q_m was 55.3% (±0.32) and the difference between this value and the value of 60.3% (±0.31) found in series G on approximately the same proportion of C/R was highly significant (Table 21). Compared on high feeding level at the same C/R values the difference in Q-values between series H and G was highly significant. The lowest metabolizability was obtained in series H with clover-grass pellets and straw, but it is obvious that by comparing Q-values the values of C/R must be considered.

The equation (1) obtained for estimation of ME based on the amount of digested nutrients on high feeding level (RSD = ±307 kcal, CV = 2.8%) corresponds fairly well to the equation given by Schiemann et al. (1971) for adult cattle in which RSD was ±287 kcal (CV = 1.5%). It can be calculated that 60% of the total amount derives from digested NFE and about 20% from digested protein for calves on high feeding level. The regression coefficient of 4.16 for NFE was estimated with an acceptable accuracy (s_b = 0.11) and considering the lower contribution of digested protein to ME the accuracy could also be accepted for the regression coefficient of 4.04 for digested protein (s_b = 0.50). For digested fat and crude fibre the coefficients are not acceptable. A similar calculation for ME on maintenance level gave an equation (2) with the same accuracy (RSD = ±165 kcal, CV = 2.6%) as obtained in the equation for calves on high feeding level, but the regression coefficients are unacceptable from a biological point of view, and the difference between the two equations is highly significant.

The content of ME in a diet could be estimated with an acceptable accuracy by using the amount of digested organic matter as demonstrated in the equations (3) and (4) which is an accordance with the proposal of Blaxter (1974) to use organic matter as a basis.

5.6. Conclusions

1. The energy loss in urine was rather constant about 4% of GE in the present investigation where the protein intake on high level of concentrates was planned to be near the calves' requirement for maximal protein retention.
2. The energy loss in methane varied from 3.2% to 7.2% of GE on high level of concentrates and from 7.8% to 11.3% on maintenance level, depending on the sources of roughage and the proportion between concentrates and roughages.

3. The digestibility of energy varied from 68.7% to 78.4% on high feeding level and from 67.3% to 80.3% on maintenance. The lowest values were found in series H where the roughage applied was clover-grass pellets + straw.
4. A close relationship was found between metabolizability and the proportion between concentrates (C) and roughages (R). Q decreased on high feeding level from 69.2% to 57.4% with C/R decreasing from 8.3 to 2.6. Q_m decreased on maintenance level from 63.8% to 54.7% with C/R decreasing from 4.1 to 1.2. By comparing Q-values from different diets the ratio of C/R must be taken into consideration.
5. No difference was found in metabolizability between series F (clover-grass hay) and series G (dried sugar beet pulp + straw) when compared on the same ratio of C/R.
6. A lower metabolizability was obtained in series H (clover-grass pellets) compared with series F and G.
7. Metabolizable energy in diets for growing calves on high feeding level can be estimated by means of the equation for adult cattle given by Schiemann et al. (1971), based on digested nutrients.
8. A fairly good estimation of ME could be obtained based on digested organic matter (DOM) as: ME, kcal = 4.07 DOM, g on high feeding level or ME, kcal = 3.77 DOM, g on maintenance level.

VI Nitrogen metabolism

Individual figures concerning intake of nitrogen (IN), digested nitrogen (DN), nitrogen excreted in urine (UN) and retained nitrogen (RN) are tabulated in the appendix.

6.1. Nitrogen metabolism in series F. G and H

Mean values of nitrogen intake, digested and retained nitrogen together with mean values of metabolizable energy for each period in series F, G and H are shown in Tables 23, 24 and 25, respectively.

Table 23. Nitrogen metabolism. Series F. Concentrates + clover-grass hay
Tabel 23. Kvælstofomsætning. Serie F. Kraftfoderblanding + kløver-græs hø

Per. no.	Level of conc.	n	Live weight kg	Metabolizable energy Mcal	Metabolizable energy kcal/kg^{0,75}	Nitrogen Intake g	Nitrogen Digested g	Nitrogen Retained Mean	Nitrogen Retained SE	RN/DN %
I	H	7	173	9.93	208	110.7	85.3	38.9	1.2	46
II	H	7	189	11.31	222	121.0	94.3	43.1	0.8	46
III	H	8	207	12.26	225	128.1	99.3	48.8	1.9	49
IV	H	8	224	13.59	236	128.4	100.0	48.0	1.5	48
V	H	7	242	15.38	250	130.8	104.8	49.8	2.8	48
VII	L	6	257	7.78	122	80.5	66.5	14.9	1.6	22
VIII	L	7	261	7.71	119	82.9	67.1	15.4	1.8	23

Metabolizable energy increased from 10 to 15 Mcal or 208 to 250 kcal ME/kg$^{0.75}$ in series F on constant high feeding levels from period I to V and digested nitrogen increased from 85 to 105 g (Table 23). In the same periods the retained nitrogen increased from 39 to 50 g corresponding to an almost constant utilization of digested nitrogen of about 47%. On the low feeding level metabolizable energy was 120 kcal/kg$^{0.75}$ and digested nitrogen about 67 g, which resulted in a nitrogen retention of 15 g, which was 22% of digested nitrogen.

Table 24. Nitrogen metabolism. Series G. Concentrates + dried sugar beet pulp + straw
Tabel 24. Kvælstofomsætning. Serie G. Kraftfoderblanding + Kosetter + halm

Per.	Level		Live weight	Metabolizable energy		Nitrogen				
	of					Intake	Digested	Retained		RN/DN
no.	conc.	n	kg	Mcal	kcal/kg$^{0.75}$	g	g	Mean	SE	%
I	H	8	160	9.71	216	109.4	86.7	39.8	2.1	46
III	H	8	190	11.31	221	130.0	102.9	52.3	1.0	51
IV	H	8	229	11.62	197	126.6	97.9	41.4	2.2	42
VI	H	8	268	12.80	193	136.8	107.4	45.4	1.6	42
II	L	8	158	4.48	101	48.9	36.1	9.7	1.0	27
V	L	8	232	6.72	113	58.4	41.8	14.5	1.2	35
VII	L	8	264	7.37	113	63.6	44.6	12.6	1.3	28

In series G on the high feeding level metabolizable energy was about 200 kcal./kg$^{0.75}$ and about 110 kcal ME/kg$^{0.75}$ on the low level (Table 24). The variation in digested nitrogen from 87 to 107 g was similar to that in series F on the high feeding level. However, on the low level, digested nitrogen was only about 41 g. Retained nitrogen in relation to digested notrogen on the high feeding level was of the same magnitude, about 45%, as in series F. The nitrogen retention on low level varied from 10 to 15 g, but the utilization (RN/DN) increased to about 30% caused by the lower amount of digested nitrogen in series G.

Table 25. Nitrogen metabolism. Series H. Concentrates + clover-grass pellets + straw
Tabel 25. Kvælstofomsætning. Serie H. Kraftfoderblanding + kløver-græs piller + halm

Per.	Level		Live weight	Metabolizable energy		Nitrogen				
	of					Intake	Digested	Retained		RN/DN
no.	conc.	n	kg	Mcal	kcal/kg$^{0.75}$	g	g	Mean	SE	%
I	H	8	117	5.81	165	86.0	67.3	29.4	0.8	44
III	H	7	154	9.33	214	117.7	93.1	43.5	1.4	47
V	H	8	191	8.56	167	95.6	71.4	31.8	1.1	45
VII	H	5	226	11.06	190	112.8	81.7	41.1	2.8	50
II	L	8	118	3.99	113	44.0	31.7	7.0	0.9	22
IV	L	8	154	4.73	108	50.1	35.7	14.0	1.0	39
VI	L	8	191	4.84	95	71.2	56.9	31.2	1.5	55
VIII	L	8	224	5.51	95	51.4	36.1	6.4	1.3	18

In series H, where the diet had a pronounced tendency to produce bloat, the energy intake on the high feeding level was lower than in series F and G. Thus the metabolizable energy was reduced to about 180 kcal/kg$^{0.75}$ with variation ranging from 165 to 214 kcal/kg$^{0.75}$ (Table 25). On the low feeding level where no bloat occured, metabolizable energy was about 103 kcal/kg$^{0.75}$ as planned. With the lower feed intake on the high feeding level the amount of digested nitrogen was reduced (67 to 93 g), but retained nitrogen in relation to digested nitrogen was the same as in series F, (47%). On the low feeding level a great variation in retained nitrogen was found caused by variation in intake and digested nitrogen.

6.2. Prediction of maximum nitrogen retention in growing calves

With an approximately constant utilization of digested nitrogen (RN/DN) independent of the sources of roughage all individual observations concerning live weight, metabolizable energy and nitrogen metabolism on the high feeding level in series F, G and H (n = 97) have been pooled in live weight groups from 100 to 275 kg, with intervals of 25 kg, and the results given in Table 26.

Table 26. Nitrogen metabolism in different live weight groups. Calves on high feeding levels from series F, G and H. n = 97

Tabel 26. Kvælstofomsætning i forskellige vægtklasser. Kalve på højt foderniveau fra serie F, G og H. n= 97

Live weight groups		Live weight, kg		Metabolizable energy		Nitrogen			
						Digested	Retained		RN/DN
kg	n	Mean	SE	Mcal	kcal/kg$^{0.75}$	g	Mean	SE	%
100–125	6	112	3.4	5.84	170	67.4	29.8	0.9	44
125–150	5	140	3.3	8.04	198	82.6	39.0	4.4	47
150–175	17	163	1.9	9.60	211	86.2	39.3	1.1	46
175–200	22	188	1.2	10.48	206	91.2	44.0	1.8	48
200–225	18	212	1.8	11.81	212	94.5	44.7	1.9	47
225–250	20	234	1.6	13.15	220	98.0	44.6	1.4	46
250–275	9	267	2.4	13.09	198	107.3	47.2	2.2	44

Mean metabolizable energy for the whole live weight range was about 208 kcal/kg$^{0.75}$ except for the first group from 100 to 125 kg, where the intake of energy was lower. Digested nitrogen increased from 67 to 107 g and retained nitrogen increased from 30 to 47 g as the animal grew. The mean value of nitrogen retained in relation to digested nitrogen (RN/DN) was 46.3 ±0.5%. The relationship between retained nitrogen and live weight is presented in Figure 3 demonstrating the mean values of digested and retained nitrogen in relation to mean values of live weight.

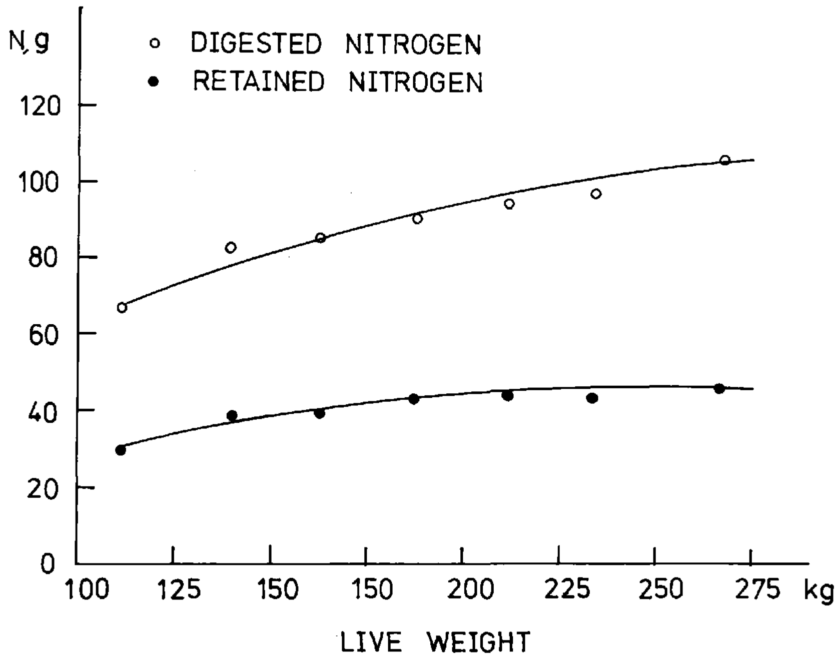

Figure 3
Digested and retained nitrogen in relation to live weight in series F, G and H on high feeding level (mean values).
Fordøjet og aflejret kvælstof i relation til legemsvægt i serie F, G and H på højt foderniveau (middelværdier).

The graph demonstrates that nitrogen retention in the present investigation was curvlinear in relation to live weight. By transforming live weight to metabolic live weight it was sought to find a linear function between nitrogen retention and metabolic live weight, but a regression gave $r^2 = 0.170$ and the graph shows a curvlinear function (Figure 4).

A quadratic function: $y = ax + bx^2 + c$ with $x = kg^{0.75}$ was then applied using all individual data. The calculation gave a non-significant intercept (Student's $t = -1.16$) and the following function through the origin ($c = 0$) was found:

$$\text{Nitrogen retention, g} = 1.276\,kg^{0.75} - 0.00871\,kg^{1.50}$$

$$s_b = 0.10 \qquad 0.0019$$

RSD = ±7.4 (CV = 17.5%) (n = 97)

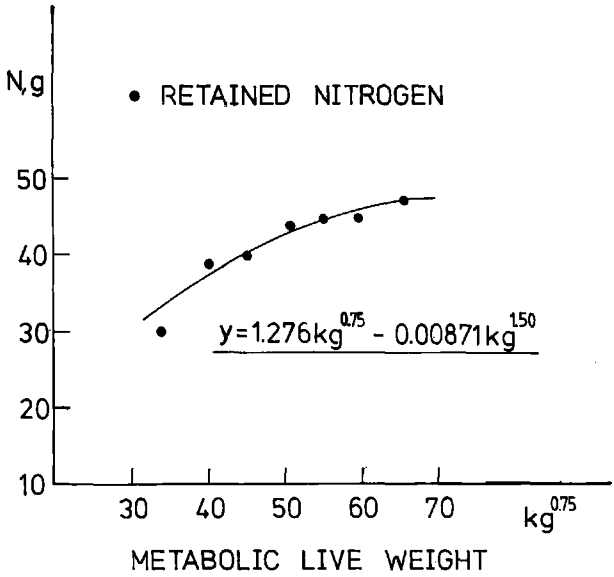

Figure 4
Retained nitrogen in relation to metabolic live weight in series F, G and H on high feeding level (mean values).
Aflejret kvælstof i relation til metabolisk legemsvægt i serie F, G og H på højt foderniveau (middelværdier).

From the equation the maximum retention was calculated to be 46.7 g nitrogen at a metabolic live weight of 73.2 $kg^{0.75}$, corresponding to 306 kg live weight. Extrapolation based on this equation would indicate a nitrogen retention of zero at a live weight of 770 kg.

6.3. Discussion

The intake of energy and protein on high feeding level was planned to secure a fast growth and a maximum protein retention in accordance with results obtained in earlier experiments (cf. Chapter 2.3 and Table 2). The nitrogen retention measured on high feeding level in series F, G and H increased from about 30 g to 50 g during the growth period in question, (Table 23, 24 and 25). The utilization of digested nitrogen was fairly constant about 46% and the energy loss in urine was about 4% (cf. Chapter 5.5), which indicates that the norm applied must have been close to the calves' capacity to utilize the digested nitrogen.

The nitrogen retention on low feeding level, near maintenance, was about 13 g in series F and G with variation from 9.7 g to 15.4. The lower utilization of digested nitrogen in series F (23%) compared with series G (30%) was caused by the higher intake of nitrogen in series F. The nitrogen retention in series H was about 15 g but with great variation from 6.4 g to 31.2 caused by variation in the intake of nitrogen.

With the consistencies obtained in the results from calves on high feeding level, independent of diets applied, it seems acceptable to pool all observations and rearrange them in relation to live weight groups from 100 to 275 kg (Table 26). The intake of energy increased from 5.8 to 13.1 Mcal, ME in accordance with the feeding plan being based on the appetite of the calves. In relation to metabolic size the intake was 170 kcal, ME/kg$^{0.75}$ in the first period (100–125 kg) increasing to a maximum of 220 kcal, ME/kg$^{0.75}$ at a live weight of 225–250 kg, and then declining in the following period to about 200 kcal, ME/kg$^{0.75}$.

The intake of digestible nitrogen increased from 67.4 g to 107.3 g corresponding to an intake of 420 g to 670 g digestible protein. The norm applied has been compared with different standards as shown in Table 27.

Table 27. Protein allowances for growing calves

Tabel 27. Protein normer for voksende kalve

Live weight kg	Digestible protein, g/daily					
	ARC[1]	DLG[2]	Völken-rode[3]	DDR[4]	DK[5]	Present invest.
125–175	419			540	495	528
175–225	447	500	410	555	540	580
225–275	474	550	450	580	540	642

1) ARC (1965). Calculations from Kielanowski (1972).
2) DLG (1973).
3) Daenicke & Oslage (1976).
4) Schiemann et al. (1971).
5) Andersen, Larsen, Sørensen & Østergaard (1973).

The standards are based on a live weight gain of about 1200 g daily except for the DDR-norm in the group from 225 to 275 kg, where the gain is supposed to be about 1400 g. The protein supply in the present investigation is rather close to the DDR-norm but otherwise it is above the standards indicated. The aim of our experiments concerning nitrogen metabolism was to investigate the possibility of establishing a function for maximum nitrogen retention more than to look for an optimum level and a high utilization of nitrogen and for that reason the protein supply was kept on a high level.

The nitrogen retention increased from 29.8 g to 47.2 g with coefficients of variation (CV%) of about 15% in most cases. The rather great variation between the calves on the same nitrogen intake was caused more by a great variation in nitrogen excretion in urine than by a variation of nitrogen digestibility, similar to results obtained in experiments with pigs (Thorbek, 1975).

For a number of years it has been discussed whether the nitrogen retention in growing animals is a function of the protein and energy intake (Miller & Payne, 1963) or a function of the capability of the cells to form protein, thereby related to age (Møllgaard, 1955). The problem has been discussed in detail by Hock & Püschner (1966), Gebhardt (1966) and Kielanowski (1972). The latter assumes that the cells in the first stage of growth have such a great capability to form protein that a maximum cannot be reached but the retention will be a function of protein and energy intake. As the capability of the cells to form protein decreases with age a maximum level can then be obtained as a function of age or live weight if the protein and energy intake is sufficient to reach that maximum.

In the present investigation with a high intake of energy and protein the data have been used to look after functions for maximum nitrogen retention. In relation to live weight (Figure 3) or metabolic live weight (Figure 4) the nitrogen retention indicates curvlinear functions. A quadratic function on metabolic live weight gave a function for maximum nitrogen retention as: Max. N-retention, g $= 1.276\ kg^{0.75} - 0.00871\ kg^{1.50}$. A maximum of 46.7 g N or 292 g protein should then be achieved at a metabolic live weight of 73.2 $kg^{0.75}$ corresponding to 306 kg live weight. The standard deviation of residuals was high, RSD = ±7.4 g (CV = 17.5%) being higher than found in experiments with pigs, where CV was 9.7% (Thorbek, 1975). The lower accuracy obtained in this experiment with calves may be caused by fewer observations (97 against 381 in pigs) and/or a greater variation between calves than between pigs.

It is well known that values for protein retention obtained by balance technique often are higher than values obtained by slaughter technique. Part of this discrepancy is caused by systematic errors connected with the two methods, thereby giving values below »true values« by the slaughter technique and above »true values« by the balance technique. Furthermore the cummulation used in balance technique will increase the deviation, as discussed in detail by Schulz et al. (1974).

In slaughter experiments with calves, Schulz et al. (1974), found a mean protein retention of 164 g with a variation from 150 to 180 g in bull calves from 152 to 267 kg live weight. In the following period from 267 to 370 kg live weight the mean protein retention was 179 g with a variation from 156 to 206 g. The variation found in the slaughter experiments is of the same magnitude as found in our investigation, but the protein retention measured in our balance experiment was higher than the values found by the slaughter method.

In slaughter experiments with steers from 250 kg to 430 kg live weight Garrett (1977) found a daily protein gain from 140 g to 150 g, but he reports to have found values of 175 g to 200 g in Hereford yearling steers being full fed after 6 to 8 months on maintenance or slow growth. It is a question whether the high values of protein retention found in the present investigation could be caused by a compensatory growth. Comparing the values from series F on continously high feeding in 5 periods with results obtained in serie G and H where the calves shifted between high and low level, no influence by compensatory growth could be found.

High values of nitrogen retention have been reported by Poppe (1964) in balance experiments with bull calves from 200 to 335 kg live weight in which he found a mean nitrogen retention of 58 g corresponding to 360 g protein being above our results. In experiments with bull calves from 170 to 200 kg live weight Piatkowski et al. (1967) found a rather constant nitrogen retention of 40 g or 250 g protein daily, close to the results obtained in the present investigation.

With steers somewhat lower results have been reported. In balance experiments with Friesian and Angus steers from 100 to 450 kg live weight the nitrogen retention varied from 32 g to 37 g corresponding to 200–233 g protein (Webster et al., 1974b).

In balance experiments with 56 bull calves on different diets, Schiemann et al. (1976) found a mean nitrogen retention of 22.9 g in calves below 120 kg live weight and 30.0 g in the following group from 120 to 220 kg increasing to 32.0 g corrsponding to 200 g protein from 220 to 330 kg live weight. In this experiments with 56 growing bull calves from 50 to 550 kg live weight fed different diets the nitrogen retention was measured frequently and a regression equation for maximum retention in relation to live weight gain and live weight has been established as: max. N-retention, g = 0.02093 Weight gain, g + 0.06366 LW, kg – 0.00010957 LW, kg^2, SD = ±5.1 (Hoffmann, Jentsch & Schiemann, 1977). Using this function for calves at 200 kg live weight and with a weight gain of 1200 g a nitrogen retention of 33.5±5.1 g should be obtained. At 250 kg and 1400 g gain in weight the nitrogen retention should be 38.4±5.1 g. By using the function found in the present investigation based on live weight a somewhat higher nitrogen retention of 43.2 g and 45.8 g (±7.4) at 200 kg and 250 kg live weight, respectively, could be expected.

From experiments with growing Friesian bull calves, Ørskov (1977) has suggested a function for maximal obtainable rate of protein deposition in relation to digested organic matter (DOM) and live weight. For calves between 60 and 200 kg live weight the function was found to be: N retained, g/DOM, kg = (27.4 – 0.089 LW, kg). After 200 kg live weight there was no relation to weight and the function was 8.8±1.5 g N/DOM, kg. At 250 kg live weight and with an intake of 4 kg digested organic matter the max. nitrogen retention should then be 35 g close to the value found by using the Rostock function, but about 10 g lower than actually found in our experiment. As the nitrogen retention must be a curvlinear function ending at zero for adult animals the linear functions found by Ørskov is limited to describe the nitrogen retention in the first part of the growth, but cannot be used in the latter part.

6.4. Conclusions

1. The nitrogen metabolism in 24 Holstein-Frisian bull calves from 100 to 275 kg live weight has been measured on 3 diets in 97 periods on high feeding level and 76 periods on low feeding level, near maintenance.
2. The nitrogen retention increased on high feeding level from 30 g to 50 g with a rather constant utilization of 46% of the digested nitrogen independent of diet applied.
3. Data from the measurements on high feeding level were pooled and rearranged in live weight groups from 100 to 275 kg with 25 kg intervals. The nitrogen intake increased from 67 g to 107 g digestible nitrogen in this range of live weight and the energy intake increased from 170 to 220 kcal $ME/kg^{0.75}$ except in the last period from 250 to 275 kg live weight where the intake was 198 kcal $ME/kg^{0.75}$.
4. The nitrogen retention from 100 kg to 275 kg live weight increased from 29.8 g (SE = ±0.94) to 47.2 g (±2.23) with a rather great variation between animals (CV about 15%).
5. The nitrogen retention in relation to live weight or metabolic live weight describes a curvlinear function for calves on high feeding level. With the high intake of energy and protein the curves are supposed to indicate a maximum nitrogen retention and the function in relation to metabolic live weight was found to be: max. N-retention, g = $1.276\ kg^{0.75} - 0.00871\ kg^{1.50}$. RSD = ±7.4 g (CV = 17.5%).

VII Energy metabolism

All individual figures for gross energy (GE), metabolizable energy (ME), heat production (HE(CN)) and total energy gain (RE(CN)) together with protein and fat gain are tabulated in the appendix. Retained energy is calculated according to the measured carbon and nitrogen balances and heat production is calculated as the difference between metabolizable energy and retained energy.

7.1. Energy metabolism in series F, G and H

The mean energy metabolism values for each period in series F, G and H are shown in Tables 28, 29 and 30, respectively.

Table 28. Energy metabolism. Series F. Concentrates + clover-grass hay
Tabel 28. Energiomsætning. Serie F. Kraftfoderblanding + kløver-græs hø

Per. no.	Level of conc.	n	Live weight kg	GE Mcal	ME, Mcal		HE, Mcal		HE/ME	RE, Mcal	
					Mean	SE	Mean	SE	%	Mean	SE
I	H	7	173	15.46	9.93	0.38	7.28	0.12	73.6	2.65	0.25
II	H	7	189	17.18	11.31	0.22	8.42	0.20	74.6	2.89	0.25
III	H	8	207	18.53	12.26	0.13	9.14	0.23	74.6	3.12	0.22
IV	H	8	224	20.39	13.59	0.17	10.03	0.18	73.8	3.57	0.21
V	H	7	242	22.21	15.38	0.22	11.03	0.19	71.8	4.35	0.22
VII	L	6	257	12.21	7.78	0.04	7.38	0.13	94.8	0.41	0.22
VIII	L	7	261	12.30	7.71	0.02	7.24	0.11	93.9	0.47	0.08

The mean value of retained energy in relation to metabolizable energy was 26.3±0.72% in series F on the high feeding level with a corresponding heat production of 73.7±0.72% (Table 28). On the low feeding level which was planned to be near maintenance level the mean heat production was 94.3±1.02% of ME with a slight energy gain of 440 kcal corresponding to 5.7±1.02% of ME.

Table 29. Energy metabolism. Series G. Concentrates + dried sugar beet pulp + straw
Tabel 29. Energiomsætning. Serie G. Kraftfoderblanding + Kosetter + halm

Per. no.	Level of conc.	n	Live weight kg	GE Mcal	ME, Mcal Mean	ME, Mcal SE	HE, Mcal Mean	HE, Mcal SE	HE/ME %	RE, Mcal Mean	RE, Mcal SE
I	H	8	160	15.04	9.71	0.05	7.22	0.13	74.4	2.49	0.11
III	H	8	190	17.68	11.31	0.09	8.49	0.16	75.0	2.82	0.14
IV	H	8	229	17.93	11.62	0.04	8.68	0.15	74.7	2.94	0.15
VI	H	8	268	19.71	12.80	0.09	9.53	0.21	74.4	3.28	0.19
II	L	8	158	7.57	4.48	0.02	4.84	0.06	107.9	–0.36	0.06
V	L	8	232	10.98	6.72	0.05	6.41	0.07	95.4	0.31	0.09
VII	L	8	264	12.19	7.37	0.07	7.23	0.10	98.2	0.14	0.13

The mean energy gain was 25.4±0.62% of ME in series G on the high feeding level and mean heat production was 74.6±0.62% (Table 29). On the low feeding level the mean heat production was 100.5±1.41% of ME, (107.9±1.44% in period II, 95.4±1.33% in period V and 98.2±1.83% in period VII).

Table 30. Energy metabolism. Series H. Concentrates + clover-grass pellets + straw
Tabel 30. Energiomsætning. Serie H. Kraftfoderblanding + kløver-græs piller + halm

Per. no.	Level of conc.	n	Live weight kg	GE Mcal	ME, Mcal Mean	ME, Mcal SE	HE, Mcal Mean	HE, Mcal SE	HE/ME %	RE, Mcal Mean	RE, Mcal SE
I	H	8	117	10.12	5.81	0.06	4.39	0.08	75.7	1.42	0.13
III	H	7	154	15.13	9.33	0.12	6.87	0.09	73.7	2.46	0.19
V	H	8	191	14.55	8.56	0.08	6.61	0.09	77.3	1.95	0.08
VII	H	5	226	18.47	11.06	0.10	8.16	0.16	73.7	2.90	0.09
II	L	8	118	7.20	3.99	0.04	3.58	0.07	89.8	0.41	0.09
IV	L	8	154	8.49	4.73	0.06	5.02	0.12	106.4	–0.29	0.17
VI	L	8	191	8.85	4.84	0.02	5.14	0.06	106.1	–0.30	0.05
VIII	L	8	224	9.99	5.51	0.09	5.65	0.09	102.5	–0.13	0.10

The mean energy gain was 24.7±0.78% of ME in series H on the high feeding level with a corresponding heat production of 75.3±0.78% (Table 30). On the low feeding level planned to be near the maintenance level, the mean heat production was 89.8±2.27% in period II with a slight energy gain of 410 kcal corresponding to 10.2±2.27% of ME. In the following periods on the low level, the energy intake was not high enough to cover the maintenance requirement, as indicated by a heat production of 106.4±3.77%, 106.1±1.07% and 102.5±1.79% of ME in period IV, VI and VIII, respectively, and by a negative energy retention.

7.2. Energy metabolism in growing calves from 100 to 275 kg live weight

The mean heat production in relation to metabolizable energy was 73.7, 74.6 and 75.3% on the high feeding level in series F, G and H, respectively, with differences not being significant. Therefore all individual measurements concerning energy metabolism on the high feeding level have been pooled in live weight groups from 100 to 275 kg with intervals of 25 kg, and the results are shown in Table 31.

Table 31. Energy metabolism in different live weight groups. Calves on high feeding levels from series F, G and H. n= 97

Tabel 31. Energiomsætning i forskellige vægtklasser. Kalve på højt foderniveau fra serie F, G og H. n = 97

Live weight		GE, Mcal		ME, Mcal		HE, Mcal		HE/ME	RE, Mcal	
kg	n	Mean	SE	Mean	SE	Mean	SE	%	Mean	SE
100–125	6	10.12	0.00	5.84	0.07	4.37	0.08	75.0	1.47	0.14
125–150	5	13.13	1.23	8.04	0.95	5.80	0.56	73.1	2.24	0.42
150–175	17	15.12	0.08	9.60	0.14	7.13	0.08	74.4	2.47	0.13
175–200	22	16.55	0.28	10.48	0.28	7.89	0.21	75.8	2.59	0.13
200–225	18	18.22	0.38	11.81	0.34	8.76	0.25	74.3	3.03	0.17
225–250	20	19.93	0.41	13.15	0.39	9.71	0.26	74.0	3.44	0.18
250–275	9	19.96	0.25	13.09	0.30	9.67	0.23	73.9	3.43	0.23

With an increasing intake of energy the metabolizable energy increased from about 6 Mcal to 13 Mcal and the retained energy increased from 1.5 Mcal to 3.4 Mcal. The mean energy retention in relation to ME was 25.5±0.41% with a corresponding heat production of 74.5±0.41%. The curve for retained energy during the growth period from 100 to 275 kg live weight is demonstrated in Figure 5.

Energy retention in growing calves observed in the present investigation have been compared with predicted energy retention according to the function established by Schiemann et al. (1971) from experiments with steers on high feeding level.

$$\text{RE, kcal} = 2.12\ x_1 + 7.00\ x_2 + 1.57\ x_3 + 2.12\ x_4 - 60.57\ x_5$$

where x_1 = g digested crude protein
x_2 = g digested crude fat
x_3 = g digested crude fibre (Weende-method)
x_4 = g digested nitrogen free extract
x_5 = metabolic live weight ($kg^{0.75}$)

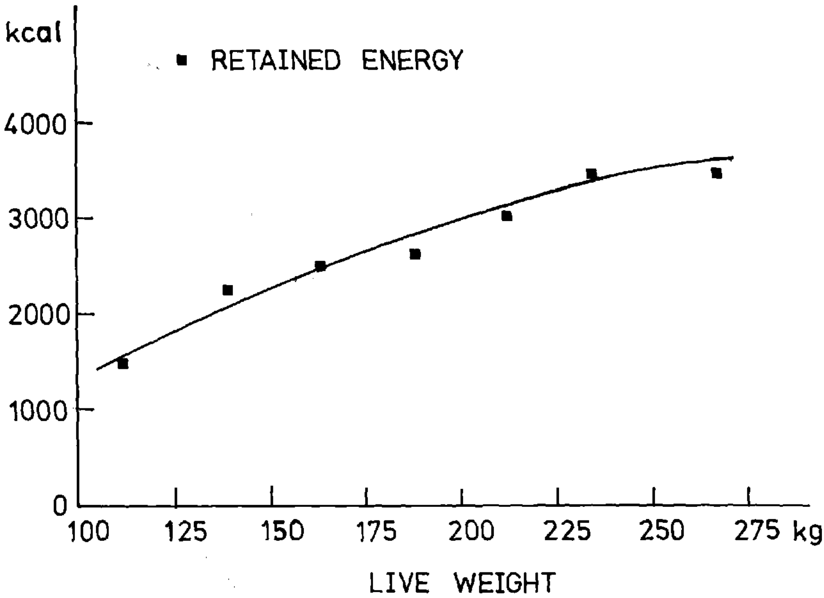

Figure 5
Retained energy in relation to live weight in series F, G and H on high feeding level (mean values).
Aflejret energi i relation til legemsvægt i serie F, G og H på højt foderniveau (middelværdier).

By using the regression coefficients found by Schiemann et al. (1971) together with our measurements of digested nutrients and live weight on high feeding level (n = 97) a regression coefficient of 0.945, s_b = 0.016 was found between the calculated and actually measured energy retention. On low feeding level the regression coefficient was 0.795, s_b = 0.054.

7.3. Protein and fat retention in series F, G and H

Protein retention is calculated from the individual nitrogen balances and fat retention is calculated from the corresponding carbon balances. The mean values for each period in series F, G and H are shown in Tables 32, 33 and 34, respectively.

The protein retention on high feeding level increased in series F from 243 g at 173 kg live weight to 311 g at 242 kg live weight corresponding to 1387 and 1775 kcal, respectively. At the same time fat retention increased from 133 to 271 g or from 1260 to 2574 kcal, corresponding to a total energy retention ranging from

2.65 to 4.35 Mcal as demonstrated in Table 28. Fat retention was 48% of total retained energy (RE) in period I increasing to 59% in period V. On the low level of concentrates the protein gain was markedly reduced, but was still positive at about 540 kcal while the fat gain was negative, at about –100 kcal.

Table 32. Protein- and fat retention. Series F. Concentrates + clover-grass hay
Tabel 32. Protein- og fedtaflejring. Serie F. Kraftfoderblanding + kløver-græs hø

Per. no.	Level of conc.	n	Live weight kg	ME		Protein retained		Fat retained		RFE/RE
				Mcal	$kcal/kg^{0,75}$	g	kcal	g	kcal	%
I	H	7	173	9.93	208	243	1387	133	1260	48
II	H	7	189	11.31	222	269	1535	143	1354	47
III	H	8	207	12.26	225	305	1738	145	1382	44
IV	H	8	224	13.59	236	300	1707	196	1859	52
V	H	7	242	15.38	250	311	1775	271	2574	59
VII	L	6	257	7.78	122	93	529	–13	–124	
VIII	L	7	261	7.71	119	96	547	– 8	– 76	

Table 33. Protein- and fat retention. Series G. Concentrates + dried sugat beet pulp + straw
Tabel 33. Protein- og fedtaflejring. Serie G. Kraftfoderblanding + Kosetter + halm

Per. no.	Level of conc.	n	Live weight kg	ME		Protein retained		Fat retained		RFE/RE
				Mcal	$kcal/kg^{0,75}$	g	kcal	g	kcal	%
I	H	8	160	9.71	216	249	1418	113	1071	43
III	H	8	190	11.31	221	327	1863	101	962	34
IV	H	8	229	11.62	197	259	1476	148	1410	49
VI	H	8	268	12.80	193	284	1618	174	1657	51
II	L	8	158	4.48	101	61	345	–74	–699	
V	L	8	232	6.72	113	91	516	–21	–202	
VII	L	8	264	7.37	113	79	447	–33	–311	

The protein retention on high feeding level was of the same magnitude in series G as in series F, (Table 33). Protein retention increased from 249 to 284 g (1418 to 1618 kcal), while the fat gain was somewhat lower increasing from 113 to 174 g (1071 to 1657 kcal) which corresponds to 43 to 51% of the total energy retention. On the low feeding level the protein retention was still positive while the fat gain was negative, varying from –200 to –700 kcal.

Table 34. Protein- and fat retention. Series H. Concentrates + clover-grass pellets + straw
Tabel 34. Protein- og fedtaflejring. Serie H. Kraftfoderblanding + kløver-græs piller + halm

Per. no.	Level of conc.	n	Live weight kg	ME Mcal	ME $kcal/kg^{0,75}$	Protein retained g	Protein retained kcal	Fat retained g	Fat retained kcal	RFE/RE %
I	H	8	117	5.81	165	184	1048	39	371	26
III	H	7	154	9.33	214	272	1549	96	908	37
V	H	8	191	8.56	167	199	1132	86	813	42
VII	H	5	226	11.06	190	257	1465	151	1436	50
II	L	8	118	3.99	113	44	250	17	163	
IV	L	8	154	4.73	108	88	498	–83	–788	
VI	L	8	191	4.84	95	195	1111	–148	–1408	
VIII	L	8	224	5.51	95	40	227	–38	–359	

In series H (Table 34), where the calves were of a lower live weight range (117 to 226 kg), the protein gain was at a lower level, starting at 184 g and increasing to 257 g (1048 to 1465 kcal). The fat gain started at 39 g and increased to 151 g on the high feeding level, corresponding to an increase from 371 to 1436 kcal. The fat gain was no more than 26% of RE in the first period, increasing to 50% in period VII. On the low feeding level the protein gain was positive while the fat gain was negative, except for period II where there was a slight positive fat gain of 17 g.

7.4. Protein and fat retention in growing calves from 100 to 275 kg live weight

By pooling all the individual measurements of energy metabolism obtained with the high feeding level a table was prepared (Table 35) to show the partitioning between protein gain and fat gain for live weight groups from 100 to 275 kg.

Table 35. Protein- and fat retention in different live weight groups. Calves on high feeding levels from series F, G and H. n = 97
Tabel 35. Protein- og fedtaflejring i forskellige vægtklasser. Kalve på højt foderniveau fra serie F, G og H. n = 97

Live weight group kg	n	ME Mcal	ME $kcal/kg^{0,75}$	Protein retained g	Protein retained kcal	Fat retained g	Fat retained kcal	RFE/RE %
100–125	6	5.84	170	186	1060	43	405	28
125–150	5	8.04	198	244	1389	89	849	38
150–175	17	9.60	211	246	1400	113	1069	43
175–200	22	10.48	206	275	1566	108	1028	40
200–225	18	11.81	212	280	1594	151	1438	47
225–250	20	13.15	220	279	1589	195	1851	54
250–275	9	13.09	198	295	1681	184	1746	51

In the present investigation the protein retention increased from 186 to 295 g corresponding to an increase from 1060 to 1681 kcal, with fat retention increasing from 43 to 184 g or from 405 to 1746 kcal. Thereby the fat gain increased from 28 to 51% of the total energy retention. The curves of protein and fat gain in relation to live weight are shown in Figure 6.

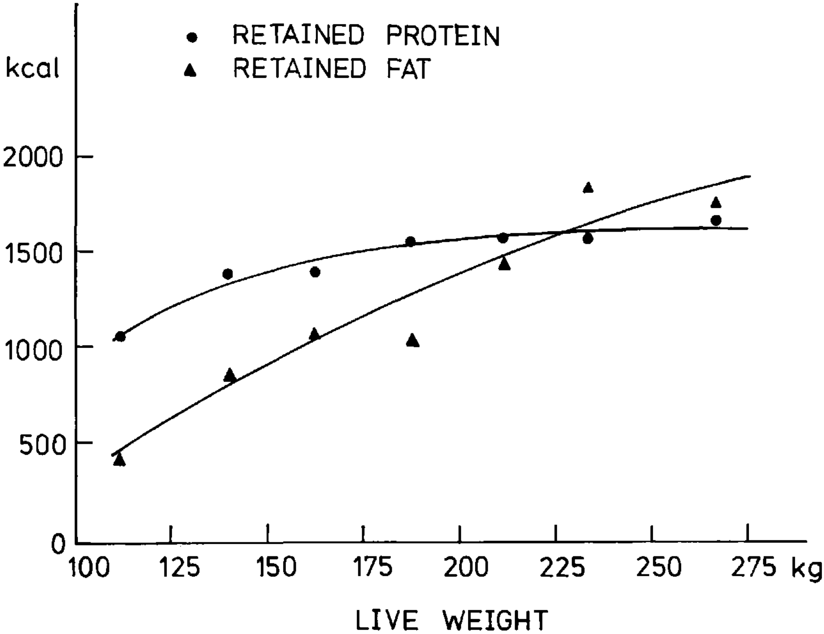

Figure 6
Retained protein and fat in relation to live weight in series F, G and H on high feeding level (mean values).
Aflejret protein og fedt i relation til legemsvægt i serie F, G og H på højt foderniveau (middelværdier).

7.5. Energy requirement for maintenance

The data from the measurement of energy metabolism have been used to evaluate the energy requirement for maintenance in order to be able to estimate the efficiency of utilization of ME for energy retention in growing calves.

All individual measurements in the live weight groups from 100 to 275 kg concerning live weight, intake of metabolizable energy (ME) and total retained energy (RE) from calves on high or low feeding levels in series F, G and H have been pooled and used for regression of RE on ME. The results are shown in Table 36.

Table 36. Estimates of energy requirements for maintenance (ME_m) in different live weight groups. Regression of retained energy (RE) on metabolizable energy (ME). Calves on high or low feeding levels from series F, G and H. (n = 176)

Tabel 36. Estimater af energibehovet til vedligeholdelse (ME_m) indenfor forskellige legemsvægt klasser. Regressioner af aflejret energi (RE) på omsættelig energi. Kalve på højt eller lavt foderniveau fra serie F, G og H. (n = 176)

Live weight groups kg	n	Live weight kg	Live weight $kg^{0.75}$	Intercept kcal	Intercept s_I	RE/ME (b)	RE/ME s_b	ME_m kcal	ME_m kcal/$kg^{0.75}$
100–125	10	108	33.5	–1559	401	0.517	0.080	3015	90
125–150	6	133	39.2	–2486	603	0.674	0.121	3688	94
150–175	39	160	45.0	–2944	182	0.564	0.023	5220	116
175–200	32	190	51.2	–2506	302	0.477	0.032	5254	103
200–225	24	215	56.1	–2515	424	0.463	0.037	5432	97
225–250	28	235	60.0	–2700	292	0.456	0.027	5921	99
250–275	37	261	64.9	–3953	284	0.563	0.029	7021	108

By dividing the intercepts (I) with the regression coefficients of RE on ME (b) estimates of energy requirement for maintenance (ME_m) was obtained for the different live weight groups. In the present investigation a variation from 90 to 116 kcal/$kg^{0.75}$ was found with no pronounced relation to age or live weight.

Another attempt to estimate ME_m was made earlier (Thorbek & Henckel, 1976) by pooling data from calves receiving below 175 kcal ME/$kg^{0.75}$ (n = 21) in series F, G and H. Regression of ME/$kg^{0.75}$ on RE/$kg^{0.75}$ gave the following equation:

$$ME/kg^{0.75}, \text{kcal} = 101.1 + 1.62\ RE/kg^{0.75}$$

$$s_I \text{ and } s_b = \quad 3.9 \quad 0.11$$

$$RSD = -10.6 \qquad (CV = 8.2\%) \qquad (r^2 = 0.808) \qquad (n = 21)$$

if RE = 0 then $\quad ME_m, \text{kcal} = 101 \times W, kg^{0.75}$

Finally an estimate of ME_m was made by using the results from the present investigation where the protein and fat gain were near zero (n = 68) (Thorbek & Henckel, 1976). The intake of ME was corrected to zero level by using factors of 1.3 kcal/kcal fat gain and 2.0 kcal/kcal protein gain for each individual. The corrections were below 5%. A regression of corrected ME on metabolic live weight gave the following equation:

$$ME_m, \text{kcal} = 103.0 \times W, kg^{0.75} \pm 375 \qquad (CV = 6.5\%)$$

$$s_b = \quad 0.9$$

7.6. Efficiency of utilization of ME for energy retention in growing calves

The net availability of ME for growth (k_g) has been calculated according to:

$$ME_g = ME - ME_m$$
$$k_g = RE/ME_g$$

From the results obtained in the present investigation two levels of estimates of the energy requirement for maintenance have been chosen (101 or 108 kcal ME/$kg^{0.75}$). By using the individual data for retained energy (RE) and energy available for growth (ME_g) regressions of RE on ME_g have been calculated for all calves on the high feeding level (n = 97) and the following results have been obtained:

If $ME_m = 101$ kcal/$kg^{0.75}$ then $k_g = 0.491$, $s_b = 0.008$

If $ME_m = 108$ kcal/$kg^{0.75}$ then $k_g = 0.522$, $s_b = 0.009$

By using the lower value for ME_m (101 kcal ME/$kg^{0.75}$) the net availability of ME for growth was 49.1±0.8%, while by using the higher value for ME_m (108 kcal/$kg^{0.75}$) the efficiency was 52.2±0.9%.

7.7. Efficiency of utilization of ME for protein and fat retention

A partial efficiency of utilization of ME for protein and fat gain has been calculated by a multiple regression according to:

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

The efficiency of utilization of ME for protein gain will then be $k_{gp} = 1/\alpha$ and for fat gain $k_{gf} = 1/\beta$.

By using the individual measurements from the calves on high feeding level (n = 97) and with an estimate of $ME_m = 108$ kcal/$kg^{0.75}$ the following equation was found:

$$ME_g = 2.45 \times \text{protein gain, kcal} + 1.26 \times \text{fat gain, kcal}$$
$$s_b = 0.110 \qquad\qquad 0.113$$
$$RSD = \pm 791 \qquad (CV = 15.0\%) \qquad (n = 97)$$

The efficiency of utilization of ME for protein gain would then be 40.8% and for fat gain 79.4%

7.8. Discussion

The energy retention (RE) and heat production (HE) in relation to ME seems not to be influenced by the source of roughages applied or the proportion between concentrate and roughage (C/R) in the different series on high feeding level (Table 28, 29 and 30). RE was 26.3±0.72% of ME in series F with clover-grass hay and C/R between 5.6 and 8.3 (cf. Table 22). In series G with dried sugar beet pulp + straw and C/R between 3.9 and 4.4 the mean value of RE was 25.4±0.62% of ME and in series H with clower-grass pellets+straw and C/R between 2.6 and 4.3 the mean value of RE was 24.7±0.78% of ME. As discussed earlier a close relationship was found between metabolizability, Q(= ME/GE) and C/R as suggested by Blaxter (1974), but no relation could be found on the efficiency of utilization of ME for growth, (RE/ME).

All data on high feeding level have been pooled and organized in relation to live weight groups (Table 31). It is remarkable that a very constant heat production in relation to metabolizable energy (74.5±0.41%) was found between 100 and 275 kg live weight. In experiment with growing pigs from 20 to 80 kg decreasing values from 85% to 50% of ME was found (Thorbek, 1977) being related to a decreasing proportion between protein and fat gain.

From the results it can be calculated that the total heat production for calves at 200 kg live weight would be 8.33 Mcal/24 h or about 350 kcal/h. By using the new heat production unit (Statens Byggeforskningsinstitut) vpe, (= 1000 W total heat production at 20°C) our results correspond to 0.41 vpe (350/860) being close to the value of 0.42 given by Statens Byggeforskningsinstitut (Strøm, 1978).

The comparison between actually measured and calculated values of RE, based on the amount of digested nutrients, gave a regression coefficient of 0.945, $s_b = 0.016$, which indicates that the equation established by Schiemann et al. (1971) from experiments wiht steers can be used for growing calves on high feeding level. On low feeding level the application of the equation is questionable with a regression coefficient of 0.795, $s_b = 0.054$.

The total energy retention has been partitioned in protein and fat retention for all series (Table 32, 33 and 34) by means of the nitrogen and carbon balances. On low feeding level, near maintenance, it is remarkable that protein retention was positive in alle measurements (n = 76) even on a negative fat retention indicating that body fat can be oxidized and protein synthesized simultaneously as found by Blaxter et al. (1966). The protein and fat gain on high feeding levels in the different series are in accordance with each other when compared on the same live weight and intake of energy, and the data have been pooled and grouped in relation to live weight (Table 35), and compared with values from the literature.

In slaughter experiments with bull calves (152 to 267 kg live weight) fed restricted in order to obtain a daily gain of 1.0 kg, Schulz et al. (1974) found a mean protein gain of 935 kcal and a fat gain of 715 kcal. In slaughter experiments with steers (193 to 295 kg live weight) fed ad lib. about 600 kcal protein and 1450 kcal fat per kg gain was found by Garrett (1970) with a total energy gain of 4.33 Mcal per day. In the present investigations with calves on high feeding level, being fed near ad lib., a fat gain increasing from about 400 kcal to 1800 kcal (Table 35) was found when the live weight increased from 100 kg to 275 kg. The values are close to the results obtained by Garrett but above results on restricted feeding (Schulz). As discussed earlier higher values of protein gain was found by using balance technique compared with slaughter technique.

In balance experiments with steers (289 kg) a protein retention of 25% of the total energy was found by Blaxter et al. (1966) while Burlacu et al. (1976) in experiments with heifers (329 to 350 kg) measured 46% protein and 54% fat of the total energy retention. In our experiment with bull calves the proportion between energy retained in protein and energy retained in fat was near 1:1 in the live weight group from 200 to 275 kg while it was about 2:1 in the younger calves from 100 to 150 kg live weight (Table 35).

Energy requirements for maintenance is usually expressed in the form of $ME_m = a\, W^b$, where W = live weight in kg. The values of the exponent »b« for different species have been discussed by Blaxter (1972). It is now commonly accepted to express metabolic live weight as $kg^{0.75}$. The values of the coefficient »a« can be estimated by different methods as outlined in detail by van Es (1972). Measurement of heat production in fasting experiments is a method applicable in non-ruminants but questionable in ruminants (Webster et al., 1974a). Measurement of energy retention in relation to intake of ME is often used to estimate ME_m. The applicability and weakness of the different methods and ways of calculation have been discussed by Henckel (1976).

Different values for maintenance can be found in the literature. From slaughter experiments with steers from 193 to 295 kg live weight (Garrett, 1970) a maintenance requirement of 130 kcal/$kg^{0.75}$ was found by regression of log HE/$kg^{0.75}$ on ME/$kg^{0.75}$ with k_m = 63% which is an efficiency of about 10% lower than indicated by ARC (1965). Values of 116 and 112 kcal, ME/$kg^{0.75}$ were found by Ayala (1974) and Crabtree (1976) in experiments with bull calves from 100 to 200 kg live weight. Kirchgessner et al. (1976) have reported values of 103 or 119 kcal, ME/$kg^{0.75}$ using different methods of calculating their slaughter experiments with veal calves from 99 to 155 kg live weight.

In balance experiments with bull calves, 16 months old, a value of ME_m = 113 kcal/$kg^{0.75}$ was found by Vermorel et al. (1976). Values of 108 or 112 kcal, ME/$kg^{0.75}$ were found in feeding experiments with 56 bull calves fed above or near zero energy retention, respectively, (Hoffmann et al., 1977).

Agricultural Research Council (1975) indicates a daily maintenance allowance of 31 MJ for beef calves at 250 kg live weight, corresponding to 493 KJ, $ME/kg^{0.75}$ or 118 kcal, $ME/kg^{0.75}$. With Q_m = 60% or 70%, k_m should be 72.6% or 75.6% (ARC, 1965), which has been confirmed by Blaxter (1974).

In the present investigation different methods have been used to estimate ME_m. Data concerning ME and RE from calves on high or low feeding levels have been pooled and grouped according to live weight (Table 36). For each live weight group regressions of RE on ME have been calculated and by dividing intercept (I) with the regression coefficient (b) the values for ME_m was found. The variation from 90 to 116 kcal, $ME/kg^{0.75}$ was not related to live weight (age), as expected. Relationship between live weight and ME_m was recently found by Tyrrell and Moe (1980) in balance experiments with heifers, where ME_m decreased from 120 kcal to 85 $kcal/kg^{0.75}$ by an increased live weight from 220 kg to 390 kg.

Data from the present investigation have been used earlier to estimate ME_m (Thorbek and Henckel, 1976). Regression of $ME/kg^{0.75}$ on $RE/kg^{0.75}$ from calves receiving above or below 175 kcal, $ME/kg^{0.75}$ gave ME_m-values of 124 or 101 $kcal/kg^{0.75}$, respectively. Regression of corrected ME (zero energy retention) on metabolic live weight gave ME_m = 103 $kcal/kg^{0.75}$. As discussed by Henckel (1976) and Thorbek (1977) the variation in ME_m-values estimated from our experiments, being in accordance with the variation found in the literature may partly be caused by the assumption that the efficiency of utilization of ME is the same for energy retention in protein as in fat, or if this is not the case, then the ratio protein energy/fat energy should be constant on different intake of ME, which is not the case (Thorbek, 1969b).

The efficiency of utilization of ME for energy retention in growing animals has for many years been expressed by the symbol k_f. According to the definition it indicates the »efficiency with which an increment of metabolizable energy is used to fatten animals« (ARC, 1965). In growing animals where a great part of the energy retention is protein energy the symbol k_f could cause some misunderstanding. For that reason the symbol k_g has been used here to express the net availability of ME for growth, RE/ME_g, where $ME_g = ME–ME_m$ and k_{gp} and k_{gf} will be used for expressing the partial efficiency for protein and fat retention, respectively (Thorbek, 1977).

Different values for k_g can be found in the literature depending on live weight, ratio of energy retained in protein/fat and values applied for ME_m. Garrett (1970) found k_g = 44% in slaughter experiments with steers from 193 to 295 kg live weight, using ME_m = 130 $kcal/kg^{0.75}$ and Kirchgessner et al. (1976) found an efficiency of 64.8±5.5% by using ME_m = 110 $kcal/kg^{0.75}$ in slaughter experiments with calves from 98 to 158 kg live weight. In balance experiments with 16 months old bull calves Vermorel et al. (1976) found k_g = 45±5% with ME_m = 113 $kcal/kg^{0.75}$.

The net availability of ME for growth in the present investigation has been calculated using two levels of ME_m. Assuming the energy requirement for maintenance to be 101 kcal/kg$^{0.75}$ the net availability (k_g) was 49.1±0.8% and with ME_m = 108 kcal/kg$^{0.75}$ the net availability increased to 52.2±0.9% for calves from 100 to 275 kg live weight on high feeding levels. The results beeing obtained by using different values of ME_m on the same data confirmed what was stressed by Moe and Tyrell (1974) »that a well-defined method of computing the efficiency must be used consistently«.

In the last decade a great deal of interest has been connected with problems concerning energy cost of protein and fat retention in different species. From slaughter experiments with calves and using ME_m = 110 kcal/kg$^{0.75}$ Kirschgessner et al. (1976) found ME_g = 2.21±0.49 × protein energy + 1.15±0.36 × fat energy corresponding to k_{gp} = 45% and k_{gf} = 87%. From balance experiments Schiemann et al. (1976) found the following equation: ME= 1.93 × protein energy + 1.04 × fat energy + 135.9 kg$^{0.75}$, RSD = ±986 (CV = 6.8%). Maintenance requirement was here used as a variable giving a comparatively high value of ME_m = 136 kcal/kg$^{0.75}$, k_{gp} was then 52% and k_{gf} = 96%, the latter seems to be rather high.

In the present investigation the energy cost of fat retention was found to be 1.26±0.11 kcal/kcal fat gain, when using ME_m = 108 kcal/kg$^{0.75}$, which corresponds to the value obtained by Kirchgessner et al. (1976). The energy cost of protein retention found in our experiments was 2.45±0.11 kcal/kcal protein gain being higher than the value of 2.21±0.49 kcal found by Kirchgessner et al. and the value of 1.93 kcal/kcal protein given by Schiemann et al. (1976).

A great constancy exists in the results concerning energy cost of fat deposition given by different investigators from experiment with pigs (Thorbek, 1977) and values of the same magnitude and with small variations are now found in experiments with ruminants. Most of the values given are between 1.2 and 1.3 kcal/kcal fat gain, corresponding to k_{gf} = 83% to 77%, and close to the theoretical value for fat formation based on biochemical investigation.

From metabolic studies with different species many values have been given for the energy cost of protein deposition. For non-ruminants Müller and Kirchgessner (1979) have reported values from the literature from 1.6 to 2.8 kcal/kcal protein gain, corresponding to k_{gp} = 63% to 36%, and for ruminants Schiemann and Klein (1978) have reported values from 1.6 to 3.0 kcal close to the variations found in non-ruminants. Both have discussed the reason for the great variations found in metabolic studies and the reason for the deviation from the theoretical cost estimated to 1.1 to 1.4 kcal based on biochemical investigations. Müller and Kirchgessner (1979) have concluded that the main reason for the deviation from the theoretical costs is that protein turnover is not included in the calculation from metabolic studies, in which protein retention and not protein synthesis is used as the base.

Recent studies in man as well as in animals have shown that there is a high turnover of protein depending on age and that no constant proportion exists between protein synthesis and protein retention. Ratios from 10:1 to 4:1 have been reported (Young et al., 1975, Pencharez et al., 1977, Nicholas et al., 1977, Simon et al., 1978 and Edmunds & Buttery, 1978).

It is obvious that no constant value for k_{gp} during the growth period could be expected from metabolic studies with animals of different age and with different but unknown ratio of protein synthesis/protein retention and applying different values of ME_m in the calculations. Further isotope studies are needed to give information about the ratio and bring the energy cost of protein synthesis closer to the theoretical value, but it should not be forgotten that k_{gp} found in metabolic studies is the actual energy cost of the protein retention measured under the given experimental conditions.

7.9. Conclusions

1. The energy metabolism in 24 Holstein-Friesian bull calves from 100 to 275 kg live weight has been measured on 3 diets in 97 periods on high feeding level and 76 periods on low feeding level, near maintenance.
2. Energy retention (RE) and heat production (HE) in relation to ME was not influenced by the sources of roughages applied or the proportion between concentrate and roughage, so the data were pooled and arranged in relation to live weight groups (Table 31). A rather constant heat production of HE = 74.5±0.41% of ME corresponding to 0.41 vpe was found from 100 to 275 kg live weight.
3. Energy retention increased from 1.47 to 3.43 Mcal, with protein retention increasing from 186 g to 295 g corresponding to 1.06 to 1.68 Mcal and with fat retention increasing from 43 g to 184 g or 0.41 to 1.75 Mcal (Table 35).
4. Retained energy in growing calves on high feeding level can be estimated by means of the equation for adult cattle given by Schiemann et al. (1971), based on digested nutrients and metabolic live weight.
5. Energy requirement for maintenance was calculated by different methods and the values of 101 and 108 kcal, $ME/kg^{0.75}$ were chosen for further calculations.
6. Net availability of ME for growth (k_g) was calculated to be 49.1±0.8% and 52.2±0.9 by using ME_m = 101 or 108 $kcal/kg^{0.75}$, respectively.
7. The energy cost of fat retention was 1.26±0.11 kcal/kcal fat gain and for protein retention the value was 2.45±0.11 kcal/kcal protein gain, corresponding to k_{gf} = 79% and k_{gp} = 41%.

VIII Dansk sammendrag

8.1. Indledning

Fra 1959–1963 blev der ved Statens Husydrbrugsforsøgs afdeling for dyrefysiologi, biokemi og analytisk kemi opbygget og kalibreret et nyt respirationsanlæg for svin. Efter foreløbige undersøgelser til fastlæggelse af den mest hensigtsmæssige metodik til gennemførelse af balance- og respirations-forsøg blev der fra 1964–66 gennemført en serie systematiske målinger af protein- og energiomsætningen hos voksende svin.

På grundlag af de opnåede resultater med det nye respirationsanlæg blev der givet bevilling til at bygge et tilsvarende anlæg for kvæg. Anlægget, der blev bygget fra 1967–1969, består af to af hinanden uafhængige respirationskamre, beregnet til kvæg fra 50 til 800 kg legemsvægt og indrettet således, at de også kan anvendes til malkekvæg. Hvert kammer har et grundareal på 280 × 170 cm med en højde på 200 cm, og det er forsynet med et bevægeligt fodertrug og anordninger til kvantitativ opsamling af gødning og urin. Anlæggene, der er udstyret med klima-anlæg, er automatiserede, således at tilsynet og arbejdsforbruget ved driften er meget ringe. Systemet, der virker efter »åben-luft-cirkulations« princippet, er beskrevet af Thorbek & Neergaard (1970).

Samtidig med bygning af respirationsanlæggene blev stalden udstyret med 8 opsamlingsbokse til kalve fra 50 til 300 kg legemsvægt. Boksene, der er justerbare til kvantitativ opsamling af gødning og urin, blev benyttet til et indledende forsøg til fastlæggelse af en foderplan (kraftfoderblanding + hø), der skulle kunne sikre en maximal kvælstofaflejring.

Fra 1970–1972 gennemførtes derefter 3 forsøgsserier til bestemmelse af fordøjelighed, omsættelighed, luftstofskifte, varmeproduktion samt protein- og fedtaflejring hos voksende kalve fra 100 til 300 kg legemsvægt. I alle 3 serier blev der fodret med samme kraftfoderblanding, men med 3 forskellige grovfodertyper bestående af kløvergræs hø, tørrede sukkerroesnitter (Kosetter) + halm eller kløvergræs piller + halm. For at kunne fastlægge kalvenes energetiske vedligeholdelesebehov blev der fodret på henholdsvis højt og lavt niveau.

8.2. Metoder og materialer

Forsøgsoversigt

Efter at respirationsanlæggene for kvæg var færdigbyggede og kalibrerede i 1969 gennemførtes 3 forsøgsserier, F 1970, G 1971 og H 1972 med ialt 24 tyrekalve til måling af deres protein- og energiomsætning indenfor vægtklassen 100–275 kg. Alle kalve fik samme kraftfoderblanding, men forskelligt grovfodertilskud, henholdsvis kløvergræs hø i serie F, tørret sukkerroe pulp (kosetter) + byghalm i serie G og kløvergræs piller + byghalm i serie H. Der blev gennemført 7–8 balanceforsøg med hver kalv på henholdsvis højt eller lavt kraftfoderniveau, som angivet i tabel 1. Hvert balanceforsøg bestod af en 7 døgns opsamlingsperiode med et 24-timers respirationsforsøg i midten af hver periode. Forperiodens længde (2–6 uger) var betinget af, at hvert dyr skulle måles såvel på højt som på lavt kraftfoderniveau indenfor samme legemsvægtklasse, og at dyrene såvidt muligt skulle være i »ligevægt« på det nye foderniveau. De længste forperioder forekom ved skift fra lavt til højt kraftfoderniveau.

Forsøgsdyr

I hver serie er der anvendt 8 tyrekalve (SDM), der inden leveringen var fodret med sødmælkserstatning + kraftfoderblanding svarende til den blanding der blev anvendt på laboratoriet. Ved ankomsten til laboratoriet gik kalvene gradvis over til de respektive forsøgsrationer og indgik i forsøgene ved en alder af 4–6 mdr. og med en legemsvægt på 117–173 kg (Tabel 1). I tilvænningsperioden blev dyrene trænet i respirationskamrene, og samtidig blev de behandlet med Thibenzole til udryddelse af tarmparasitter.

Journal

I serie F havde kalv nr. 2 i periode I,II og V væsentlige foderrester og er derfor udgået af målingerne i disse perioder. Kalv nr. 5 døde pludselig af trommesyge kort før periode VI, uden tidligere at have vist symptomer på denne lidelse. Kalv nr. 7 udgik af periode VII, da respirationsforsøget ikke kunne gennemføres på grund af tekniske årsager. Samtlige målinger i serie G blev gennemført uden forstyrrelser. I serie H havde kalv nr. 3 foderrest i periode III og i periode VII havde nr. 1, 3 og 4 varierende grader af trommesyge, hvorfor målingerne ikke kunne gennemføres.

Foderplan

På grundlag af resultaterne fra det indledende forsøg er der opstillet en plan for den ønskede kraftfodertildeling af byg, havre, hørfrøkager og soyaskrå indenfor de forskellige vægtklasser (Tabel 2). Denne plan er benyttet i samtlige serier i de perioder, hvor dyrene har været på højt foderniveau. På lavt foderniveau er de respektive grovfodermængder holdt konstant, medens kraftfodermængden blev reduceret, således at det samlede foder skulle svare til kalvenes energibehov til vedligeholdelse ved den pågældende legemsvægt.

I serie F er der i samtlige perioder givet et dagligt tilskud af 600 g kløverhø (Tabel 3). I serie G er der i de to første perioder givet et tilskud af 400 g tørrede sukkerroesnitter (Kosetter) + 300 g byghalm, og derefter er tilskuddet forhøjet til henholdsvis 500 g og 400 g (Tabel 4). I serie H var tilskuddet konstant 400 g kløvergræs piller. Af hensyn til risikoen for trommesyge, blev dette tilskud ikke forøget, hvorimod halmtilførslen blev forøget fra 300 til 600 g (Tabel 5). Tilskud af mineralstoffer og vitaminer fremgår af tabel 3, 4 og 5. Mikromineralblandingens sammensætning er vist i tabel 6.

Forsøgsteknik

Kalvene var under hele forsøget opstaldet i gummibelagte boxe, hvor den forreste del kunne reguleres til sikring af kvantitativ opsamling af gødning og urin. Samtlige foderkomponenter blev udvejet individuelt for hver periode og aliquote prøver blev udtaget til kemiske analyser. Gødning- og urinprøver blev opsamlet 3 gange dagligt og opbevaret i kølerum indtil næste morgen, hvor prøverne blev vejede. Efter omhyggelig blanding blev der for hvert døgn i den 7 døgns opsamlingsperiode udtaget 20% af gødningsmængden og 5% af urinprøven til samleprøve til kemiske analyser. Samleprøverne opbevaredes ved 5–7°C, og til urinprøverne var der tilsat 1 teskefuld merkurijodid, medens gødningsprøverne opbevaredes uden tilsætningsmidler.

Kemiske analyser og nøjagtighed

Analyserne er gennemførte efter laboratoriets sædvanlige metodik med anvendelse af Stoldt-metoden til bestemmelse af råfedt. Fodermidlernes kemiske sammensætning fremgår af tabel 7. Den analytiske nøjagtighed vedrørende kvælstof, kulstof og energibestemmelserne i foder, gødning og urin er beregnet efter den metode, der er angivet af Rasch et al. (1958) og resultaterne er angivet i tabel 8.

Respirationsforsøg

Måling af dyrenes luftstofskifte over 24-timers perioder er foretaget ved hjælp af afdelingens respirationsanlæg for kvæg, (Thorbek og Neergaard, 1970). Med jævne mellemrum er anlæggene kalibrerede ved hjælp af CO_2 som beskrevet af Thorbek (1969a) og resultaterne er vist i tabel 9 og 10. Middeldifferencen mellem registreret ind- og udgående CO_2 var henholdsvis $0{,}68 \pm 1{,}25$ liter og $0{,}78 \pm 1{,}73$ liter for kammer A og B og en t-test viste, at der ikke var systematiske fejl på de to kamre. Dyrenes varmeproduktion (HE, CN) er beregnet på grundlag af de målte kulstof (C)- og kvælstof (N) balancer med anvendelse af de internationalt vedtagne faktorer (Brouwer, 1965).

8.3. Energi- og proteintilførsel

Samtlige individuelle målinger vedrørende kalvenes alder, legemsvægt, tilførsel af nærongsstoffer og energi samt fordøjeligheden af disse er angivet i hovedtabel I i appendix (side 85). På grundlag af disse enkeltværdier er middelværdierne beregnet for hver periode indenfor de 3 forsøgsserier F, G og H.

Serie F. Kraftfoderblanding + kløvergræs hø

I denne serie blev kalvene fodret kontinuerligt på højt kraftfoderniveau (H) i 10 uger og målt i 5 balanceperioder. Derefter blev kraftfodermængden reduceret og dyrene blev målt på lavt niveau (M og L) i 3 perioder. De tilførte fodermængder fremgår af tabel 3. Kalvenes alder og legemsvægt samt energi- og proteintilførsel er vist i tabel 11. Dyrene var ca. 6 mdr. gamle med en middelvægt på 173 kg ved forsøgets begyndelse. Energitilførslen steg fra 9,9 til 15,4 Mcal omsættelig energi (ME), medens proteintilførslen steg fra 533 til 655 g ford. råprotein fra per. I til V, hvilket svarer til et fald fra 54 til 43 g ford. råprotein/Mcal omsættelig energi. På lavt kraftfoderniveau (per. VII og VIII) var energitilførslen omkring 7,8 Mcal ME svarende til 120 kcal ME/kg^{0,75} og proteintilførslen var ca. 418 g ford. råprotein. Kalvenes vægtkurve er vist i figur 1, og den gennemsnitlige daglige tilvækst for de første 5 perioder var 1250 g. Fra per. VII og VIII på lavt foderniveau var der en svag tilvækst på 4 kg svarende til en daglig tilvækst på 286 g, hvilket tyder på, at 120 kcal ME/kg^{0,75} har været noget over dyrenes energibehov til vedligeholdelse.

Serie G. Kraftfoderblanding + Kosetter + halm

Ved forsøgets begyndelse var kalvene knap 6 mdr. gamle med en middelvægt på 160 kg (Tabel 12). Per. I – III – IV og VI blev gennemført på højt kraftfoderniveau, medens per. II – V og VII er udført på lavt niveau. De anvendte fodermængder fremgår af tabel 4. Energitilførslen i de tre periode på lavt foderniveau svarede til 101, 113 og 113 kcal ME/kg^{0,75}. Vægtkurven, der fremgår af fig. 1, viser, at det har været muligt at fodre kalvene således, at vægtklassen stort set fastholdes indenfor to balanceperioder på henholdsvis højt og lavt kraftfoderniveau.

Serie H. Kraftfoderblanding + kløvergræs piller + halm

I denne serie var kalvene ca. 4½ mdr. gamle og vejede i gennemsnit 117 kg ved forsøgets begyndelse (Tabel 13). De blev målt alternativt på højt og lavt kraftfoderniveau (cf. tabel 5) ved henholdsvis 118, 154, 191 og 225 kg legemsvægt, som det fremgår af tabel 13 og fig. 1. På lavt niveau var energitilførslen henholdsvis 113, 108, 95 og 95 kcal ME/kg^{0,75}.

8.4. Luftstofskifte

Samtlige individuelle målinger af kalvenes CO_2- og CH_4-produktion fremgår af hovedtabel II i appendix (side 95). Dyrenes O_2 forbrug er ikke angivet, da vi i den første serie (F) af tekniske grunde ikke kunne opnå samme analyse nøjagtighed ved O_2-bestemmelserne (Magnos) som ved CO_2-analyserne (Uras).

CO_2- og CH_4-produktion i serie F, G og H

Middelværdierne for CO_2- og CH_4-produktionen for de enkelte balanceperioder i serie F, G og H er vist i tabellerne 14, 15 og 16 sammen med de tilhørende værdier for legemsvægt og tilførsel af organisk stof. For samtlige serier og perioder blev der med hensyn til CO_2-produktionen fundet relativt lave variationskoefficienter, CV (SD/$\bar{x}$), fra 2,6 til 5,0%. For CH_4-produktionen var variationen betydelig større med variationskoefficienter fra 11 til 51% for kalvene på højt kraftfoderniveau, reduceret til 4–10% for kalvene på lavt foderniveau.

Af tabellerne fremgår det, at CO_2-produktionen ved 150 kg legemsvægt var omkring 1500 liter daglig på højt kraftfoderniveau og ca. 1000 liter ved lavt niveau. Ved 250 kg legemsvægt og højt kraftfoderniveau var CO_2-produktionen omkring 2000 liter (Ser. G) og 2400 liter (Ser. F) afhængig af tilførslen af organisk stof, medens produktionen kun var omkring 1500 liter for kalvene på lavt kraftfoderniveau.

Estimation af CO_2-produktion hos voksende kalve

Da CO_2produktionen må forventes at være en funktion af såvel legemsvægt som foderoptagelse er forsøgsmaterialet benyttet til beregning af forskellige regressionsligninger såvel på højt ($n = 97$) som på lavt kraftfoderniveau ($n = 76$). Det første beregningssæt omfatter regression af CO_2-produktion på metabolisk legemsvægt, som vist i ligning (1) og (2) (side 25). Det næste sæt omfatter regression af CO_2-produktion på tilførsel af organisk stof, som vist i ligning (3) og (4), og endelig blev det tredie sæt beregnet som en multipel regression på metabolisk legemsvægt og tilførsel af organisk stof og resultatet heraf fremgår af ligning (5) og (6).

Diskussion

Den foreliggende undersøgelse bekræfter, at variationen imellem dyr er væsentlig større ved CH_4-produktionen end ved CO_2-produktionen (Schiemann et al., 1976), hvilket hænger sammen med, at CO_2-produktionen i det væsentlige er afhængig af vedligeholdelsesstofskiftet og foderniveau, medens CH_4-produktionen er stærkt afhængig af vomgæringsprocesserne, der er betinget af foderets sammensætning og fysiske struktur.

Med hensyn til CO_2-produktionen i relation til metabolisk legemsvægt fandtes ingen signifikant forskel mellem serie F, G og H, hvorfor data blev »pooled« på henholdsvis højt (n = 97) og lavt kraftfoderniveau (n = 76). Regression af CO_2 på metabolisk legemsvægt gav ligningerne (1) og (2) med relativ stor residualspredning (RSD) på omkring 10%, der gør det problematisk at anvende disse ligninger i modsætning til tilsvarende beregninger på svin (Thorbek, 1975).

Regression af CO_2 på indtag af organisk stof (IOM) gav væsentlig bedre tilpasning med CV = 4,6% og 6,2% på henholdsvis højt og lavt kraftfoderniveau. Ved at benytte såvel metabolisk legemsvægt som IOM blev ligningen for lavt niveau yderligere forbedret (CV = 4,6%). Forsøgene tyder på, at tilførslen af organisk stof alene kan benyttes som grundlag for beregning af CO_2-produktion for kalve, der fodres på højt niveau (nær ad lib. fodring), medens den metaboliske legemsvægt bør inddrages for kalve på lavt foderniveau (nær vedligeholdelsesbehov).

CH_4-produktionen på lavt foderniveau var omkring 70 liter ved 150 kg legemsvægt og omkring 120 liter ved 250 kg. På højt kraftfoderniveau var det muligt at foretage en sammenligning af CH_4-produktionen ved en legemsvægt på omkring 190 kg. Den laveste produktion på 75 liter blev fundet i serie G, hvor grovfoder tilskuddet var Kosetter + halm. Med anvendelse af hø (serie F) eller græspiller (serie H) var CH_4-produktionen henholdsvis 101 liter og 110 liter med stærkt signifikante forskelle mellem disse serier og serie G.

Konklusion

1. Ved 150 kg legemsvægt var CO_2-produktionen omkring 1000 liter på lavt kraftfoderniveau (nær vedligeholdelsesbehov) og 1500 liter på højt niveau. Ved 250 kg legemsvægt var de tilsvarende værdier 1500 liter og 2200 liter. Variationen imellem dyrene var ringe med variationskoefficienter (CV) mellem 2,6 og 5,0%.

2. CH_4-produktionen varierede mellem 50 og 150 liter. Variationskoefficienterne var store, fra 11 til 51% for kalvene på højt kraftfoderniveau reduceret til 4 til 10% på lavt niveau.

3. Det bedste »fit« for regressionsligninger til estimering af CO_2-produktion var CO_2, liter = –180 + 0,54 IOM, g (indtag af organisk stof) (r^2 = 0,950 g, CV = 4,6%) for kalve på højt kraftfoderniveau og CO_2, liter = –191 + 9,78 W, $kg^{0,75}$ + 0,42 IOM, g (r^2 = 0,968, CV = 4,6%) for kalve på lavt kraftfoderniveau.

8.5. Omsættelig energi

Alle individuelle målinger vedrørende brutto energi (GE), fordøjet energi (DE) og omsættelig energi (ME) samt metanproduktion findes i hovedtabel I og II i appendix. Energitab i gødning (FE) er ikke tabuleret, men kan beregnes udfra GE – DE. Energitabet i metan (ECH_4) er beregnet udfra ECH_4, kcal = liter $CH_4 \times 9{,}45$.

Energitab i gødning, urin og metan

Middelværdierne for energitabet i relation til brutto energien (GE) er vist i tabel 17, 18 og 19 for samtlige perioder i serie F, G og H. Energitabet i gødningen har varieret fra 20 til 33%, og energitabet i urinen har varieret fra 3 til 6%, medens energitabet i form af metan har varieret fra 3 til 11% af brutto energien.

Fordøjelig energi (DE/GE) i serie F, G og H

Energitabet i gødningen viser, at fordøjeligheden af den tilførte energi var afhængig af den anvendte grovfoder type. Med anvendelse af kløvergræs hø (serie F) var middelfordøjeligheden 75,9±0,3% og 79,9±0,3% på henholdsvis højt og lavt kraftfoderniveau, medens den faldt til henholdsvis 69,5±0,4 og 67,6±0,3% med anvendelse af kløvergræspiller (serie H). I begge tilfælde var forskellen mellem højt og lavt kraftfoderniveau stærkt signifikant. Med anvendelse af kosetter var middelfordøjeligheden henholdsvis 73,2±0,3% og 73,6±0,3%, og der var ingen forskel m.h.t. foderniveau. Forskellen mellem de tre grovfoder typer på henholdsvis højt og lavt kraftfoderniveau er vist i tabel 20 og samtlige differencer er stærkt signifikante.

Omsættelig energi i relation til brutto energi (ME/GE)

Omsætteligheden var afhængig af grovfodertype som vist i figur 2. I serie F, hvor der blev anvendt kløvergræs hø var den omsættelige energi 66,4±0,5% og 63,2±0,2% af brutto energien på henholdsvis højt og lavt kraftfoderniveau, medens den faldt til 59,3±0,4% og 55,3±0,3% med anvendelse af kløvergræs piller (ser. H). I serie G, hvor der blev anvendt Kosetter, var omsætteligheden 64,6±0,2% og 60,3±0,3% på henholdsvis højt og lavt kraftfoderniveau. I samtlige serier var forskellene mellem højt og lavt kraftfoderniveau stærkt signifikante. Forskellen mellem de tre grovfodertyper på henholdsvis højt og lavt foderniveau er vist i tabel 21 og samtlige differencer er stærkt signifikante.

Estimation af fodermidlers indhold af omsættelig energi

I det foreliggende materiale med individuelle målinger af omsættelig energi og indhold af fordøjeligt protein, fedt, træstof og NFE er disse data benyttet til multiple regressioner på henholdsvis højt og lavt kraftfoderniveau. Resultaterne fremgår af ligning (1) og (2) (side 33) og beregningerne viste, at forskellen mellem de to ligninger var stærkt signifikant ($P < 0,001$). En regressionsberegning alene baseret på indholdet af fordøjet organisk stof er vist i ligningerne (3) og (4).

Diskussion

I forsøg med kalve fandt Schiemann et al. (1976), at energitabet i urin varierede fra 3 til 9% af brutto energien afhængig af proteintilførslen. I det her fremlagte materiale var det planlagt at tilføre kalvene en proteinmængde, der så nær som muligt svarede til deres behov for maximal proteinaflejring, og med et ret konstant energitab i urinen på 4% synes dette at være opnået. Energitabet i metan på højt kraftfoderniveau varierede fra 3,2 til 7,2% af brutto energien afhængig af den anvendte grovfodertype og af forholdet mellem kraftfoder og grovfoder, og resultaterne er i overnesstemmelse med Webster et al. (1974a), og Schiemann et al. (1976). På lavt foderniveau, nær vedligeholdelse, var energitabet i metan større fra 7,8 til 11,3%, hvilket svarer til resultaterne fra Blaxter og Clapperton (1965).

Omsætteligheden (Q = ME/GE på produktionsniveau og Q_m = ME/GE på vedligeholdelsesniveau) varierede for Q mellem 69,2% (SE ±0,98) til 57,4% (±0,57) og for Q_m mellem 63,8% (±0,29) til 54,7% (±0,28). Som først påvist af Blaxter (1974) og senere diskuteret af van Es (1976, 1978) synes der at være en nær sammenhæng mellem omsætteligheden af en ration og forholdet mellem kraftfoder og grovfoder ((C/R) i rationen. På grundlag af tabel 4, 5 og 6 er disse forhold beregnet for de enkelte perioder i serie F, G og H og sat i relation til Q og Q_m i tabel 22.

Det fremgår heraf, at i serie F, hvor grovfoderet bestod af kløvergræs hø, faldt Q fra 69,2 til 64,2% samtidig med at C/R faldt fra 8,3 til 5,6. På vedligeholdelsesniveau, hvor C/R = 4,1, faldt Q_m til 63,2% (SE ±0,22), hvilket nøje svarer til de resultater, der er opnået af Blaxter (1974) og Webster et al. (1974b). I serie G, hvor grovfoderet bestod af Kosetter + halm var Q_m i middel 60,3% (±0,31), hvilket var signifikant lavere end i serie F. Dette skyldes sandsynligvis mere en forskel i C/R (4,1 i serie F og 2,1 i serie G) end en forskel imellem de to anvendte grovfodertyper, hvilket også en sammenligning mellem Q på samme C/R-forhold tyder på.

I serie H, hvor der blev anvendt kløvergræs piller + halm, var Q_m i gennemsnit 55,3% (±0,32), hvilket var signifikant lavere end Q_m i serie G (60,3%), hvor forholdet mellem kraftfoder og grovfoder var af samme størrelsesorden. En sammenligning mellem Q fra serie H og G på samme C/R forhold tyder ligeledes på, at omsætteligheden af den samlede ration har været lavere, hvor kløvergræs piller + halm har været anvendt som grovfoder.

Den fundne regressionsligning (1) til beregning af et fodermiddels indhold af omsættelig energi baseret på kendskab til mængden af de fordøjede næringsstoffer stemmer ret godt overens med ligningen fra Rostock (Schiemann et al., 1971) med hensyn til regressionskoefficienterne for fordøjet protein og NFE. Koefficienterne for fordøjet fedt og protein er uacceptable, men disse dækker kun ca. 20% af den omsættelige energi. Beregningerne tyder på, at ligningen fra Rostock, der er etableret på grundlag af forsøg med udvoksede stude også kan anvendes overfor voksende kalve på højt foderniveau.

En tilsvarende beregning alene baseret på indholdet af fordøjeligt organisk stof viser, at der kan opnås en ligning, hvormed indholdet af omsættelig energi kan beregnes med ret god tilnærmelse.

Konklusion

1. Energitabet i urinen var med den anvendte foderplan ret konstant omkring 4% af brutto energien.
2. Energitabet i metan varierede fra 3,2 til 7,2% af GE på højt foderniveau og fra 7,8 til 11,3% på vedligeholdelsesniveau afhængig af den anvendte grovfodertype og forholdet mellem kraftfoder og grovfoder.
3. Omsætteligheden (Q) varierede fra 69,2 til 57,4% af GE på højt foderniveau og på vedligeholdelsesfoder varierede Q_m fra 63,8 til 54,7%.
4. Omsætteligheden var stærkt afhængig af forholdet mellem kraftfoder og grovfoder (C/R). Q aftog fra 69,2 til 57,4% med C/R faldende fra 8,3 til 2,6, og på vedligeholdelsesniveauet, hvor C/R faldt fra 4,1 til 1,2 faldt Q_m fra 63,8 til 54,7%.
5. Omsætteligheden var lavere ved anvendelse af kløvergræs piller + halm (serie H) end ved anvendelse af kløvergræs hø (serie F) eller Kosetter + halm (serie G).

8.6. Kvælstofomsætning

Samtlige enkeltmålinger vedrørende kvælstoftilførsel (IN), fordøjet kvælstof (DN), kvælstof udskilt i urinen (UN) samt aflejret kvælstof (RN) findes i hovedtabel I og II i appendix.

Kvælstofomsætningen i serie F, G og H

Middelværdier for kvælstofomsætning, omsættelig energi og legemsvægt for de enkelte perioder i serie F, G og H er angivet i tabel 23, 24 og 25. I serie F, hvor grovfoderet var kløvergræs hø, steg energitilførslen fra 10 til 15 Mcal omsættelig energi (ME) svarende til 208–250 kcal ME/kg^{0,75} i de første perioder fra 170 til 250 kg legemsvægt. Kvælstoftilførslen steg fra 85 til 105 g fordøjet kvælstof og kvælstofaflejringen steg fra 39 til 50 g, hvilket gav en næsten konstant udnyttelsesgrad på 47% af det fordøjede kvælstof. På lavt foderniveau med en energitilførsel på 120 kcal ME/kg^{0,75} og 67 g fordøjeligt kvælstof faldt kvælstofaflejringen til 15 g og udnyttelsesgraden var omkring 22%.

I serie G, hvor grovfoderet var Kosetter + halm, var energitilførslen omkring 200 kcal ME/kg^{0,75} på højt foderniveau og omkring 110 kcal ME/kg^{0,75} på lavt niveau. Kvælstofomsætningen på højt foderniveau var af samme størrelsesorden som i serie F med en udnyttelsesgrad på omkring 45% af det fordøjede kvælstof. På lavt foderniveau varierede kvælstofaflejringen fra 10 til 15 g med en udnyttelsesgrad på omkring 30%.

I serie H, hvor grovfodertilskuddet af kløvergræs piller gav anledning til trommesyge på højt foderniveau, var det ikke muligt at nå op på samme foder- og energitilførsel som i serie F og G. Den gennemsnitlige tilførsel var omkring 180 kcal ME/kg^{0,75} med variationer fra 165 til 214 kcal, ME/kg^{0,75} og svarende hertil var kvælstoftilførslen mindre og ret varierende. Kvælstofaflejringen i per. III og VII var af samme størrelsesorden som i serie F og G på tilsvarende legemsvægt og energitilførsel, men resultaterne fra per. I og V tyder på, at en energitilførsel på omkring 165 kcal ME/kg^{0,75} er for lav til at opnå maximal kvælstofaflejring. På lavt foderniveau, nær vedligeholdelsesbehovet, var energitilførslen i gennemsnit 103 kcal, ME/kg^{0,75} og kvælstofaflejringen 15 g med store variationer forårsaget af variationer i kvælstoftilførslen.

Estimation af maximal kvælstofaflejring

Da målingerne har vist, at kvælstofaflejringen på højt foderniveau har været af samme størrelsesorden indenfor samme vægtklasse uafhængig af den anvendte grovfodertype er samtlige observationer (n = 97) benyttet til vurdering af kvælstofomsætningen som vist i tabel 26. Observationerne er ordnet i vægtklasser à 25 kg fra 100 til 275 kg legemsvægt, og kvælstofaflejringen i relation til legemsvægten er vist grafisk i figur 3, og relationen til metabolisk legemsvægt fremgår af figur 4. Da data ikke kan tilpasses en lineær funktion, er der anvendt en kvadratisk funktion: $y = ax + bx^2 + c$, hvor $x = kg^{0,75}$. Beregningerne viste en ikke signifikant intercept (Student's t = 1,16) hvorefter funktionen med c = o blev: max. N-aflejring = $1{,}276\,kg^{0,75} - 0{,}00871\,kg^{1,50}$ med s_b henholdsvis på 0,10 og 0,0019 og RSD = $\pm 7{,}4$ svarende til CV = 17,5%. Funktionen viser et maximum på 46,7 g kvælstofaflejring ved en metabolisk vægt på 73,2 kg^{0,75} svarende til 306 kg legemsvægt.

Diskussion

Tilførslen af energi og protein på højt foderniveau, planlagt i henhold til tidligere undersøgelser (jvf. Chapter 2.3 og Tabel 2), skulle sikre stor tilvækst og maximal proteinaflejring. Med en ret konstant udnyttelsesgrad på 46% af fordøjet protein og med et ret konstant energitab i urinen på 4% af GE, synes den anvendte norm at være tæt på kalvenes evne til at udnytte det fordøjede protein. Som det fremgår af tabel 26 har energitilførslen fra 100 til 275 kg legemsvægt været stigende fra 5,8 til 13 Mcal ME med en kvælstoftilførsel stigende fra 67 til 107 g fordøjeligt kvælstof svarende til 420–670 g fordøjeligt protein. Den anvendte norm er i tabel 27 sammenlignet med andre proteinnormer for optimal tilførsel. Den norm, der har været anvendt i nærværende forsøg har skullet sikre den størst mulige proteinaflejring og ligger derfor væsentlig over disse normer.

Kvælstofaflejringen i de undersøgte vægtklasser steg fra 30 til 47 g svarende til 186–295 g protein med en variationskoefficient (CV) på omkring 15%. Det har i mange år været diskuteret om kvælstofaflejringen hos voksende dyr er en funktion af protein- og energitilførslen (Miller & Payne, 1963) eller en funktion af cellernes evne til at danne protein (Møllgaard, 1955). Dette problem er i detaljer diskuteret af Hock & Püschner (1966), Gebhardt (1966) og Kielanowski (1972). Sidstnævnte forener de to synspunkter ved at antage, at cellerne i den første vækstperiode har en så stor evne til at danne protein, at den maximale aflejring ikke kan nås, men at aflejringen bliver en funktion af energi- og proteintilførslen. Da cellernes evne til at danne protein aftager med alderen vil dyrene fra et vist tidspunkt være i stand til at optage tilstrækkelig energi og protein, og der kan opnås en maximal proteinaflejring, der vil være en funktion af dyrenes alder (legemsvægt).

Det er velkendt, at værdier for proteinaflejring målt ved balanceteknik i almindelighed ligger over værdier målt ved slagte-teknik. Det skyldes bl.a., at de systematiske fejl ved de to metoder trækker i hver sin retning, således at slagteresultater vil være under og balanceresultater over »sand værdi«. Samtidig vil der ske en akkumulering af fejlene ved opsummering af balanceforsøg som vil forøge afvigelsen, som diskuteret af Schulz et al. (1974).

Ved slagteforsøg med tyrekalve fandt Schulz et al. (1974) proteinaflejringer fra 150 til 180 g i vægtklassen 152–267 kg og fra 156 til 206 g i vægtklassen 267–370 kg. I forsøg med stude fra 250 til 430 kg legemsvægt fandt Garrett (1977) proteinaflejringer mellem 140 og 150 g, medens han i slagteforsøg med stude, der i 6–8 mdr. havde været på lavt foderniveau, fandt højere proteinaflejringer mellem 175 og 200 g, muligvis på grund af kompensatorisk vækst. I de her foreliggende forsøg har der næppe været tale om kompensatorisk vækst, idet der er opnået samme proteinaflejring uanset om kalvene over en længere periode har været på konstant højt foderniveau (serie F) eller skiftet mellem højt og lavt foderniveau (serie G og H).

I balanceforsøg med tyrekalve fra 200 til 335 kg fandt Poppe (1964) særdeles høje værdier på omkring 360 g proteinaflejring, medens Piatkowski et al. (1967) i balanceforsøg med tyrekalve fra 170 til 200 kg fandt en kvælstofaflejring på 40 g svarende til 250 g protein, hvilket svarer til vor undersøgelse. I forsøg med stude fandt Webster et al. (1974b) en noget lavere proteinaflejring fra 200 til 233 g.

I omfattende balanceforsøg med 56 tyrekalve fra 50 til 550 kg fandt Schiemann et al. (1976) en gennemsnitlig proteinaflejring på omkring 154 g for vægtklassen under 120 kg og 185 g fra 120 til 220 kg stigende til 200 g protein i vægtklassen fra 220 til 330 kg. På grundlag af disse forsøg blev den maximale proteinaflejring sat i relation til tilvækst og legemsvægt, hvilket gav følgende regression:

$$\text{max. N-retention, g} = 0{,}02093 \times \text{tilvækst, g} + 0{,}06366 \times \text{legemsvægt, kg} - 0{,}00010957 \times \text{legemsvægt, kg}^2, \quad \text{RSD} = \pm 5{,}1$$

(Hoffmann et al., 1977). Ved 250 kg legemsvægt og 1400 g dgl. tilvækst ville denne funktion give en kvælstofaflejring på 38,4±5,1 g, medens en aflejring på 45,8±7,4 g kunne forventes på grundlag af vor undersøgelse, men forskellen er næppe signifikant.

Ørskov (1977) har på grundlag af forsøg med tyrekalve sat den maximale proteinaflejring i relation til fordøjet organisk stof (DOM) og legemsvægt for kalve under 200 kg og angiver funktionen til max. N-retention, g/DOM, kg = 27,4 – 0,089 LW, kg. Over 200 kg fandtes ingen relation til legemsvægten og funktionen var 8,8±1,5 g N/DOM, kg. Ved 250 kg legemsvægt og 4 kg DOM ville funktionen give 35 g kvælstofaflejring. Funktionen kan næppe anvendes for større dyr, der er i stand til at optage mere foder, idet kvælstofaflejringen ikke fortsætter lineært, men bøjer af for at være omkring nulpunktet, når dyrene er udvoksede.

Konklusion

1. Kvælstofomsætningen er blevet målt med anvendelse af 24 tyrekalve (SDM) fra 100 til 275 kg legemsvægt. Der er anvendt 3 fodringstyper med henholdsvis kløvergræs hø (Ser. F), Kosetter + halm (Ser. G) eller kløvergræs piller + halm (Ser. H) som grovfoder. Der er gennemført 97 balancer på højt foderniveau og 76 balancer på lavt niveau, nær vedligeholdelsesbehovet.
2. Kvælstofaflejringen på højt foderniveau steg fra 30 til 50 dgl. med en ret konstant udnyttelsesgrad på 46% af det fordøjede kvælstof uafhængig af fodringstype.
3. Fra de samlede data på højt foderniveau i relation til legemsvægten fremgår det, at kvælstoftilførslen steg fra 67 til 107 g fordøjet kvælstof fra 100 til 275 kg legemsvægt. Energitilførslen steg fra 170 til 220 kcal ME/kg^{0,75} indtil 250 kg, hvorefter den faldt til 198 kcal ME/kg^{0,75} i perioden fra 250 til 275 kg.
4. Kvælstofaflejringen steg fra 29,8 g (SE = ±0,94) til 47,2 g (±2,23) med relativ stor variation mellem kalvene (CV omkring 15%).
5. Kvælstofaflejringen i relation til legemsvægt eller metabolisk vægt er krumlinet.
6. På grundlag af den store energi- og proteintilførsel formodes kvælstofaflejringen at være maximal og at kunne beskrives ved en kvadratisk funktion baseret på metabolisk legemsvægt:

   $$\text{max. N-aflejring, g} = 1{,}276 \text{ kg}^{0,75} - 0{,}00871 \text{ kg}^{1,50}, \quad \text{RSD} = \pm 7{,}4 \text{ g}$$

   (CV = 17,5%).

8.7. Energiomsætning

Samtlige enkeltmålinger vedrørende bruttoenergi (GE), omsættelig energi (ME), varmeproduktion (HE,CN) og total energi aflejring (RE,CN) samt energiaflejringen i protein og fedt findes i hovedtabel II i appendix.

Energiomsætning i serie F, G og H

Middelværdierne for de tre serier findes i tabel 28, 29 og 30. Den totale energiaflejring i perioderne på højt foderniveau var 26,3±0,72% i serie F, 25,4±9,62% i serie G og 24,7±0,78% af omsættelig energi, hvilket svarer til et gennemsnitligt varmetab på 74,5% af omsættelig energi. På lavt foderniveau svingede energiaflejringen fra 470 kcal til -300 kcal, hvorved varmetabet svingede fra 90% til 106% af omsættelig energi svarende til at energitilførslen har været omkring vedligeholdelsesbehovet.

Energiomsætning hos voksende kalve fra 100 til 275 kg legemsvægt

Da der ikke kunne påvises signifikante forskelle i energiaflejringen på højt foderniveau i de tre forsøgsserier er samtlige individuelle målinger vedrørende energiomsætningen (n = 97) sorteret i vægtklasser fra 100 til 275 kg med intervaller på 25 kg og resultaterne er vist i tabel 31. Med en fodertilførsel nær ad libitum er energitilførelen steget fra omkring 6 Mcal til 13 Mcal omsættelig energi (ME) og den totale energiaflejring er steget fra 1,5 til 3,4 Mcal svarende til 25,5±0,41% af ME. Kurven for energiaflejringen gennem denne vækstperiode er vist i figur 5.

Protein- og fedtaflejring i serie F, G og H

Proteinaflejringen er beregnet på grundlag af de målte kvælstofbalancer og fedtaflejringen er beregnet udfra kulstofbalancerne. Middelværdierne for de tre serier findes i tabel 32, 33 og 34. I serie F, hvor dyrene på højt foderniveau vejede fra 170 til 250 kg steg proteinaflejringen fra 243 g til 311 g svarende til 1387–1775 kcal medens fedtaflejringen steg fra 133 g til 271 g (1260–2574 kcal). På det lave foderniveau faldt proteinaflejringen til omkring 540 kcal med en negativ fedtaflejring på -100 kcal. I serie G steg proteinaflejringen tilsvarende som i serie F fra 249 g til 284 g, medens stigningen i fedtaflejringen var mindre, fra 113 g til 174 g, på grund af den lavere energitilførsel i serie G. På vedligeholdelsesniveauet var proteinaflejringen stadig positiv omkring 435 kcal, medens fedtaflejringen var negativ på ca. -400 kcal. I serie H, hvor dyrene var i en lavere vægtklasse (117–226 kg) var proteinaflejringen mindre med en stigning fra 184 g til 257 g (1048–1465 kcal) ligesom fedtaflejringen var lavere fra 39 g til 151 g (371–1436 kcal). På det lave foderniveau var proteinaflejringen omkring 520 kcal og fedtaflejringen ca. -600 kcal med store afvigelser for de enkelte perioder på grund af variationer i tilført protein og energi.

Protein- og fedtaflejring hos voksende kalve fra 100 til 275 kg legemsvægt

Samtlige individuelle målinger vedrørende protein- og fedtaflejringen på højt foderniveau er grupperet i de respektive vægtklasser fra 100 til 275 kg og resultatet er vist i tabel 35. Det fremgår heraf, at der er fundet en proteinaflejring på 186 g (1060 kcal) i vægtklassen 100–125 kg stigende til 295 g (1681 kcal) i vægtklassen 250–275 kg, medens fedtaflejringen steg fra 43 g (405 kcal) til 184 g (1746 kcal). I forhold til den totale energiaflejring (RE) steg fedtaflejringen fra 28% til omkring 50% og forholdet mellem protein- og fedtaflejringen er vist i figur 6.

Energibehov til vedligeholdelse

En nødvendig forudsætning for at kunne vurdere den energetiske udnyttelsesgrad til vækst og andre produktioner er at man kender energibehovet til vedligeholdelse. Samtlige målinger på højt og lavt foderniveau vedrørende legemsvægt, omsættelig energi (ME) og aflejret energi (RE) er benyttet til regression af RE på ME indenfor de enkelte vægtklasser fra 100 til 275 kg og resultaterne fremgår af tabel 36. Ved at dividere intercept (I) med de respektive regressionskoefficienter fås et skøn over vedligeholdelsesbehovet (ME_m), der i denne undersøgelsesrække varierede fra 90 til 116 kcal/kg^{0,75}, uden påviselig afhængighed af alder eller legemsvægt.

Det foreliggende forsøgsmateriale har tidligere været benyttet til vurdering af vedligeholdelsesbehovet (Thorbek & Henckel, 1976). Ved regression af ME/kg^{0,75} på RE/kg^{0,75} fandtes et vedligeholdelsesbehov på 101 eller 124 kcal, ME/kg^{0,75} ved at benytte data fra kalve, der fik henholdsvis under (n = 21) eller over (n = 132) 175 kcal, ME/kg^{0,75}. Endelig har materialet været benyttet til et estimat af ME_m ved at anvende data (n = 68) fra de kalve, hvor protein- og fedtaflejringen var nær nulpunktet. ME-tilførslen er korrigeret til ME_o ved benyttelse af faktorerne 1,3 kcal/kcal fedtaflejring og 2,0 kcal/kcal proteinaflejring. Størrelsen af korrektionerne var under 5%. Regression af ME_o på metabolisk legemsvægt gav ME_m = 103 kcal ME/kg^{0,75}.

Udnyttelsesgrad af omsættelig energi til energiaflejring hos voksende kalve fra 100 til 275 kg

Udnyttelsesgraden af ME til vækst (k_g) er beregnet på grundlag af:

$$k_g = RE/ME_g$$

hvor $ME_g = ME - ME_m$

Beregningerne er gennemførte med anvendelse af to værdier for ME_m på henholdsvis 101 eller 108 kcal ME/kg^{0,75}. Regression af RE på ME_g med anvendelse af data (n = 97) fra kalve på højt foderniveau gav en udnyttelsesgrad på 49,1±0,8% ved at anvende ME = 101 kcal/kg^{0,75} og 52,2±0,9% ved at benytte ME_m = 108 kcal/kg^{0,75}.

Udnyttelsesgrad af omsættelig energi til protein- og fedtaflejring

Den partielle udnyttelsesgrad er beregnet som en multipel regression, hvor

$$ME_g = \alpha \times \text{proteinaflejring, kcal} + \beta \times \text{fedtaflejring, kcal}$$

Med anvendelse af $ME_m = 108\ kcal/kg^{0,75}$ blev $\alpha = 2,45$ og $\beta = 1,26$ svarende til en energetisk udnyttelsesgrad af 40,8% ved proteinaflejring og 79,4% ved fedtaflejring.

Diskussion

Den gennemsnitlige energiaflejring (RE) på højt foderniveau var 25,5±0,41% af omsættelig energi (ME) og der kunne ikke påvises nogen afhængighed af den anvendte grovfodertype eller af forholdet mellem kraftfoder og grovfoder, (C/R). Forsøgene tyder på, som diskuteret tidligere, at der er stærk afhængighed mellem omsættelighed (ME/GE) og C/R forholdet (Blaxter, 1974), medens energiudnyttelsen (RE/ME) ikke synes at være påvirket af dette forhold.

Samtlige data fra kalvene på højt foderniveau er sorteret i forhold til deres legemsvægt fra 100 til 275 kg og det er bemærkelsesværdigt, at varmetabet i denne vækstperiode er ret konstant 74,5±0,41% af ME, hvor man i forsøg med svin fra 20 til 90 kg finder et aftagende varmetab fra 85% til 50%, hvilket skyldes et stærkt aftagende forhold mellem protein og fedt (Thorbek, 1977). Forsøgene viser en varmeproduktion på omkring 8,33 Mcal/24 timer eller 350 kcal/time for kalve omkring 200 kg legemsvægt. Omregnet til nye varmeproduktionsenheder svarer dette til 0,41 vpe, hvilket er i god overensstemmelse med de værdier, der angives fra Statens Byggeforskningsinstitut (Strøm, 1978).

Fra 100 til 275 kg legemsvægt steg den samlede energiaflejring fra 1,47 til 3,43 Mcal (Tabel 31 og figur 5), og der var god overensstemmelse mellem de fundne værdier på højt foderniveau og beregnede værdier baseret på mængden af fordøjede næringsstoffer (Schiemann et al., 1971).

På lavt foderniveau, nær vedligeholdelsesbehovet, er det bemærkelsesværdigt, at samtlige proteinbalancer er positive, medens de fleste fedtbalancer er negative, hvilket viser, at der samtidigt kan opbygges protein og nedbrydes fedt, som påpeget af Blaxter et al. (1966).

På højt foderniveau steg proteinaflejringen fra 186 til 295 g (1060–1681 kcal) medens fedtaflejringen steg fra 43 til 184 g (405–1746) som vist i tabel 35 og figur 6. Som tidligere omtalt er den fundne proteinafljering højere end resultater opnået ved slagteforsøg (Schulz et al., 1974 og Garrett, 1970) medens fedtaflejringen svarer til de resultater, der er opnået ved ad libitum fodring (Garrett, 1970).

Energibehovet til vedligeholdelse er ofte udtrykt ved $ME_m = a\,W^b$, hvor W er legemsvægten i kg. Hvilken værdi eksponenten »b« skal tillæges for de forskellige dyrearter er indgående diskuteret af Blaxter (1972) og det er nu almindeligt at udtrykke den metaboliske legemsvægt ved $kg^{0,75}$. Forskellige metoder, såvel eksperimentelle som beregningsmæssige, kan benyttes til bestemmelse af koefficienten »a«, som detaljeret beskrevet af van Es (1972). Måling af varmeproduktionen ved hunger er en metode, der kan anvendes overfor ikke-drøvtyggere, men den er problematisk overfor drøvtyggere, som fremhævet af Webster et al. (1974a). Måling af energiaflejring i forhold til ME benyttes ofte til beregning af ME_m, og her kan forskellige beregningsmetoder benyttes. Deres forudsætninger og svagheder er bl.a. diskuteret af Henckel (1976).

Der foreligger i litteraturen en række angivelser over energibehovet til vedligeholdelse (ME_m). Fra den senere tid har Kirchgessner et al. (1976) på grundlag af slagteforsøg med kalve fra 99 til 155 kg angivet ME_m = 103 eller 119 kcal/kg^{0,75}, afhængig af beregningsmetoden. Ligeledes ved slagteforsøg har Garrett (1970) fundet et vedligeholdelsesbehov på 130 kcal/kg^{0,75} hos kalve fra 193 til 295 kg. Ved balanceforsøg med kalve indenfor disse vægtklasser har Vermorel (1976) angivet ME_m = 113 kcal/kg^{0,75}, medens Hoffmann et al. (1977) har fundet værdier mellem 108 og 112 kcal/kg^{0,75}. Tyrell og Moe (1980) har i balanceforsøg med kvier fra 220 til 390 kg fundet, at ME_m aftog fra 120 til 85 kcal/kg^{0,75}.

I vore undersøgelser fandt vi en lignende variation fra 90 til 116 kcal, ME/kg^{0,75} ved at opdele materialet i vægtklasser fra 100 til 275 kg og foretage regressioner af RE på ME, men uden at vi kunne påvise relationer til vægtklassen. Regression af ME/kg^{0,75} på RE/kg^{0,75} har i det foreliggende materiale givet ME_m-værdier på 101 eller 124 kcal/kg^{0,75} ved at benytte data fra kalve der fik henholdsvis under eller over 175 kcal ME/kg^{0,75}. Ved at benytte korrigerede ME_o-værdier i relation til metabolisk legemsvægt blev ME_m= 103 kcal/kg^{0,75}. Det fremgår heraf, at man på grundlag af samme data kan opnå ganske varierende estimater af ME_m afhængig af beregningsmåder og forudsætninger, således som det er diskuteret af Thorbek (1969b), Henckel (1976) og Thorbek (1977).

Udnyttelsesgraden af omsættelig energi til total energiaflejring (k_g = RE/ME_g) er bl.a. afhængig af dyrenes legemsvægt, forholdet mellem protein- og fedtaflejring samt den anvendte værdi for ME_m. Det er derfor forståeligt, at der i litteraturen findes stærkt varierende værdier for k_g. Garrett (1970) finder således fra sine slagteundersøgelser (193 til 295 kg legemsvægt), at k_g = 44% med anvendelse af ME_m = 130 kcal/kg^{0,75}, medens Kirchgessner angiver k_g = 64,8±5,5% fra slagteforsøg med kalve fra 98 til 158 kg ved at anvende ME_m = 110 kcal/kg^{0,75}. I balanceforsøg med 16 mdr. gamle tyrekalve fandt Vermorel (1976) k_g = 45±5% med ME_m = 113 kcal/kg^{0,75} og i det foreliggende forsøg med tyrekalve fra 100 til 275 kg fandt vi k_g = 49,1±0,8% med anvendelse af ME_m = 101 kcal/kg^{0,75} og k_g = 52,2±0,9% såfremt vi anvendte ME_m = 108 kcal/kg^{0,75}. Disse resultater understreger, hvad der er fremhævet af Moe og Tyrrell (1974), at det er nødvendigt at benytte en veldefineret metode til beregning af den energetiske udnyttelsesgrad, såfremt man ønsker at opnå værdier, der kan sammenlignes.

I de senere år har der været en del interesse i at få bestemt det partielle energibehov til protein- og fedtaflejring beregnet ved hjælp af multiple regressioner. På grundlag af slagteforsøg og med anvendelse af $ME_m = 110$ kcal/kg^{0,75} har Kirchgessner et al. (1976) fundet følgende ligning: $ME_g = 2{,}21 \pm 0{,}49 \times$ energi aflejret i protein + $1{,}15 \pm 0{,}36 \times$ energi aflejret i fedt svarende til en udnyttelsesgrad ved proteinaflejring (k_{gp}) på 45% og ved fedtaflejring (k_{gf}) på 87%. Fra balanceforsøg fandt Schiemann et al. (1976) ME = 1,93 × protein energi + 1,04 × fedt energi + 135,9 kg^{0,75}. Vedligeholdelsesbehovet er her anvendt som den tredie variabel, hvilket har givet en relativ høj ME_m-værdi på 136 kcal/kg^{0,75}, hvilket antagelig påvirker k_{gf}, der her er fundet til 96% medens k_{gp} bliver 52%. I de foreliggende undersøgelser fandtes følgende ligning: $ME_g = 2{,}45 \pm 0{,}11 \times$ protein energi + $1{,}26 \pm 0{,}11 \times$ fedt energi med anvendelse af ME_m = 108 kcal/kg^{0,75}.

Der foreligger i litteraturen mange samstemmende værdier vedrørende energibehovet til fedtaflejring hos voksende svin med angivelser fra 1,2 til 1,4 kcal/kcal fedtaflejring (Thorbek, 1977). De værdier, der nu foreligger fra forsøg med voksende kalve, synes at være af samme størrelsesorden fra 1,2 til 1,3 kcal/kcal fedtaflejring, svarende til k_{gf}-værdier fra 83% til 77% og tæt på de teoretiske værdier baseret på biokemiske beregninger.

Med hensyn til energibehov til proteinaflejring er der stor variation i de fundne værdier. For ikke-drøvtyggere har Müller og Kirchgessner (1979) i litteraturen fundet værdier, der svinger fra 1,6 til 2,8 kcal/kcal proteinaflejring svarende til en variation i k_{gp} fra 63% til 36%. For drøvtyggere har Schiemann og Klein (1978) sammenstillet lignende værdier og har fundet variationer fra 1,6 til 3,0 kcal/kcal protein svarende til værdierne for ikke-drøvtyggere. Begge har indgående diskuteret årsagerne til disse variationer samt den store afvigelse fra den teoretiske værdi på 1,1–1,4 kcal/kcal protein fundet ved biokemiske beregninger. Müller og Kirchgessner (1979) drager den konklusion, at den væsentligste årsag til den store afvigelse mellem de teoretiske værdier og de fundne værdier skyldes protein-turnover, der ikke indgår i værdierne fra stofskifteforsøgene, hvor proteinaflejringen og ikke proteinsyntesen danner grundlaget for beregningerne.

Studier fra de senere år med anvendelse af isotoper har vist en meget høj protein-turnover hos nyfødte børn og unge dyr. Forholdet mellem proteinsyntese og proteinaflejring er ikke konstant, men synes at være aftagende med alderen. I litteraturen foreligger der angivelser, hvor dette forhold varierer fra 10:1 til 4:1 (Young et al., 1975, Pencharez et al., 1977, Nicholas et al., 1977, Simon et al., 1978 og Edmunds & Buttery, 1978).

Det er forståeligt, at man ved stofskiftemålinger på voksende dyr ikke har kunnet finde konstante værdier for k_{gp} idet dyrene ofte har været af forskellig alder, der har været anvendt forskellige værdier for ME_m, og forholdet mellem protein syntese og protein retention har været ukendt. Fremtidige isotop undersøgelser skulle gøre det muligt at få bedre kendskab til forholdet mellem syntese og aflejring og derved bringe værdierne tættere sammen.

På den anden side må det understreges, at de værdier for k_{gp}, der er fundet i de forskellige stofskiftemålinger, er det aktuelle energibehov for den proteinaflejring, der har fundet sted under de eksperimentelle betingelser.

Konklusion

1. Energiomsætningen er blevet målt hos 24 tyrekalve (SDM) fra 100 til 275 kg legemsvægt. Der er anvendt 3 forskellige grovfodertyper og der er gennemført 97 balancer på højt foderniveau og 76 balancer på lavt niveau, nær vedligeholdelsesbehovet.
2. Energiaflejringen (RE) og varmeproduktionen (HE) i forhold til omsættelig energi (ME) var uafhængig af den anvendte grovfodertype og forholdet mellem kraftfoder og grovfoder (Tabel 31).
3. På højt foderniveau var varmetabet fra 100 til 275 kg legemsvægt meget konstant HE = 74,5±0,41% af ME, hvilket svarer til 0,41 vpe for kalve omkring 200 kg legemsvægt.
4. Fra 100 til 275 kg legemsvægt steg den samlede energiaflejring fra 1,47 til 3,43 Mcal, medens proteinaflejringen steg fra 186 g til 295 g svarende til 1,06 til 1,68 Mcal. I samme periode steg fedtaflejringen fra 43 g til 184 g eller 0,41 til 1,75 Mcal (Tabel 35).
5. Aflejret energi hos voksende kalve på højt foderniveau kan estimeres på grundlag af den ligning, der er angivet for udvokset kvæg (Schiemann et al., 1971) baseret på mængden af fordøjede næringsstoffer og den metaboliske legemsvægt ($kg^{0,75}$).
6. Energibehovet til vedligeholdelse er beregnet efter forskellige metoder og de fundne værdier på 101 og 108 kcal, $ME/kg^{0,75}$ er benyttet til de videre beregninger.
7. Udnyttelsesgraden af ME til samlet energiaflejring (k_g) var 49,1±0,8% eller 52,2±0,9% afhængig af om man benyttede 101 eller 108 kcal, $ME/kg^{0,75}$ som udtryk for vedligeholdelsesbehovet.
8. Energibehovet til fedtaflejring var 1,26±0,11 kcal/kcal fedt og til proteinaflejring 2,45±0,11 kcal/kcal protein svarende til k_{gf} = 79% og k_{gp} = 41%.

8.8. Oversættelsesliste vedrørende tabeller

Age	Alder
Ash	Aske
Barley	Byg
Calves	Kalve
Carbon	Kulstof
Clover-grass	Kløvergræs
Concentrates	Kraftfoder
Crude fat	Råfedt
Crude fibre	Træstof
Crude protein	Råprotein
CV	Variationskoefficient
Daily	Daglig
Days	Dage
DE, digested energy	Fordøjet energi
Digested	Fordøjet
Dried sugar beet pulp	Tørrede sukkerroe snitter (Kosetter)
Dry matter	Tørstof
ECH_4	Energi i metan (CH_4)
Fat	Fedt
FE, faeces energy	Energi i gødning
GE, gross energy	Brutto energi
Hay	Hø
HE, heat energy	Energi i varme
High	Høj
Initial	Begyndelse
Intake	Optagelse
Level	Niveau
Linseed expeller	Hørfrøexpeller
Live weight	Legemsvægt
Low	Lav

Mean	Middelværdi
ME, metabolizable energy	Omsættelig energi
N-free extracts	Kvælstoffri ekstraktstoffer
Nitrogen	Kvælstof
Oats	Havre
Organic matter	Organisk stof
Pellets	Piller
RE, retained energy	Aflejret energi
SD, standard deviation	Spredning
SE, standard error of mean	Middelfejl på middeltal
Soybean meal	Sojaskrå
Straw	Halm
UE, urine energy	Energi i urin
Year	År

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Main Tables I

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Contents	Indhold
Age and live weight	Alder og legemsvægt
Intake of nutrients and gross energy	Optaget næringsstoffer og brutto energi
Digestibility of nutrients and gross energy	Fordøjelighed af næringsstoffer og brutto energi

	Abbreviations	Forkortelser
Age:	Age	Alder
W:	Live weight	Legemsvægt
IDM:	Intake of dry matter	Optagelse af tørstof
IOM:	Intake of organic matter	Optagelse af organisk stof
IN:	Intake of nitrogen	Optagelse af kvælstof
IFAT:	Intake of fat	Optagelse af fedt
ICF:	Intake of crude fibre	Optagelse af træstof
INFE:	Intake of N-free extracts	Optagelse af N-fri ekstraktstoffer
IE:	Intake of gross energy	Optagelse af brutto energi
DDM:	Digested dry matter	Fordøjet tørstof
DOM:	Digested organic matter	Fordøjet organisk stof
DN:	Digested nitrogen	Fordøjet kvælstof
DFAT:	Digested fat	Fordøjet fedt
DCF:	Digested crude fibre	Fordøjet træstof
DNFE:	Digested N-free extracts	Fordøjet N-fri ekstraktstoffer
DE:	Digested gross energy	Fordøjet brutto energi

Kalve Serie F 1970 Kraftfoder + hø. (Calves Series F 1970 Concentrates + hay)

Per. No.	Feed Level	Age Days	W kg	IDM g	IOM g	IN g	IFAT g	ICF g	INFE g	IE Mcal	DDM g	DOM g	DN g	DFAT g	DCF g	DNFE g	DE Mcal
Kalv nr. 1																	
I	H	205	184	3453	3263	112	139	374	2046	15.73	2662	2550	88	90	195	1712	11.93
II	H	219	201	3798	3590	121	152	394	2285	17.17	3049	2930	99	82	235	1997	13.39
III	H	233	219	4101	3885	129	168	404	2504	18.68	3112	2994	100	105	156	2105	13.91
IV	H	247	236	4479	4253	128	184	460	2807	20.34	3444	3311	102	141	175	2359	15.46
V	H	261	254	4837	4585	129	198	495	3088	21.92	3827	3673	106	133	238	2638	17.09
VI	L	275	266	3538	3355	99	149	392	2196	16.05	2813	2717	80	104	226	1885	12.66
VII	L	289	273	2683	2521	81	115	328	1576	12.21	2202	2111	68	87	218	1383	10.00
VIII	L	303	281	2722	2557	83	115	333	1591	12.30	2220	2145	69	79	231	1400	10.02
Kalv nr. 2																	
I	H	186	177		Ingen målinger (No measurements)												
II	H	200	189		"		"	"	"								
III	H	214	201	3917	3747	121	163	395	2434	18.01	2990	2898	96	113	147	2038	13.60
IV	H	228	218	4441	4227	126	183	463	2794	20.21	3356	3236	99	125	166	2330	15.09
V	H	242	235		Ingen målinger (No measurements)												
VI	L	256	244	3538	3355	99	149	392	2196	16.05	2865	2751	81	107	237	1901	12.87
VII	L	270	250	2683	2521	81	115	328	1576	12.21	2141	2058	65	84	207	1362	9.71
VIII	L	284	256	2722	2557	83	115	333	1591	12.30	2194	2113	68	79	228	1384	9.88
Kalv nr. 3																	
I	H	169	178	3453	3263	112	139	374	2046	15.73	2594	2492	87	86	161	1701	11.58
II	H	183	196	3746	3541	121	151	377	2261	16.94	2800	2693	97	82	147	1855	12.32
III	H	197	214	4101	3885	129	168	404	2504	18.68	3117	2997	103	106	156	2089	14.07
IV	H	211	230	4496	4269	129	184	466	2815	20.42	3454	3323	105	120	184	2367	15.42
V	H	225	248	4917	4657	131	200	500	3138	22.26	3869	3706	107	137	225	2671	17.38
VI	L	239	261	3487	3307	98	147	376	2171	15.83	2760	2676	79	87	234	1860	12.25
VII	L	253	262	2683	2521	81	115	328	1576	12.21	2194	2097	67	83	215	1377	9.93
VIII	L	267	263	2722	2557	83	115	333	1591	12.30	2188	2104	69	77	224	1371	9.82

Kalve Serie F 1970 Kraftfoder + hø. (Calves Series F 1970 Concentrates + hay)

Per. No.	Feed Level	Age Days	W kg	IDM g	IOM g	IN g	IFAT g	ICF g	INFE g	IE Mcal	DDM g	DOM g	DN g	DFAT g	DCF g	DNFE g	DE Mcal
Kalv nr. 4																	
I	H	177	169	3453	3263	112	139	374	2046	15.73	2675	2553	90	101	173	1713	12.02
II	H	191	185	3832	3622	122	153	406	2301	17.32	3010	2882	100	98	201	1959	13.43
III	H	2o5	2o2	4101	3885	129	168	404	2504	18.68	3048	2928	102	114	125	2047	13.70
IV	H	219	220	4496	4269	129	184	466	2815	20.42	3474	3338	103	132	188	2377	15.60
V	H	233	239	4917	4657	131	200	500	3138	22.26	3870	3704	1o5	140	231	2678	17.38
VI	L	247	254	3496	3315	98	147	378	2175	15.86	2701	2625	78	84	207	1844	11.90
VII	L	261	255	2683	2521	81	115	328	1576	12.21	2173	2073	67	83	200	1368	9.84
VIII	L	275	254	2722	2557	83	115	333	1591	12.30	2171	2080	68	82	214	1357	9.75
Kalv nr. 5																	
I	H	179	174	3453	3263	112	139	374	2046	15.73	2647	2547	84	96	197	1729	11.87
II	H	193	189	3832	3622	122	153	406	2301	17.32	3039	2924	93	108	225	2010	13.55
III	H	207	208	4101	3885	129	168	404	2504	18.68	3244	3117	98	127	210	2167	14.53
IV	H	221	226	4496	4269	129	184	466	2815	20.42	3414	3312	96	97	231	2387	14.94
V	H	235	242	4917	4657	131	200	500	3138	22.26	3990	3837	103	145	317	2729	17.72
Kalv nr. 6																	
I	H	191	176	3272	3095	107	134	345	1947	14.92	2486	2392	82	86	164	1630	11.15
II	H	205	190	3832	3622	122	153	406	2301	17.32	2914	2791	91	95	182	1945	12.90
III	H	219	209	4101	3885	129	168	404	2504	18.68	3161	3040	98	114	192	2121	14.08
IV	H	233	227	4496	4269	129	184	466	2815	20.42	3540	3419	99	106	259	2432	15.65
V	H	247	245	4917	4657	131	200	500	3138	22.26	3881	3721	103	136	258	2684	17.36
VI	L	261	258	3538	3355	99	149	392	2196	16.05	2801	2705	77	92	233	1901	12.54
VII	L	275	256	2683	2521	81	115	328	1576	12.21	2145	2051	66	87	203	1350	9.71
VIII	L	289	261	2722	2557	83	115	333	1591	12.30	2165	2076	64	84	209	1381	9.72

Kalve Serie F 1970 Kraftfoder + hø. (Calves Series F 1970 Concentrates + hay)

Per. No.	Feed Level	AGE Days	W kg	IDM g	IOM g	IN g	IFAT g	ICF g	INFE g	IE Mcal	DDM g	DOM g	DN g	DFAT g	DCF g	DNFE g	DE Mcal
Kalv nr. 7																	
I	H	185	171	3453	3263	112	139	374	2046	15.73	2618	2520	87	94	178	1703	11.81
II	H	199	187	3759	3566	119	152	402	2271	17.06	2722	2622	85	99	167	1825	12.15
III	H	213	208	4101	3885	129	168	404	2504	18.68	3074	2961	95	117	192	2056	13.75
IV	H	227	225	4496	4269	129	184	466	2815	20.42	3513	3377	97	141	246	2385	15.71
V	H	241	240	4917	4657	131	200	500	3138	22.26	3869	3744	101	141	254	2718	17.45
VI	L	255	253	3538	3355	99	149	392	2196	16.05	2777	2680	77	99	225	1876	12.45
VII	L	269	257	Ingen målinger (No measurements)													
VIII	L	283	260	2722	2557	83	115	333	1591	12.30	2135	2048	64	77	201	1368	9.57
Kalv nr. 8																	
I	H	190	162	3212	3037	106	132	331	1913	14.64	2365	2292	79	83	127	1591	10.66
II	H	204	177	3789	3582	121	152	391	2281	17.13	2948	2831	95	89	214	1934	13.02
III	H	218	197	3993	3784	128	164	369	2453	18.19	3143	3026	101	108	173	2111	13.96
IV	H	232	214	4496	4269	129	184	466	2815	20.42	3447	3304	101	126	190	2355	15.40
V	H	246	231	4917	4657	131	200	500	3138	22.26	3918	3778	108	134	264	2706	17.44
VI	L	260	245	3538	3355	99	149	392	2196	16.05	2832	2719	80	111	224	1882	12.68
VII	L	274	248	2683	2521	81	115	328	1576	12.21	2122	2033	65	83	202	1339	9.60
VIII	L	288	252	2722	2557	83	115	333	1591	12.30	2186	2095	67	78	211	1389	9.81

Kalve Serie G 1971 Kraftfoder + kosetter (Calves Series G 1971 Concentrates + dried sugar beet pulp).

Per. No.	Feed Level	AGE Days	W kg	IDM g	IOM g	IN g	IFAT g	ICF g	INFE g	IE Mcal	DDM g	DOM g	DN g	DFAT g	DCF g	DNFE g	DE Mcal
Kalv nr. 1																	
I	H	177	172	3281	3116	109	157	429	1845	15.04	2455	2360	88	116	196	1498	11.15
II	L	198	174	1689	1591	49	67	289	929	7.57	1218	1186	36	43	161	759	5.45
III	H	219	202	3896	3686	130	178	470	2226	17.68	2949	2841	105	130	204	1852	13.28
IV	H	254	243	3960	3749	127	154	495	2309	17.93	2956	2866	96	111	243	1910	13.33
V	L	275	246	2531	2339	58	94	343	1537	10.98	1938	1822	43	65	200	1290	8.30
VI	H	303	279	4359	4131	137	161	510	2604	19.71	3366	3242	107	124	275	2172	15.11
VII	L	324	277	2808	2618	64	92	368	1761	12.19	2130	2026	44	60	208	1484	9.09
Kalv nr. 2																	
I	H	177	164	3281	3116	109	157	429	1845	15.04	2438	2342	87	108	171	1517	11.07
II	L	198	163	1689	1591	49	67	289	929	7.57	1239	1202	37	43	161	766	5.54
III	H	219	190	3896	3686	130	178	470	2226	17.68	2893	2780	103	127	185	1821	12.98
IV	H	254	235	3960	3749	127	154	495	2309	17.93	2854	2758	99	114	183	1841	12.87
V	L	275	231	2531	2339	58	94	343	1537	10.98	1876	1770	41	64	187	1261	8.04
VI	H	303	269	4359	4131	137	161	510	2604	19.71	3192	3092	106	105	200	2124	14.26
VII	L	324	263	2808	2618	64	92	368	1761	12.19	2126	2020	44	61	202	1484	9.06
Kalv nr. 3																	
I	H	168	162	3281	3116	109	157	429	1845	15.04	2400	2303	86	113	172	1478	10.87
II	L	189	156	1689	1591	49	67	289	929	7.57	1221	1184	35	45	166	754	5.43
III	H	210	194	3896	3686	130	178	470	2226	17.68	2862	2741	103	122	171	1801	12.78
IV	H	245	231	3960	3749	127	154	495	2309	17.93	2951	2855	98	113	228	1903	13.25
V	L	266	229	2531	2339	58	94	343	1537	10.98	1894	1788	41	65	192	1271	8.14
VI	H	294	267	4359	4131	137	161	510	2604	19.71	3282	3163	108	119	217	2155	14.68
VII	L	315	263	2808	2618	64	92	368	1761	12.19	2091	1992	44	52	196	1469	8.88

Kalve Serie G 1971 Kraftfoder + kosetter. (Calves Series G 1971 (Concentrates + dried sugar beet pulp).

Per. No.	Feed Level	Age Days	W kg	IDM g	IOM g	IN g	IFAT g	ICF g	INFE g	IE Mcal	DDM g	DOM g	DN g	DFAT g	DCF g	DNFE g	DE Mcal
Kalv nr. 4																	
I	H	172	158	3281	3116	109	157	429	1845	15.04	2436	2344	87	112	189	1498	11.07
II	L	193	156	1689	1591	49	67	289	929	7.57	1236	1195	37	44	164	759	5.51
III	H	214	185	3848	3641	130	177	449	2229	17.46	2841	2717	104	123	159	1786	12.68
IV	H	249	228	3960	3749	127	154	495	2309	17.93	2930	2818	99	118	222	1858	13.16
V	L	270	234	2531	2339	58	94	343	1537	10.98	1917	1805	42	66	201	1275	8.21
VI	H	298	269	4359	4131	137	161	510	2604	19.71	3266	3159	107	114	224	2152	14.66
VII	L	319	262	2808	2618	64	92	368	1761	12.19	2089	1986	45	60	188	1461	8.92
Kalv nr. 5																	
I	H	177	159	3281	3116	109	157	429	1845	15.04	2425	2331	86	104	188	1500	10.95
II	L	198	158	1689	1591	49	67	289	929	7.57	1251	1213	37	48	172	763	5.60
III	H	219	191	3896	3686	130	178	470	2226	17.68	2857	2735	102	121	165	1813	12.78
IV	H	254	225	3960	3749	127	154	495	2309	17.93	2970	2853	97	115	229	1902	13.33
V	L	275	233	2531	2339	58	94	343	1537	10.98	1914	1808	42	69	192	1285	8.23
VI	H	303	272	4359	4131	137	161	510	2604	19.71	3313	3194	108	118	233	2172	14.90
VII	L	324	267	2808	2618	64	92	368	1761	12.19	2171	2060	47	62	214	1491	9.32
Kalv nr. 6																	
I	H	162	154	3281	3116	109	157	429	1845	15.04	2386	2296	87	112	200	1438	10.84
II	L	183	150	1689	1591	49	67	289	929	15.05	1225	1183	36	47	159	751	5.46
III	H	204	185	3896	3886	130	178	470	2226	17.68	2779	2668	101	121	147	1769	12.44
IV	H	239	223	3960	3749	127	154	495	2309	17,93	2948	2837	97	115	233	1883	13.25
V	L	260	224	2531	2339	58	94	343	1537	10.98	1894	1787	42	66	188	1274	8,15
VI	H	288	259	4359	4131	137	161	510	2604	19.71	3302	3179	109	117	241	2138	14.84
VII	L	309	256	2808	2618	64	92	368	1761	12,19	2070	1970	45	58	184	1448	8.87
VIII																	

Kalve Serie G 1971 Kraftfoder + kosetter. (Calves Series G 1971 (Concentrates + dried sugar beet pulp).

Per. No.	Feed Level	Age Days	W kg	IDM g	IOM g	IN g	IFAT g	ICF g	INFE g	IE Mcal	DDM g	DOM g	DN g	DFAT g	DCF g	DNFE g	DE Mcal
Kalv nr. 7																	
I	H	175	154	3281	3116	109	157	429	1845	15.04	2388	2293	85	122	158	1480	1o.83
II	L	196	156	1689	1591	49	67	289	929	7.57	1232	1195	36	49	167	755	5.49
III	H	217	189	3896	3686	130	178	470	2226	17.68	2744	2623	102	110	131	1746	12.19
IV	H	252	228	3960	3749	127	154	495	2309	17.93	2948	2837	98	117	231	1879	13.25
V	L	273	230	2531	2339	58	94	343	1537	10.98	1956	1840	42	68	206	1303	8.39
VI	H	301	267	4359	4131	137	161	510	2604	19.71	3128	3041	107	113	178	2080	13.99
VII	L	322	261	2808	2618	64	92	368	1761	12.19	2069	1977	44	60	187	1457	8.91
Kalv nr. 8																	
I	H	158	154	3281	3116	109	157	429	1845	15.04	2370	2282	86	108	170	1464	10.76
II	L	179	153	1689	1591	49	67	289	929	7.57	1206	1169	36	46	157	741	5.40
III	H	200	189	3896	3686	130	178	470	2226	17.68	2839	2715	103	132	155	1783	12.67
IV	H	235	223	3960	3749	127	154	495	2309	17.93	2947	2841	98	110	226	1891	13.28
V	L	256	228	2531	2339	58	94	343	1537	10.98	1836	1740	41	64	159	1259	7.91
VI	H	284	263	4359	4131	137	161	510	2604	19.71	3197	3081	107	107	182	2125	14.34
VII	L	305	264	2808	2618	64	92	368	1761	12.91	2127	2023	46	61	200	1472	9.15

Kalve Serie H 1972 Kraftfoder + græspiller (Calves Series H 1972 Concentrates + grasspellets).

Per. No.	Feed Level	Age Days	W kg	IDM g	IOM g	IN g	IFAT g	ICF g	INFE g	IE Mcal	DDM g	DOM g	DN g	DFAT g	DCF g	DNFE g	DE Mcal
Kalv nr. 1																	
I	H	160	139	2237	2081	86	112	374	1133	10.12	1568	1480	68	77	174	879	6.98
II	L	181	143	1642	1482	44	77	316	814	7.20	1135	1036	32	51	181	604	4.84
III	H	216	178	3293	3108	118	164	409	1799	15.13	2219	2117	93	115	80	1342	10.05
IV	L	237	173	1961	1757	50	84	328	1032	8.49	1370	1239	36	58	156	799	5.77
V	H	279	212	3247	3030	96	115	559	1759	14.55	2343	2220	72	77	296	1394	1o.34
VI	L	300	209	2079	1846	71	65	443	1049	8.85	1472	1325	58	36	278	806	6.11
VII	H	335	246				Ingen målinger				(No measurements)						
VIII	L	356	241	2348	2090	51	79	432	1258	9.99	1692	1527	37	48	246	1000	7.04
Kalv nr. 2																	
I	H	171	130	2237	2081	86	112	374	1133	10.12	1567	1482	66	73	184	889	6.95
II	L	192	132	1642	1482	44	77	316	814	7.20	1160	1062	32	50	191	624	4.96
III	H	227	164	3293	3108	118	164	409	1799	15.13	2369	2268	91	117	157	1428	10.71
IV	L	248	170	1961	1757	50	84	328	1032	8.49	1322	1197	34	57	150	776	5.53
V	H	290	205	3247	3030	96	115	559	1759	14.55	2390	2257	72	77	314	1417	10.51
VI	L	311	204	2079	1846	71	65	443	1049	8.85	1476	1330	57	37	277	816	6.12
VII	H	346	235	4132	3884	113	160	610	2408	18.47	2961	2837	80	108	287	1945	13.03
VIII	L	367	237	2348	2090	51	79	432	1258	9.99	1703	1541	37	50	249	1011	7.14
Kalv nr. 3																	
I	H	146	125	2237	2081	86	112	374	1133	10.12	1611	1521	68	83	190	900	7.19
II	L	167	129	1642	1482	44	77	316	814	7.20	1109	1017	32	53	170	596	4.76
III	H	202	163				Ingen målinger				(No. Measurements)						
IV	L	223	160	1961	1757	50	84	328	1032	8.49	1303	1174	35	59	138	758	5.44
V	H	265	193	3247	3030	96	115	559	1759	14.55	2248	2127	70	71	263	1353	9.89
VI	L	286	190	2079	1846	71	65	443	1049	8.85	1430	1290	58	39	259	785	5.93
VII	H	321	223				Ingen målinger				(No measurements)						
VIII	L	342	214	2348	2090	51	79	432	1258	9.99	1628	1470	36	52	216	975	6.81

Kalve Serie H 1972 Kraftfoder + græspiller. (Calves Series H 1972 Concentrates + grasspellets).

Per. No.	Feed Level	Age Days	W kg	IDM g	IOM g	IN g	IFAT g	ICF g	INFE g	IE Mcal	DDM g	DOM g	DN g	DFAT g	DCF g	DNFE g	DE Mcal
Kalv nr. 4																	
I	H	130	114	2237	2081	86	112	374	1133	10.12	1591	1508	67	81	184	899	7.13
II	L	151	114	1642	1482	44	77	316	814	7.20	1134	1038	32	55	180	606	4.90
III	H	186	154	3293	3108	118	164	409	1799	15.13	2303	2214	96	62	130	1423	10.24
IV	L	207	150	1961	1757	50	84	328	1032	8.49	1365	1234	36	62	155	790	5.75
V	H	249	194	3247	3030	96	115	559	1759	14.55	2317	2193	72	77	280	1387	10.20
VI	L	270	189	2079	1846	71	65	443	1049	8.85	1431	1295	56	38	267	792	5.92
VII	H	305	233			Ingen målinger				(No measurements)							
VIII	L	326	220	2348	2090	51	79	432	1258	9.99	1637		37	53	223	973	6.84
Kalv nr. 5																	
I	H	141	108	2237	2081	86	112	374	1133	10.12	1538	1452	66	76	173	865	6.85
II	L	162	106	1642	1482	44	77	316	814	7.20	1104	1006	32	57	152	598	4.73
III	H	197	146	3293	3108	118	164	409	1799	15.13	2347	2249	93	109	134	1427	10.65
IV	L	218	143	1961	1757	50	84	328	1032	8.49	1403	1263	37	63	150	821	5.92
V	H	260	183	3247	3030	96	115	559	1759	14.55	2238	2115	70	76	270	1333	9.82
VI	L	281	176	2079	1846	71	65	443	1049	8.85	1409	1258	55	36	242	792	5.83
VII	H	316	219	4132	3884	113	160	610	2408	18.47	2834	2712	80	109	251	1852	12.46
VIII	L	337	210	2348	2090	51	79	432	1258	9.99	1590	1428	35	48	216	947	6.58
Kalv nr. 6																	
I	H	135	114	2237	2081	86	112	374	1133	10.12	1579	1485	67	78	183	879	7.00
II	L	156	116	1642	1482	44	77	316	814	7.20	1152	1053	32	55	178	621	4.94
III	H	191	154	3293	3108	118	164	409	1799	15.13	2310	2213	94	113	127	1387	10.52
IV	L	212	155	1961	1757	50	84	328	1032	8.49	1386	1248	35	61	144	823	5.82
V	H	254	187	3247	3030	96	115	559	1759	14.55	2333	2207	71	75	289	1397	10.23
VI	L	275	193	2079	1846	71	65	443	1049	8.85	1454	1301	57	37	262	802	6.01
VII	H	310	232	4132	3884	113	160	610	2408	18.47	2986	2860	82	117	320	1911	13.15
VIII	L	331	227	2348	2090	51	79	432	1258	9.99	1627	1466	35	49	222	976	6.75

Kalve Serie H 1972 Kraftfoder + græspiller. (Calves Series H 1972 Concentrates + grasspellets).

Per. No.	Feed Level	Age Days	W kg	IDM g	IOM g	IN g	IFAT g	ICF g	INFE g	IE Mcal	DDM g	DOM g	DN g	DFAT g	DCF g	DNFE g	DE Mcal
Kalv nr. 7																	
I	H	101	100	2237	2081	86	112	374	1133	10.12	1497	1417	65	47	157	882	6.56
II	L	122	98	1642	1482	44	77	316	814	7.20	1140	1038	31	50	169	624	4.85
III	H	157	136	3293	3108	118	164	409	1799	15.13	2230	2130	90	118	99	1354	10.11
IV	L	178	139	1961	1757	50	84	328	1032	8.49	1408	1263	37	63	139	831	5.91
V	H	220	171	3247	3030	96	115	559	1759	14.55	2246	2139	69	70	260	1375	9.84
VI	L	241	177	2079	1846	71	65	443	1049	8.85	1417	1263	57	35	242	787	5.85
VII	H	276	214	4132	3884	113	160	610	2408	18.47	2910	2783	82	113	284	1873	12.81
VIII	L	297	213	2348	2090	51	79	432	1258	9.99	1569	1409	34	44	212	938	6.48
Kalv nr. 8																	
I	H	108	108	2237	2081	86	112	374	1133	10.12	1658	1564	70	66	210	925	7.34
II	L	129	107	1642	1482	44	77	316	814	7.20	1149	1048	32	53	180	613	4.91
III	H	164	148	3293	3108	118	164	409	1799	15.13	2404	2291	97	128	154	1405	10.94
IV	L	185	147	1961	1757	50	84	328	1032	8.49	1388	1249	35	57	161	809	5.78
V	H	227	187	3247	3030	96	115	559	1759	14.55	2393	2261	74	68	324	1404	10.54
VI	L	248	188	2079	1846	71	65	443	1049	8.85	1420	1273	57	36	250	784	5.87
VII	H	283	231	4132	3884	113	160	610	2408	18.47	3021	2887	85	119	322	1914	13.30
VIII	L	304	231	2348	2090	51	79	432	1258	9.99	1625	1468	37	47	243	949	6.74

Main Tables II

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Metabolizable energy and heat loss	Omsættelig energi og varmetab
Protein-fat- and total energy gain	Protein-fedt- og total energiaflejring

	Abbreviations	Forkortelser
Age:	Age	Alder
W:	Live weight	Legemsvægt
CO_2:	CO_2 production	CO_2-produktion
CH_4:	CH_4 production	CH_4-produktion
RC:	Retained carbon	Aflejret kulstof
DN:	Digested nitrogen	Fordøjet kvælstof
UN:	Urine nitrogen	Urin kvælstof
RN:	Retained nitrogen	Aflejret kvælstof
IE:	Intake of gross energy	Optagelse af brutto energi
ME:	Metabolizable energy	Omsættelig energi
HE(CN):	Total heat energy	Total varme energi
PROT GAIN:	Protein gain	Aflejret protein
FAT GAIN:	Fat gain	Aflejret fedt
ENERGY GAIN:	Total energy gain	Aflejret total energi

Kalve Serie F 1970 Kraftfoder + hø. (Calves Series F 1970 Concentrates + hay).

Per. No.	Feed Level	Age Days	W kg	CO_2 l	CH_4 l	RC g	DN g	UN g	RN g	IE Mcal	ME Mcal	HE (CN) Mcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Kalv nr. 1															
I	H	205	184	1640	124	238	88.4	47.6	40.8	15.73	10.13	7.37	1454	1303	2757
II	H	219	201	1985	92	217	98.6	56.4	42.2	17.17	11.77	9.27	1504	993	2497
III	H	233	219	2033	169	205	100.3	50.9	49.4	18.68	11.63	9.33	1760	545	2306
IV	H	247	236	2212	94	276	101.9	56.5	45.4	20.34	13.78	10.57	1619	1595	3214
V	H	261	254	2288	96	398	106.0	44.5	61.5	21.92	15.41	10.77	2189	2453	4642
VI	L	275	266	1991	139	91	80.2	50.7	29.5	16.05	10.58	9.60	1052	- 66	986
VII	L	289	273	1617	138	28	67.9	51.6	16.2	12.21	7.94	7.67	578	- 309	269
VIII	L	303	281	1648	162	0	69.4	52.7	16.8	12.30	7.69	7.77	598	- 677	- 79
Kalv nr. 2															
I	H	186	177		Ingen målinger					(No measurements)					
II	H	200	189		"	"				"	"				
III	H	214	201	1985	73	223	95.8	55.4	40.4	18.01	12.17	9.59	1440	1139	2579
IV	H	228	218	2059	105	304	98.5	55.9	42.6	2o.21	13.32	9.75	1517	2053	3570
V	H	242	235		Ingen målinger					(No measurements)					
VI	L	256	244	1829	175	183	80.9	49.4	31.6	16.05	10.52	8.40	1124	996	2120
VII	L	270	250	1533	133	36	64.9	52.2	12.7	12.21	7.75	7.37	453	- 72	381
VIII	L	284	256	1579	153	41	67.7	48.0	19.7	12.30	7.78	7.36	702	- 284	418
Kalv nr. 3															
I	H	169	178	1702	135	176	87.1	45.6	41.5	15.73	9.67	7.68	1479	508	1987
II	H	183	196	1767	69	231	97.4	53.7	43.8	16.94	10.94	8.29	1559	1095	2654
III	H	197	214	2055	75	245	103.2	56.4	46.9	18.68	12.58	9.76	1669	1147	2816
IV	H	211	230	2144	68	316	104.5	51.8	52.7	20.42	14.00	10.33	1877	1799	3676
V	H	225	248	2406	101	355	107.5	57.8	49.7	22.26	15.64	11.48	1771	2393	4164
VI	L	239	261	1693	118	236	79.3	50.6	28.7	15.83	10.44	7.65	1021	1765	2786
VII	L	253	262	1561	149	43	67.4	50.4	17.1	12.21	7.81	7.36	607	- 155	452
VIII	L	267	263	1526	144	61	69.0	51.3	17.7	12.30	7.73	7.06	631	42	673

Kalve Serie F 1970 Kraftfoder + hø. (Calves Series F 1970 Concentrates + hay).

Per. No.	Feed Level	Age Days	W kg	CO_2 l	CH_4 l	RC g	DN g	UN g	RN g	IE Mcal	ME Mcal	HE (CN) Mcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Kalv nr. 4															
I	H	177	169	1610	34	318	90.4	46.2	44.2	15.73	11.08	7.35	1575	2161	3736
II	H	191	185	1843	54	307	99.8	54.1	45.7	17.32	12.22	8.62	1627	1969	3597
III	H	205	202	1895	50	309	102.4	57.7	44.7	18.68	12.47	8.84	1593	2031	3624
IV	H	219	220	2061	60	380	102.8	59.1	43.6	20.42	14.25	9.75	1554	2944	4498
V	H	233	239	2261	45	460	104.8	53.0	51.8	22.26	16.20	1o.74	1846	3616	5462
VI	L	247	254	1868	74	121	78.5	58.6	19.9	15.86	10.34	8.93	708	704	1412
VII	L	261	255	1468	136	86	67.5	49.9	17.6	12.21	7.77	6.78	625	359	984
VIII	L	275	254	1518	150	56	68.4	47.5	21.0	12.30	7.66	7.06	747	- 146	601
Kalv nr. 5															
I	H	179	174	1626	133	237	83.9	47.0	36.8	15.73	9.97	7.20	1312	1453	2766
II	H	193	189	1711	133	340	92.8	53.6	39.3	17.32	11.56	7.53	1399	2629	4028
III	H	207	208	1897	150	339	98.3	41.4	56.9	18.68	12.52	8.59	2028	1904	3932
IV	H	221	226	2149	161	237	95.8	48.8	47.0	20.42	12.70	9.99	1674	1038	2713
V	H	235	242	2332	210	357	103.4	62.3	41.1	22.26	14.81	10.58	1465	2765	4230
VI					Forsøget afbrudt						(Experiment stopped)				
Kalv nr. 6															
I	H	191	176	1516	116	237	81.6	44.9	36.7	14.92	9.47	6.70	1308	1457	2765
II	H	205	190	1809	124	242	91.2	47.8	43.4	17.32	11.08	8.29	1545	1248	2792
III	H	219	209	1905	132	296	98.0	51.4	46.6	18.68	12.14	8.69	1660	1792	3452
IV	H	233	227	2099	142	338	99.3	51.3	47.9	20.42	13.58	9.62	1707	2251	3959
V	H	247	245	2388	175	307	103.0	61.4	41.7	22.26	14.80	11.19	1484	2129	3613
VI	L	261	258	1836	122	176	76.7	47.7	29.0	16.05	10.69	8.65	1032	1011	2044
VII	L	275	256	1590	135	14	65.8	48.0	17.8	12.21	7.74	7.65	633	- 543	90
VIII	L	289	261	1560	143	30	64.3	53.8	10.5	12.30	7.70	7.38	375	- 55	320

Kalve Serie F 1970 Kraftfoder + hø. (Calves Series F 1970 Concentrates + hay).

Per. No.	Feed Level	Age Days	W kg	CO_2 l	CH_4 l	RC g	DN g	UN g	RN g	IE Mcal	ME Mcal	HE (CN) Mcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Kalv nr. 7															
I	H	185	171	1596	131	240	87.2	50.3	36.9	15.73	9.91	7.10	1313	1492	2805
II	H	199	187	1779	114	183	85.2	42.3	42.9	17.06	10.46	8.39	1527	547	2074
III	H	213	208	1804	125	316	95.4	44.9	50.5	18.68	11.91	8.23	1798	1878	3677
IV	H	227	225	2056	182	337	96.6	47.7	48.9	20.42	13.32	9.38	1741	2200	3942
V	H	241	240	2309	188	365	101.1	53.4	47.8	22.26	14.89	10.60	1701	2592	4294
VI	L	255	253	1768	166	175	76.8	45.5	31.3	16.05	10.23	8.20	1114	914	2028
VII					Ingen målinger						(No measurements)				
VIII	L	283	260	1478	136	63	64.2	51.2	13.1	12.30	7.64	6.92	466	253	719
Kalv nr. 8															
I	H	190	162	1588	84	152	78.6	42.9	35.6	14.64	9.29	7.58	1269	443	1712
II	H	204	177	1850	123	225	95.1	50.6	44.4	17.13	11.17	8.59	1583	996	2579
III	H	218	197	2082	59	228	101.3	46.5	54.8	18.19	12.68	10.11	1952	620	2572
IV	H	323	214	2221	100	259	101.1	45.9	55.3	20.42	13.77	10.82	1968	988	2956
V	H	246	231	2469	68	346	107.9	52.6	55.2	22.26	15.93	11.89	1968	2067	4035
VI	L	260	245	1799	163	181	80.4	50.6	29.8	16.05	10.37	8.27	1060	1042	2103
VII	L	274	248	1540	135	24	65.4	57.6	7.9	12.21	7.69	7.44	280	- 23	257
VIII	L	288	252	1521	138	55	66.7	58.0	8.7	12.30	7.80	7.16	310	332	641

Kalve Serie G 1971 Kraftfoder + kosetter. (Calves Series G 1971 Concentrates + dried sugar beet pulp).

Per. No.	Feed Level	Age Days	W kg	CO_2 l	CH_4 l	RC g	DN g	UN g	RN g	IE Mcal	ME Mcal	HE (CN) Mcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Kalv nr. 1															
I	H	177	172	1492	84	235	88.2	56.1	32.1	15.04	9.68	6.92	1144	1613	2757
II	L	198	174	1017	70	- 49	35.8	30.7	5.1	7.57	4.40	5.04	182	- 816	- 634
III	H	219	202	1938	108	224	104.7	52.9	51.8	17.68	11.55	9.01	1847	686	2532
IV	H	254	243	1865	111	248	96.3	64.7	31.6	17.93	11.48	8.55	1125	1799	2925
V	L	275	246	1403	136	10	42.7	28.6	14.1	10.98	6.61	6.55	503	- 440	63
VI	H	303	279	2117	139	292	107.3	65.1	42.2	19.71	13.03	9.61	1503	1916	3418
VII	L	324	277	1564	127	1	43.7	33.7	10.0	12.19	7.40	7.44	356	- 392	- 36
Kalv nr. 2															
I	H	177	164	1571	53	204	87.3	48.3	39.0	15.04	9.94	7.59	1388	962	2349
II	L	198	163	1032	71	- 42	37.0	27.4	9.6	7.57	4.51	5.08	343	- 911	- 567
III	H	219	190	1896	60	242	103.4	45.9	57.5	17.68	11.76	9.02	2047	690	2737
IV	H	254	235	1942	64	187	99.3	58.3	41.0	17.93	11.49	9.37	1461	668	2129
V	L	275	231	1416	110	- 5	41.1	25.0	16.1	10.98	6.64	6.78	573	- 710	- 136
VI	H	303	269	2199	88	201	106.1	63.6	42.5	19.71	12.67	10.37	1513	781	2294
VII	L	324	263	1557	112	15	43.5	32.5	11.0	12.19	7.58	7.45	393	- 260	133
Kalv nr. 3															
I	H	168	162	1595	63	174	86.3	41.0	45.3	15.04	9.69	7.74	1613	332	1946
II	L	189	156	978	68	- 29	35.0	26.5	8.4	7.57	4.47	4.87	301	-704	- 403
III	H	210	194	1760	70	281	103.5	51.4	52.1	17.68	11.39	8.15	1856	1379	3235
IV	H	245	231	1840	88	272	97.7	60.9	36.9	17.93	11.65	8.46	1313	1880	3193
V	L	266	229	1349	114	34	41.5	27.8	13.7	10.98	6.68	6.33	487	- 136	351
VI	H	294	267	2119	100	265	107.6	65.9	41.7	19.71	12.84	9.75	1486	1608	3094
VII	L	315	263	1480	120	31	43.7	34.9	8.8	12.19	7.29	6.95	315	26	341

Kalve Serie G 1971 Kraftfoder + kosetter. (Calves Series G 1971 Concentrates + dried sugar beet pulp).

Per. No.	Feed Level	Age Days	W kg	CO_2 l	CH_4 l	RC g	DN g	UN g	RN g	IE Mcal	ME Mcal	HE (CN) Mcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Kalv nr. 4															
I	H	172	158	1521	67	238	87.2	49.3	37.9	15.04	9.81	7.04	1350	1417	2767
II	L	193	156	974	74	- 22	36.5	26.2	10.3	7.57	4.47	4.80	368	- 693	- 325
III	H	214	185	1887	84	197	103.7	53.3	50.4	17.46	11.13	8.93	1795	407	2202
IV	H	249	228	1823	84	275	99.4	58.4	41.0	17.93	11.61	8.39	1460	1757	3217
V	L	270	234	1363	117	39	42.1	25.9	16.3	10.98	6.75	6.35	580	- 178	402
VI	H	298	269	2017	91	338	107.1	62.4	44.7	19.71	13.06	9.09	1592	2381	3973
VII	L	319	262	1608	135	- 40	44.6	32.5	12.0	12.19	7.07	7.62	428	- 982	- 553
Kalv nr. 5															
I	H	177	159	1568	61	197	86.1	42.0	44.1	15.04	9.82	7.59	1571	659	2230
II	L	198	158	993	67	- 17	36.8	24.3	12.5	7.57	4.64	4.91	445	- 710	- 265
III	H	219	191	1738	79	296	101.8	51.8	50.0	17.68	11.34	7.90	1782	1657	3439
IV	H	254	225	1925	105	231	97.4	50.8	46.5	17.93	11.70	9.06	1658	987	2645
V	L	275	233	1353	118	46	42.0	24.5	17.4	10.98	6.76	6.27	621	- 130	491
VI	H	303	272	2174	129	253	107.7	57.8	49.9	19.71	12.89	9.99	1779	1117	2896
VII	L	324	267	1514	135	66	46.8	25.9	20.9	12.19	7.67	6.96	745	- 30	715
Kalv nr. 6															
I	H	162	154	1470	58	222	87.2	55.9	31.3	15.04	9.59	6.98	1115	1492	2607
II	L	183	150	939	69	- 4	36.1	29.5	6.7	7.57	4.45	4.54	237	- 321	- 84
III	H	204	185	1745	75	256	101.1	52.4	48.7	17.68	11.03	8.08	1735	1215	2950
IV	H	239	223	1834	96	277	97.1	78.8	18.3	17.93	11.52	8.17	650	2695	3345
V	L	260	224	1327	96	60	41.6	31.1	10.5	10.98	6.90	6.21	373	324	697
VI	H	288	259	2087	145	286	109.4	56.2	53.3	19.71	12.83	9.54	1898	1392	3289
VII	L	309	256	1472	121	40	44.9	33.1	11.8	12.19	7.29	6.84	419	23	441

Kalve Serie G 1971 Kraftfoder + kosetter. (Calves Series G 1971 Concentrates + dried sugar beet pulp).

Per. No.	Feed Level	Age Days	W kg	CO_2 l	CH_4 l	RC g	DN g	UN g	RN g	IE Mcal	ME Mcal	HE (CN) Mcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Kalv nr. 7															
I	H	175	154	1497	74	216	85.3	38.1	47.1	15.o4	9.60	7.14	1679	783	2461
II	L	196	156	975	76	- 23	35.8	22.5	13.3	7.57	4.48	4.82	473	- 813	- 340
III	H	217	189	1755	49	239	101.8	46.7	55.1	17.68	11.04	8.33	1962	749	2711
IV	H	252	228	1923	89	238	97.6	46.9	50.7	17.93	11.79	9.07	1805	907	2712
V	L	273	230	1403	126	31	42.1	23.1	19.0	10.98	6.88	6.59	675	- 383	292
VI	H	301	267	1877	88	331	107.3	65.8	41.5	19.71	12.27	8.36	1478	2428	3906
VII	L	322	261	1536	130	1	43.5	30.0	13.6	12.19	7.25	7.31	483	- 540	- 57
Kalv nr. 8															
I	H	158	154	1439	60	241	86.3	44.6	41.7	15.o4	9.58	6.79	1484	1306	2790
II	L	179	153	940	70	- 13	36.1	24.6	11.4	7.57	4.44	4.66	407	- 627	- 220
III	H	200	189	1800	72	245	103.2	50.5	52.7	17.68	11.25	8.47	1877	909	2786
IV	H	235	223	1826	88	288	98.3	56.2	42.1	17.93	11.73	8.35	1499	1873	3372
V	L	256	228	1327	107	32	41.3	32.4	8.9	10.98	6.54	6.19	317	35	352
VI	H	284	263	2029	82	286	107.0	59.5	47.5	19.71	12.84	9.51	1691	1636	3327
VII	L	305	264	1561	139	13	46.4	34.0	12.4	12.19	7.40	7.29	440	- 334	106

Kalve Serie H 1972 Kraftfoder + græspiller (Calves Series H Concentrates + grasspellets).

Per. No.	Feed Level	Age Days	W kg	CO_2 l	CH_4 l	RC g	DN g	UN g	RN g	IE Mcal	ME Mcal	HE (CN) Mcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Kalv nr. 1															
I	H	160	139	925	69	143	68.3	37.8	30.5	10.12	5.80	4.17	1086	544	1630
II	L	181	143	808	67	1	32.0	23.5	8.5	7.20	3.95	3.98	302	- 329	- 27
III	H	216	178	1446	34	173	92.7	49.3	43.4	15.13	9.14	7.20	1547	393	1940
IV	L	237	173	1080	73	- 63	36.2	26.1	10.1	8.49	4.69	5.51	360	-1185	- 825
V	H	279	212	1447	93	190	72.4	45.6	26.8	14.55	8.82	6.59	955	1267	2223
VI	L	300	209	1067	82	- 21	57.7	30.1	27.7	8.85	4.89	5.28	986	-1375	- 390
VII	H	335	246			Ingen målinger				(No measurements)					
VIII	L	356	241	1236	87	- 25	37.3	31.9	5.3	9.99	5.78	6.11	189	- 522	- 333
Kalv nr. 2															
I	H	171	130	1022	86	85	65.8	39.5	26.3	10.12	5.67	4.74	938	- 8	930
II	L	192	132	763	61	39	31.6	27.8	3.8	7.20	4.07	3.60	134	331	466
III	H	227	164	1507	113	163	90.7	47.2	43.4	15.13	8.99	7.18	1547	265	1812
IV	L	248	170	1019	68	- 46	34.1	22.4	11.6	8.49	4.57	5.19	414	-1037	- 624
V	H	290	205	1537	131	146	71.9	41.6	30.3	14.55	8.66	6.99	1079	587	1667
VI	L	311	204	1085	79	- 26	56.9	30.3	26.6	8.85	4.94	5.39	948	-1396	- 448
VII	H	346	235	1775	167	273	79.6	38.3	41.3	18.47	11.08	7.88	1472	1723	3195
VIII	L	367	237	1163	89	31	37.0	31.2	5.8	9.99	5.89	5.54	207	146	353
Kalv nr. 3															
I	H	146	125	959	76	147	67.7	40.4	27.3	10.12	6.00	4.30	974	723	1697
II	L	167	129	766	62	13	31.9	27.3	4.5	7.20	3.83	3.69	162	- 23	139
III	H	202	163			Ingen målinger				(No measurements)					
IV	L	223	160	1057	81	- 77	35.1	18.9	16.2	8.49	4.38	5.40	577	-1605	-1029
V	H	265	193	1423	98	172	70.4	36.0	34.4	14.55	8.47	6.49	1226	748	1974
VI	L	286	190	1020	71	0	58.0	30.3	27.7	8.85	4.86	4.99	985	-1111	- 126
VII	H	321	223			Ingen målinger				(No measurements)					
VIII	L	342	214	1167	87	2	36.5	32.7	3.8	9.99	5.57	5.56	135	- 126	9

Kalve Serie H 1972 Kraftfoder + græspiller. (Calves Series H 1972 Concentrates + grasspellets).

Per. No.	Feed Level	Age Days	W kg	CO_2 l	CH_4 l	RC g	DN g	UN g	RN g	IE Mcal	ME Mcal	HE (CN) Mcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Kalv nr. 4															
I	H	130	114	941	83	144	67.3	40.6	26.7	10.12	5.88	4.22	951	706	1657
II	L	151	114	724	52	54	31.6	26.7	4.9	7.20	4.09	3.44	176	470	646
III	H	186	154	1427	59	195	95.9	59.7	36.2	15.13	8.97	6.72	1290	960	2250
IV	L	207	150	944	69	22	36.3	23.8	12.6	8.49	4.73	4.51	447	- 229	218
V	H	249	194	1459	128	161	71.7	37.8	34.0	14.55	8.42	6.59	1209	622	1831
VI	L	270	189	1049	79	- 20	56.4	26.3	30.1	8.85	4.77	5.15	1071	-1457	- 386
VII	H	305	233			Ingen målinger				(No measurements)					
VIII	L	326	220	1188	84	- 8	36.9	30.8	6.1	9.99	5.63	5.75	217	- 338	- 121
Kalv nr. 5															
I	H	141	108	964	65	110	66.2	34.4	31.8	10.12	5.79	4.57	1133	86	1220
II	L	162	106	738	62	26	31.8	25.9	5.9	7.20	3.84	3.54	209	87	296
III	H	197	146	1377	38	276	92.7	49.5	43,2	15.13	9.71	6.49	1538	1678	3216
IV	L	218	143	1026	71	- 9	36.6	24.4	12.3	8.49	4.91	5.08	437	- 602	- 165
V	H	260	183	1360	109	184	69.7	40.5	29.2	14.55	8.26	6.11	1040	1103	2144
VI	L	281	176	1018	75	- 13	54.9	24.9	30.0	8.85	4.74	5.03	1070	-1368	- 298
VII	H	316	219	1706	124	256	79.9	41.4	38.5	18.47	10.69	7.70	1370	1627	2998
VIII	L	337	210	1130	83	- 3	34.9	30.9	4.0	9.99	5.36	5.42	142	- 201	- 59
Kalv nr. 6															
I	H	135	114	1004	85	99	67.4	36.7	30.7	10.12	5.72	4.64	1092	- 14	1o78
II	L	156	116	748	63	42	31.8	23.8	8.0	7.20	4.04	3.56	285	197	482
III	H	191	154	1420	38	224	93.6	50.4	43.2	15.13	9.42	6.86	1538	1031	2569
IV	L	212	155	1o13	72	- 9	35.2	21.0	14.2	8.49	4.84	5.02	505	- 688	- 183
V	H	254	187	1462	112	165	71.4	40.8	30.6	14.55	8.55	6.65	1089	818	1907
VI	L	275	193	1040	83	- 5	56.9	22.8	34.1	8.85	4.88	5.10	1215	-1440	- 224
VII	H	310	232	1856	138	237	81.9	44.7	37.1	18.47	11.18	8.41	1323	1445	2768
VIII	L	331	227	1169	98	- 22	35.1	32.8	2.2	9.99	5.15	5.43	80	- 361	- 282

Kalve Serie H 1972 Kraftfoder + græspiller. (Calves Series H 1972 Concentrates + grasspellets).

Per. No.	Feed Level	Age Days	W kg	CO_2 l	CH_4 l	RC g	DN g	UN g	RN g	IE Mcal	ME Mcal	HE (CN) Mcal	PROT GAIN kcal	FAT GAIN kcal	ENERGY GAIN kcal
Kalv nr. 7															
I	H	101	100	936	57	106	65.2	35.6	29.6	10.12	5.57	4.39	1055	124	1179
II	L	122	98	740	56	47	31.1	21.5	9.7	7.20	4.05	3.51	344	188	533
III	H	157	136	1369	35	221	89.5	41.6	47.9	15.13	9.24	6.72	1707	813	2521
IV	L	178	139	962	77	28	36.8	17.9	18.9	8.49	4.91	4.65	674	- 410	264
V	H	220	171	1440	103	147	69.4	32.9	36.5	14.55	8.38	6.73	1301	353	1654
VI	L	241	177	997	78	10	56.8	18.7	38.1	8.85	4.83	4.88	1356	-1412	- 56
VII	H	276	214	1780	133	248	82.0	30.1	51.9	18.47	11.05	8.22	1849	987	2837
VIII	L	297	213	1128	85	3	34.3	20.1	14.3	9.99	5.40	5.43	508	- 542	- 34
Kalv nr. 8															
I	H	108	108	924	83	170	70.3	37.9	32.4	10.12	6.07	4.11	1153	805	1959
II	L	129	107	712	54	66	32.2	21.4	10.8	7.20	4.09	3.32	386	385	770
III	H	164	148	1431	45	251	96.7	49.6	47.1	15.13	9.80	6.90	1676	1219	2896
IV	L	185	147	977	68	8	35.4	19.5	15.9	8.49	4.82	4.80	566	- 547	19
V	H	227	187	1483	105	187	74.4	42.0	32.5	14.55	8.90	6.73	1156	1008	2164
VI	L	248	188	1044	76	- 23	57.4	22.1	35.3	8.85	4.81	5.26	1257	-1707	- 450
VII	H	283	231	1858	139	233	85.3	48.4	36.9	18.47	11.28	8.57	1313	1400	2713
VIII	L	304	231	1228	88	- 44	36.6	27.1	9.5	9.99	5.35	5.94	337	- 931	- 594