

## Effect of energy density of diets for intensive bull beef production on intake, growth rate and feed conversion

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### Abstract

The impact of the energy concentration (kg SU/kg DM) of *ad libitum* fed diets, on intake, growth rate and efficiency was investigated with 119 groups loose housed Belgian white-blue store bulls (I), 62 groups of individually tied up Belgian white-blue store bulls (II) and 42 groups of individually tied up Belgian white-red baby-beef bulls (III). We established a negative relationship between the energy density ( $x$ ) and the dry matter intake ( $y = g$  DM/kg W<sup>0.75</sup>).

Group I :  $y = 136.1 - 68.7 x$ ;  $r = -0.72^{**}$ ; SD = 5.0

Group II :  $y = 139.2 - 87.6 x$ ;  $r = -0.67^{**}$ ; SD = 7.0

Group III :  $y = 120.6 - 51.1 x$ ;  $r = -0.49^{**}$ ; SD = 5.5

Within the studied range of energy density (0.53 to 0.89 kg SU/kg DM) the relationship with energy intake ( $y = g$  SU/kg W<sup>0.75</sup>) was positive :

Group I :  $y = 33.2 + 40.0 x$ ;  $r = 0.67^{**}$ ; SD = 3.3

Group II :  $y = 41.6 + 17.9 x$ ;  $r = 0.28^*$ ; SD = 4.3

Group III :  $y = 30.6 + 41.2 x$ ;  $r = 0.52^{**}$ ; SD = 4.1

The increasing energy intake with higher energy densities ( $x$ ) resulted in an increasing growth rate ( $y = g/d$ ) (except for group II) but the correlation was lower :

Group I :  $y = 708.1 + 780.6 x$ ;  $r = 0.49^{**}$ ; SD = 105.8

Group II :  $y = 1009.4 + 119.5 x$ ;  $r = 0.09$  NS; SD = 93.8

Group III :  $y = 823.5 + 464.6 x$ ;  $r = 0.36^*$ ; SD = 71.3

The feed conversion ( $y = kg$  SU/kg gain) in function of the energy concentration ( $x$ ) did not indicate a significant relationship for two of the three groups :

Group I :  $y = 4.31 + 0.61 x$ ;  $r = 0.12$  NS; SD = 0.37

Group II :  $y = 2.84 + 2.35 x$ ;  $r = 0.42^{**}$ ; SD = 0.37

Group III :  $y = 3.79 + 0.22 x$ ;  $r = 0.06$  NS; SD = 0.22

*Ad libitum* feeding of higher energetic rations resulted in decreased dry matter and increased net energy intake. Daily liveweight gain was positively affected by a higher energy density, while the influence on the feed conversion was very small, except for the tied store bulls.

## Résumé

### *Influence de la concentration énergétique des rations sur la consommation, la vitesse de croissance et l'efficacité alimentaire de jeunes bovins intensifs*

Les auteurs ont étudié les effets de la concentration énergétique (Valeur Amidon/kg de MS) de rations offertes à volonté sur la consommation, la vitesse de croissance et l'efficacité alimentaire de 119 lots de taurillons Blanc-Bleu-Belges en stabulation libre (I), 62 lots de taurillons Blanc-Bleu-Belges en stabulation entravée (II) et de 42 groupes de taurillons Blanc-Rouge-Belges en stabulation entravée (III). Ils ont établi une liaison négative entre la concentration énergétique ( $x$ ) et la quantité de matière sèche ingérée ( $y = \text{MS/kg poids}^{0,75}$ ).

$$\text{Lot I : } y = 136,1 - 68,7 x ; r = -0,72^{**} ; \text{SD} = 5,0$$

$$\text{Lot II : } y = 139,2 - 87,6 x ; r = -0,67^{**} ; \text{SD} = 7,0$$

$$\text{Lot III : } y = 120,6 - 51,1 x ; r = -0,49^{**} ; \text{SD} = 5,5$$

Dans l'intervalle de concentration énergétique considéré (0,53 à 0,89 UA/kg MS) la liaison avec la quantité d'énergie ingérée ( $y = \text{UA/kg P}^{0,75}$ ) a été positive.

$$\text{Lot I : } y = 33,2 + 40,0 x ; r = 0,67^{**} ; \text{SD} = 3,3$$

$$\text{Lot II : } y = 41,6 + 17,9 x ; r = 0,28^* ; \text{SD} = 4,3$$

$$\text{Lot III : } y = 30,6 + 41,2 x ; r = 0,52^{**} ; \text{SD} = 4,1$$

L'accroissement de la quantité d'énergie ingérée lié à celui de la concentration énergétique ( $x$ ) a entraîné une augmentation de la vitesse de croissance ( $y = \text{g/jour}$ ) (sauf pour le lot II), mais avec de plus faibles corrélations.

$$\text{Lot I : } y = 708,1 + 780,6 x ; r = 0,49^{**} ; \text{SD} = 105,8$$

$$\text{Lot II : } y = 1009,4 + 119,5 x ; r = 0,09 \text{ NS} ; \text{SD} = 93,8$$

$$\text{Lot III : } y = 823,5 + 464,6 x ; r = 0,36^* ; \text{SD} = 71,3$$

La relation entre le coût énergétique du kg de gain ( $y = \text{VA/kg gain}$ ) et la concentration énergétique ( $x$ ) n'a pas été significative pour 2 des 3 lots.

$$\text{Lot I : } y = 4,31 + 0,61 x ; r = 0,12 \text{ NS} ; \text{SD} = 0,37$$

$$\text{Lot II : } y = 2,84 + 2,35 x ; r = 0,42^{**} ; \text{SD} = 0,37$$

$$\text{Lot III : } y = 3,79 + 0,22 x ; r = 0,06 \text{ NS} ; \text{SD} = 0,22$$

La distribution à volonté de rations de plus en plus riches en énergie a entraîné une réduction de la quantité de matière sèche ingérée et une augmentation de la quantité d'énergie ingérée ; les gains de poids vif journaliers ont été améliorés par l'accroissement de la concentration énergétique tandis que l'efficacité alimentaire a été peu modifiée, sauf pour les taurillons II en stabulation entravée.

## 1. — Introduction

There is a great diversity of beef production in Europe, due in part to the large number of breeds with their own genotype. Bulls of Anglo-Saxon and dairy breeds have an early maturity which results in fatter carcasses compared to the continental beef breeds. The variability in the performance of beef cattle can be

further enhanced when animals receive different feeding levels (GEAY and ROBELIN, 1979). A higher energy level either increased the fat content in the carcass at equal carcass weights, or decreased carcass weight at an equal fat content (CALLOW, 1961 ; HENRICKSON *et al.*, 1965 ; GARRIGUS *et al.*, 1969 ; WALDMAN *et al.*, 1971 ; BOND *et al.*, 1972 ; ANDERSEN, 1975). When reared in the same conditions, bulls of different breeds with equal carcass weights gave a different fat content in the carcass or when the fat content was comparable, there was a difference in carcass weight (GEAY and MALTERRE, 1973).

Variability also exists concerning feed conversion data cited in the literature, even within the same category of animals fattened with comparable diets. The starch equivalent intake per kg of liveweight gain of Israeli-Friesian male cattle was 3.8 to 4.2 kg (LEVY *et al.*, 1968 and 1970) while similar bulls of the Belgian white-red breed had a better feed conversion : 2.9 to 3.4 (BUYSSE, 1969 ; BUYSSE and BOUCQUE, 1975).

However, there is no agreement concerning the effect of decreasing the level of energy intake on feed efficiency. Some feeding experiments reported a better efficiency on a restricted energy level (DE BOER *et al.*, 1971 ; BOND *et al.*, 1972 ; LEVY *et al.*, 1974 ; ANDERSEN, 1975), while other trials (GUENTHER *et al.*, 1965 ; MEYER *et al.*, 1965) gave a better efficiency with *ad libitum* feeding, or no difference (GEAY *et al.*, 1976 ; LEVY *et al.*, 1976 ; ROHR and DAENICKE, 1978).

This study will not investigate the influence of energy levels, but rather the impact of the ration energy concentration on feed intake, growth rate and feed conversion of fattening bulls.

## 2. — Experimental

The bulls involved with this investigation can be divided in three groups :

- I: store bulls of the Belgian white-blue (BWB) breed, group-housed (119 rations with 929 animals, liveweight range of  $292.4 \pm 4.1$  ( $s_{\bar{x}}$ ) to  $596.2 \pm 3.1$  kg);
- II: store bulls of the BWB breed, but individually tied up (62 rations with 439 animals, liveweight range of  $260.0 \pm 3.5$  to  $543.9 \pm 4.1$  kg);
- III: baby-beef bulls of the Belgian white-red (BWR) breed, individually tied up (42 rations with 265 animals, liveweight range of  $159.2 \pm 4.2$  to  $479.9 \pm 2.5$  kg).

In each group there was a diversity of diets varying from complete dry rations to mixed rations. For the mixed diets the basic feedstuff was always administered to appetite, while the daily allowance of concentrate was restricted to 1 or 0.75 kg per 100 kg liveweight. Therefore the animals were weighed monthly and the amount of concentrate was adapted accordingly. Initial and final weights were recorded on three and two consecutive days respectively. The main roughages were maize silage, dehydrated alfalfa pellets, dehydrated whole maize plant pellets, grass hay and also some industrial by-products (BOUCQUE *et al.*, 1978) (Table 1).

All rations were chemically analysed and digestibility of the complete diets or of the main feedstuffs was determined with wethers as described by COTTYN and BOUCQUE (1969).

TABLE 1

CLASSIFICATION OF THE RATIONS FOLLOWING THE BASIC FEEDSTUFFS AND THE ENERGY DENSITY

Ration type	Group	Number of rations		
		I (n = 119)	II (n = 62)	III (n = 42)
Hay + concentrate		-	14	-
Maize silage + concentrate		18	24	-
Dehydrated maize pellets + concentrate		6	4	8
Dehydrated alfalfa pellets + concentrate		20	-	-
Fodderbeet + concentrate		1	-	-
Ensiled pressed beet pulp + concentrate		7	-	-
Dried beet pulp (> 75%) rations		14	6	-
Complete dry rations *		49	12	28
Maize grain + concentrate		4	2	6
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Energy density of the diet (kg SU/kg DM)				
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< 0.600		12	12	-
0.600 - 0.649		10	5	3
0.650 - 0.699		30	<u>21</u>	3
0.700 - 0.749		<u>33</u>	19	<u>23</u>
0.750 - 0.799		20	3	7
0.800 - 0.849		11	-	3
≥ 0.850		3	2	3

\* Mainly dried sugar beet pulp and other by-products

The impact of the energy concentration on dry matter and net energy intake, growth rate and feed conversion was studied by regression analysis (DRAPER and SMITH, 1966).

The net energy content was expressed in starch equivalents. The requirements for maintenance and daily liveweight gain (LWG) were calculated by the following regressions (BUYSSE, 1974) :

$$\text{SE for maintenance (kg/d)} = 0.8 + 0.0045 W$$

$$\text{SE for production (kg/kg LWG)} = 1.22 + 0.00273 W.$$

### 3. — Results and discussion

#### 3.1. — Feed intake

According to the studies of MONTGOMMERY and BAUMGARDT (1965) ; BAUMGARDT (1970) and DINIUS and BAUMGARDT (1970), we can expect an increasing dry matter and energy intake by enhancing the energy concentration. Once a threshold density is exceeded, there would be no point in a higher energy concentration, because animals eat for calories !

Giving more concentrated rations results in a decreasing dry matter intake and a stable or slightly decreasing energy intake. CONRAD (1966) found that the digestible dry matter intake of dairy cows levelled off and approached a straight line between 66 and 80 per cent DM digestibility. The DM digestibility of the diets concerned in this study ranged between 66 and 87 per cent.

Our investigation always resulted in a decreasing DM intake ( $y = \text{g/kg } W^{0.75}$ ) (figure 1) with increasing energy concentration ( $x = \text{kg SU/kg DM}$ ).

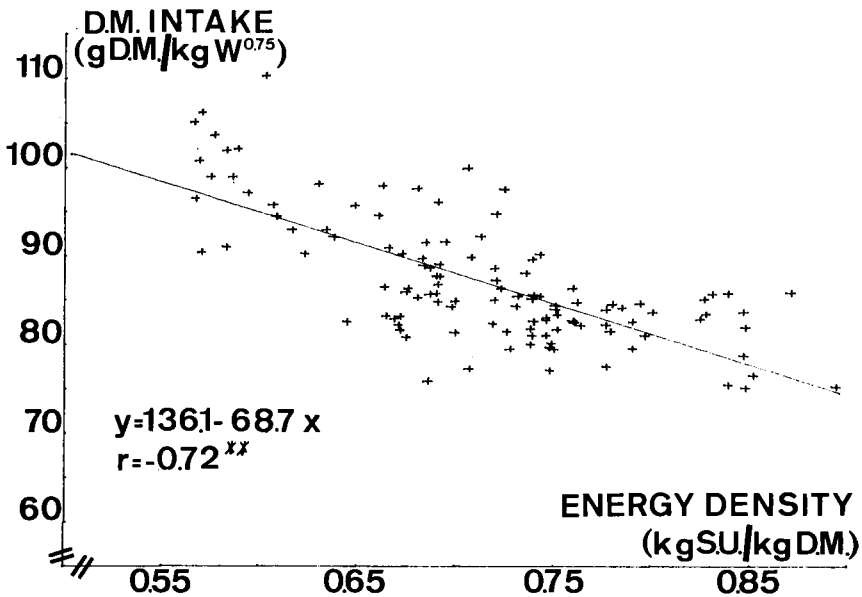


FIG 1. — Relationship, energy density and DM intake by bulls (1).

The relationship was respectively :

Group I :  $y = 136.1 - 68.7 x$  ;  $r = -0.72^{**}$  ; SD = 5.0

Group II :  $y = 139.2 - 87.6 x$  ;  $r = -0.67^{**}$  ; SD = 7.0

Group III :  $y = 120.6 - 51.1 x$  ;  $r = -0.49^{**}$  ; SD = 5.5

These findings are in accordance with most of the literature data shown in Table 2.

Table 2. Influence of the energy concentration on ad lib. intake, daily gain and energy utilization

Ref. No.	**	Liveweight interval (kg)	Energy concentration		Daily intake			Daily gain		Feed conversion			
			Units/kg DM	%	DM	%	Units	(g)	%	kg DM/kg gain	%	Units/kg gain	%
5	BWB	209 - 520	765 g SU	100	6.58 kg	100	5.04 kg SU	1358	100	4.85	100	3.71 kg SU	100
		210 - 521	663 g SU	87	7.27 kg	110	4.83 kg SU	1281	96	5.68	117	3.77 kg SU	102
		209 - 509	646 g SU	84	7.67 kg	117	4.96 kg SU	1188	87	6.48	133	4.17 kg SU	112
6	BWR	209 - 514	571 g SU	75	7.99 kg	121	4.56 kg SU	1165	86	6.86	141	3.92 kg SU	106
		148 - 488	774 g SU	100	6.09 kg	100	4.71 kg SU	1286	100	4.73	100	3.66 kg SU	100
		149 - 475	668 g SU	86	6.85 kg	112	4.57 kg SU	1221	95	5.61	119	3.74 kg SU	102
7	BWR	148 - 487	635 g SU	82	7.37 kg	121	4.68 kg SU	1286	100	5.73	121	3.64 kg SU	99
		136 - 461	736 EFr	100	5.09 kg	100	3.743 EFr	1172	100	3.46	100	2.547 EFr	100
		138 - 489	692 EFr	94	6.25 kg	123	4.528 EFr	1259	107	3.92	113	2.715 EFr	107
10	BWB	139 - 491	656 EFr	89	6.55 kg	129	4.297 EFr	1115	107	4.11	119	2.698 EFr	106
		138 - 472	623 EFr	85	6.39 kg	126	3.983 EFr	1125	96	4.34	125	2.706 EFr	106
		326 - 642	733 g SU	100	87.3 g/M <sup>0.75</sup>	100	64.0 g SU/M <sup>0.75</sup>	1263	100	7.12	100	5.22 kg SU	100
20	BWR	331 - 620	732 g SU	100	81.2 g/M <sup>0.75</sup>	93	59.4 g SU/M <sup>0.75</sup>	1112	88	7.37	104	5.40 kg SU	103
		329 - 628	696 g SU	95	85.9 g/M <sup>0.75</sup>	98	59.8 g SU/M <sup>0.75</sup>	1197	95	7.36	103	5.11 kg SU	98
		325 - 613	669 g SU	91	86.5 g/M <sup>0.75</sup>	99	57.9 g SU/M <sup>0.75</sup>	1159	92	7.52	106	5.04 kg SU	97
33	B S	157 - 480	708 g SU	100	6.37 kg	100	4.51 kg SU	1188	100	5.36	100	3.79 kg SU	100
		157 - 490	691 g SU	98	6.59 kg	103	4.55 kg SU	1175	99	5.61	105	3.88 kg SU	102
		150 - 477	649 g SU	92	5.76 kg	101	4.55 kg SU	1050	88	6.24	116	4.34 kg SU	115
34	B S	223 - 571	708 g SU	100	8.00 kg	100	5.66 kg SU	1409	100	5.68	100	4.02 kg SU	100
		222 - 575	691 g SU	98	8.58 kg	107	5.93 kg SU	1429	101	6.01	106	4.15 kg SU	103
		222 - 551	695 g SU	98	7.99 kg	104	5.55 kg SU	1241	88	6.44	113	4.47 kg SU	111
34	B S	222 - 539	649 g SU	92	8.24 kg	103	5.35 kg SU	1168	83	7.06	124	4.58 kg SU	114
		339 - 562	2.005 Meal ME	100	10.7 kg	100	21.465 Meal ME	1183	100	8.97	100	18.145 Meal ME	100
		338 - 561	2.627 Meal ME	131	9.0 kg	84	23.965 Meal ME	1186	112	10.86	84	20.207 Meal ME	111
26	F	342 - 555	2.005 Meal ME	100	9.3 kg	100	18.655 Meal ME	1134	100	8.19	100	16.451 Meal ME	100
		343 - 591	2.627 Meal ME	131	9.1 kg	98	24.039 Meal ME	1322	117	6.85	84	18.184 Meal ME	118
		343 - 533	2.005 Meal ME	100	9.1 kg	100	18.628 Meal ME	1035	100	8.79	100	17.998 Meal ME	100
27	F	339 - 564	2.627 Meal ME	131	8.4 kg	92	22.198 Meal ME	1244	120	6.94	80	17.844 Meal ME	99
		295 - 545	2.25 Meal ME	100	-	100	18.42 Meal ME	1276	100	-	100	18.42 Meal ME	100
		301 - 549	2.55 Meal ME	113	-	100	19.94 Meal ME	1264	99	-	100	19.94 Meal ME	108
28	75% F 25% J	167 - 485	650 EFr	100	5.51 kg	100	3.43 kEFr	1032	100	5.34	100	3.32 kEFr	100
		168 - 475	550 EFr	85	6.54 kg	119	3.54 kEFr	996	97	6.56	123	3.55 kEFr	107
		167 - 491	475 EFr	73	6.81 kg	124	3.24 kEFr	1052	102	6.47	121	3.08 kEFr	93
43	F	168 - 418	395 EFr	61	7.03 kg	128	2.78 kEFr	813	79	8.65	162	3.42 kEFr	103
		167 - 484	655 EFr	100	5.89 kg	100	3.86 kEFr	1020	100	5.77	100	3.79 kEFr	100
		168 - 496	556 EFr	85	6.79 kg	115	3.78 kEFr	990	97	6.86	100	3.78 kEFr	100
43	F	168 - 488	492 EFr	75	7.50 kg	127	3.69 kEFr	1017	98	7.37	128	3.63 kEFr	96
		168 - 481	416 EFr	64	7.72 kg	131	3.21 kEFr	871	85	8.86	154	3.69 kEFr	97
		240 - 489	2.41 Meal ME	100	-	100	25.71 Meal ME	1016	100	-	100	22.45 Meal ME	100
239 - 477	2.13 Meal ME	88	-	100	24.58 Meal ME	748	74	-	100	28.56 Meal ME	127		

44	B	F	200 - 400	2.54 Mcal ME 2.59 Mcal ME 2.55 Mcal ME 2.58 Mcal ME 2.54 Mcal ME 2.58 Mcal ME	100 94 100 93 100 94	7.99 kg 9.05 kg 8.37 kg 9.20 kg 8.79 kg 9.73 kg	100 113 115 110 100 111	20.36 Mcal ME 21.67 Mcal ME 21.35 Mcal ME 21.98 Mcal ME 22.41 Mcal ME 23.24 Mcal ME	100 106 100 103 100 104	1031 985 1069 1009 1122 1054	100 96 100 94 100 94	7.75 9.18 9.18 9.18 7.83 9.23	100 118 100 117 100 118	19.75 Mcal ME 22.01 Mcal ME 22.97 Mcal ME 21.78 Mcal ME 19.97 Mcal ME 22.05 Mcal ME	100 111 100 109 100 110	
36	S	HE	227 - 355 224 - 320 222 - 425 223 - 394 229 - 440	69.5 % TDN 54.3 % TDN 69.5 % TDN 54.3 % TDN 54.3 % TDN	100 78 100 78 78	3.67 kg 4.14 kg 3.76 kg 4.18 kg 4.17 kg	100 113 100 111 111	2.65 kg TDN 2.23 kg TDN 2.71 kg TDN 2.35 kg TDN 2.35 kg TDN	100 88 100 87 87	1100 890 930 790 820	100 75 100 85 88	- - - - -	2.41 kg TDN 2.81 kg TDN 2.91 kg TDN 2.98 kg TDN 2.87 kg TDN	100 117 100 102 99		
37	S	HE	220 - 400 223 - 405	1.592 kcal NE 1.502 kcal NE	100 82	7.72 kg 6.95 kg	100 90	12.2 Mcal NE 8.9 Mcal NE	100 73	852 698	100 82	- -	14.35 Mcal ME 12.58 Mcal ME	100 88		
38	S	F	150 - 350 150 - 350 150 - 350	2.95 Mcal ME 2.55 Mcal ME 2.30 Mcal ME	100 86 78	6.03 kg 6.69 kg 7.12 kg	100 111 118	17.79 Mcal ME 17.06 Mcal ME 16.38 Mcal ME	100 96 92	1200 1040 870	100 87 73	5.03 6.43 8.18	100 128 163	14.83 Mcal ME 16.40 Mcal ME 18.83 Mcal ME	100 111 127	
39	S	F	150 - 350 150 - 350 150 - 350	2.96 Mcal ME 2.87 Mcal ME 2.82 Mcal ME 2.68 Mcal ME	100 97 95 91	5.05 kg 6.99 kg 6.66 kg 6.31 kg	100 138 132 125	14.95 Mcal ME 20.06 Mcal ME 18.78 Mcal ME 16.91 Mcal ME	100 134 119 113	1180 1060 1060 880	100 90 90 75	4.28 6.59 6.28 7.17	100 154 147 168	18.67 Mcal ME 15.92 Mcal ME 17.72 Mcal ME 19.22 Mcal ME	100 149 140 152	
48	S	F	122 - 501 115 - 512 127 - 498 121 - 486 129 - 504 120 - 512	3.26 Mcal DE 2.99 Mcal DE 3.23 Mcal DE 3.00 Mcal DE 3.00 Mcal DE	100 92 100 93 100 93	6.26 kg 6.66 kg 5.94 kg 6.30 kg 6.01 kg 6.47 kg	100 106 100 106 100 108	20.43 Mcal DE 19.93 Mcal DE 19.21 Mcal DE 18.92 Mcal DE 19.41 Mcal DE 19.58 Mcal DE	100 98 100 98 100 100	1040 1190 1130 920 1040 1070	100 114 100 81 100 103	1040 1190 1130 920 1040 1070	6.07 5.65 5.32 6.54 5.63 6.04	100 93 100 123 100 107	19.64 Mcal DE 16.75 Mcal DE 17.00 Mcal DE 20.58 Mcal DE 18.66 Mcal DE 18.10 Mcal DE	100 85 100 121 100 97
49	S	F	300 - 420	12.5 MJ ME 11.1 MJ ME 10.4 MJ ME 10.1 MJ ME	100 89 83 81	7.88 kg 9.67 kg 9.23 kg 8.60 kg	100 123 117 109	98.9 MJ ME 107.2 MJ ME 96.4 MJ ME 87.3 MJ ME	100 108 97 88	1260 1120 890 850	100 89 71 67	6.25 8.63 10.4 10.1	100 138 166 162	78.49 MJ ME 95.71 MJ ME 108.31 MJ ME 102.71 MJ ME	100 122 138 131	
50	S	A x HE	255 - 495 259 - 520 258 - 540 274 - 639 275 - 661 275 - 676	2.9 Mcal ME 3.1 Mcal ME 3.2 Mcal ME 2.9 Mcal ME 3.1 Mcal ME 3.2 Mcal ME	100 107 110 100 107 110	7.6 kg 8.4 kg 8.4 kg 8.9 kg 9.5 kg 9.0 kg	100 111 111 100 107 101	22.6 Mcal ME 25.8 Mcal ME 26.5 Mcal ME 24.5 Mcal ME 26.9 Mcal ME 26.2 Mcal ME	100 114 117 100 110 107	1050 1170 1250 1200 1280 1330	100 111 119 100 107 111	7.3 7.2 6.7 7.4 7.4 6.7	100 99 92 100 100 91	21.52 Mcal ME 22.05 Mcal ME 21.20 Mcal ME 20.42 Mcal ME 21.02 Mcal ME 19.70 Mcal ME	100 102 99 100 103 96	
53	S	F	287 - 467 286 - 467 297 - 464 326 - 454 328 - 450 328 - 484	3.09 Mcal DE 2.75 Mcal DE 2.30 Mcal DE 2.496 Mcal DE 3.001 Mcal DE 3.515 Mcal DE	100 89 74 100 120 141	9.5 kg 9.7 kg 9.9 kg -	100 102 104	29.4 Mcal DE 26.7 Mcal DE 22.8 Mcal DE	100 91 78	1290 1190 1020	100 92 79	1290 1190 1020	7.4 8.1 9.8	100 109 132	22.8 Mcal DE 22.3 Mcal DE 22.3 Mcal DE	100 98 98
47	H	H	(21 days)	4.41 Mcal BE 4.46 Mcal BE 4.47 Mcal BE 4.49 Mcal BE	100 101 101 102	103 g/W <sup>0.75</sup> 90.7g/W <sup>0.75</sup> 76.4g/W <sup>0.75</sup> 81.2g/W <sup>0.75</sup>	100 88 74 76	244.7 kcal DE/W <sup>0.75</sup> 242.4 kcal DE/W <sup>0.75</sup> 234.6 kcal DE/W <sup>0.75</sup> 235.2 kcal DE/W <sup>0.75</sup>	100 99 96 96	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	
51	H	HE	283 - 393 283 - 398 283 - 410	61.8 % TDN 69.0 % TDN 68.3 % TDN	100 112 111	- - -	- - -	- - -	- - -	892 929 1028	100 104 115	- - -	- - -	- - -	- - -	

\* B : bulls, S : steers, H : heifers.

\*\* A : Angus, BWB : Belgian white-blue, BWR : Belgian white-red, CA : Charolais, CI : Chianina, F : Friesian, H : Holstein, HE : Hereford, J : Jersey, S : Salers.

A possible explanation for the diminishing DM intake may be the fact that we had already exceeded the threshold concentration for maximum DM intake.

In that case, the relationship of MONTGOMMERY and BAUMGARDT (1965) suggests a constant energy intake. Nevertheless, in our trials (figure 2) we observed a significantly higher energy intake ( $y = g \text{ SU/kg } W^{0.75}$ ) with increasing energy density ( $x$ ):

$$\text{Group I : } y = 33.2 + 40.0 x ; r = 0.67^{**} ; \text{SD} = 3.3$$

$$\text{Group III : } y = 41.6 + 17.9 x ; r = 0.28^* ; \text{SD} = 4.3$$

$$\text{Group III : } y = 30.6 + 41.2 x ; r = 0.52^{**} ; \text{SD} = 4.1$$

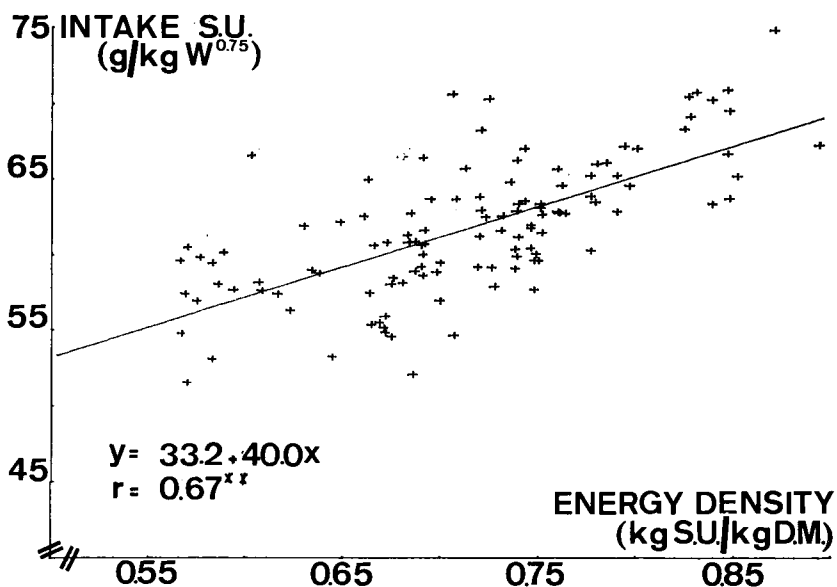


FIG. 2. — Relationship, energy density and SU intake by bulls (BWB-group housed;  $n = 119$ ) (I).

This again is in agreement with most of the cited references in Table 2. However the uniformity among the 3 groups for the energy intake as a consequence of the caloric density is less pronounced than for the DM intake. Feed intake is also influenced by other parameters of the diet such as physical form (COTTYN *et al.*, 1971) and crude fibre content (DE BRABANDER *et al.*, 1978).

FREER and CAMPLING (1963) noted a lower energy intake on very high energy rations. At our institute COTTYN *et al.* (1978) established the same phenomenon with tied bulls of the Belgian white-blue breed fed maize grain, while it was not confirmed with loose housed bulls (BOUCQUE *et al.*, 1978). This statement helps to explain the lower  $r$  value for group II.

### 3.2. — Daily liveweight gain

Because of the positive correlation between the energy concentration and the energy intake, we expect a higher growth rate ( $y = g/day$ ) with increasing energy concentration. This was confirmed by our investigation (Figure 3), but the



correlation coefficients were lower (especially for group II) than those for intake and concentration. The relationship was respectively :

$$\text{Group I : } y = 708.1 + 780.6 x ; r = 0.49^{**} ; \text{SD} = 105.8$$

$$\text{Group II : } y = 1009.4 + 119.4 x ; r = 0.09 \text{ NS} ; \text{SD} = 93.8$$

$$\text{Group III : } y = 823.5 + 464.6 x ; r = 0.36^* ; \text{SD} = 71.3$$

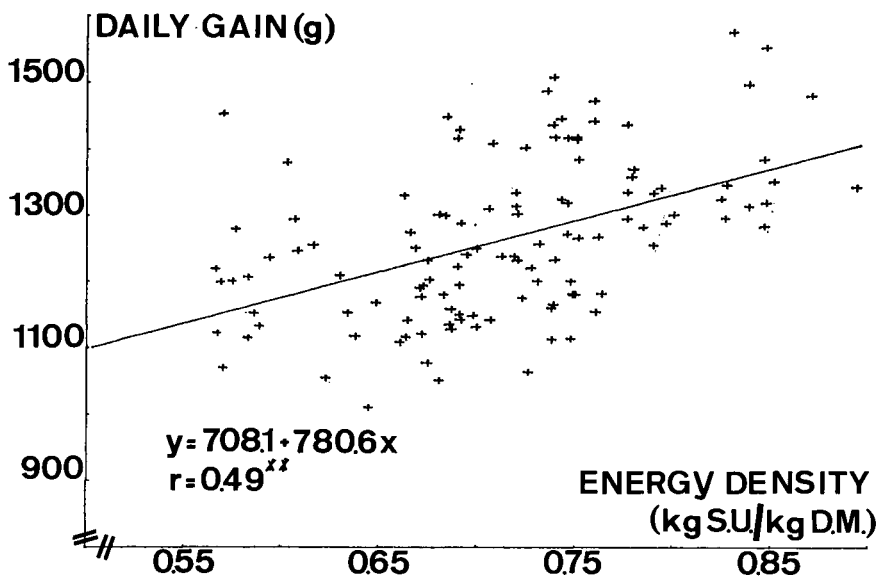


FIG. 3. — Relationship, energy density and daily gain by bulls (I).

This is also in accordance with the data in Table 2, although some investigations (FLACHOWSKY and LÖHNERT, 1977 and FLACHOWSKY, 1979), with high energetic rations but with a lack of fibrous material, resulted in a growth depression without a decreasing energy intake.

LANARI and SUSMEL (1979) found that maize rations with increasing energy concentration clearly improved daily gains of beef breed bulls ( $r = 0.80$ ), while the increase in daily gain was less evident for dairy breed bulls ( $r = 0.42$ ), light steers ( $r = 0.26$ ) and heavy steers ( $r = 0.67$ ).

In the case of store bulls only, there is a clearly better response on energy concentration with loose housed bulls (I) than with tied animals (II). This was already demonstrated with earlier results (BOUCQUE *et al.*, 1979).

The influence of the daily energy intake ( $x = \text{g SU/kg } W^{0.75}$ ) on the daily gain ( $y$ ) (figure 4) gives a more significant relationship:

$$\text{Group I : } y = 87.1 + 19.1 x ; r = 0.71^{**} ; \text{SD} = 85.8$$

$$\text{Group II : } y = 452.4 + 11.9 x ; r = 0.57^{**} ; \text{SD} = 77.4$$

$$\text{Group III : } y = 462.8 + 11.5 x ; r = 0.72^{**} ; \text{SD} = 53.3$$

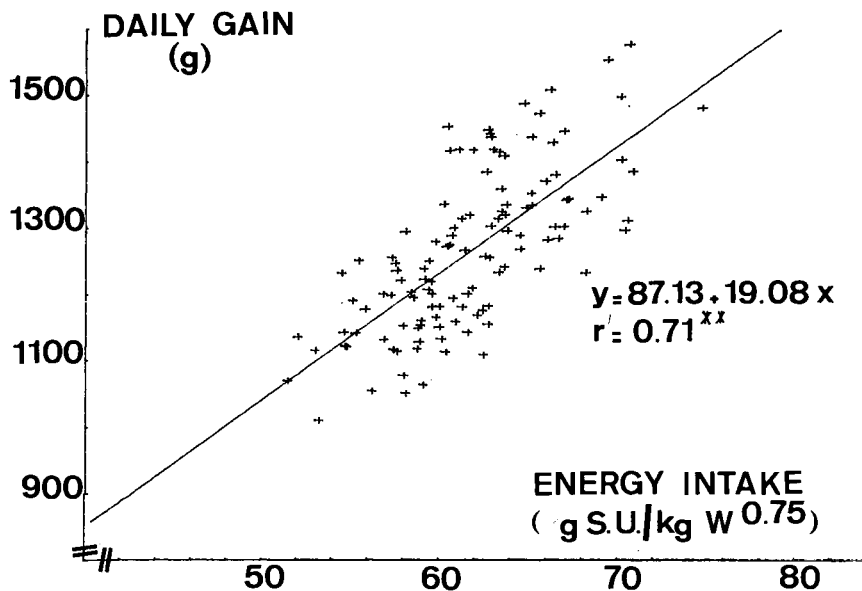


FIG. 4. — Relationship, energy intake and daily gain by bulls (I).

### 3.3 — Feed Conversion

#### 3.3.1. Ad libitum energy intake

Firstly the *total energy intake* (for maintenance and growth together) per kg liveweight gain ( $y = \text{kg SU/kg gain}$ ) was expressed in function of the energy concentration ( $x = \text{g SU/kg DM}$ ) (Figure 5). This relationship for the three groups was respectively :

Group I :  $y = 4.31 + 0.61x$  ;  $r = 0.12 \text{ NS}$  ;  $\text{SD} = 0.37$

Group II :  $y = 2.84 + 2.35x$  ;  $r = 0.42^{**}$  ;  $\text{SD} = 0.37$

Group III :  $y = 3.79 + 0.22x$  ;  $r = 0.06 \text{ NS}$  ;  $\text{SD} = 0.22$

The higher correlation of group II seems a logical consequence of the low correlation between gain and energy density. Because of the positive correlation between energy concentration and energy intake ( $r = 0.67, 0.28 \text{ and } 0.52$ ), we could expect a luxury consumption at higher densities resulting in an unfavourable conversion due to a higher fat deposition. The regression equation for I and III do not sustain this hypothesis. Comparing these results with the data in Table 2, it becomes clear that there is no uniformity in the literature.

Rations with a decreasing energy density often result in a more unfavourable energy conversion (KAY *et al.*, 1970 and 1971 ; BOUCQUE *et al.*, 1971a and 1972 ; COTTYN *et al.*, 1973 ; LEVY *et al.*, 1974 and 1975 ; PIRIE and GREENHALGH, 1978) while there are trials with opposite results (HENRICKSON *et al.*, 1965 ; GEAY *et al.*, 1976a, b ; BOUCQUE, 1979) when the range of energy concentration was quite similar. Some authors established no clear effect (GUENTHER *et al.*, 1965 ; SWAN and LAMMING, 1970 ; BOUCQUE *et al.*, 1971b ; PRIOR *et al.*,

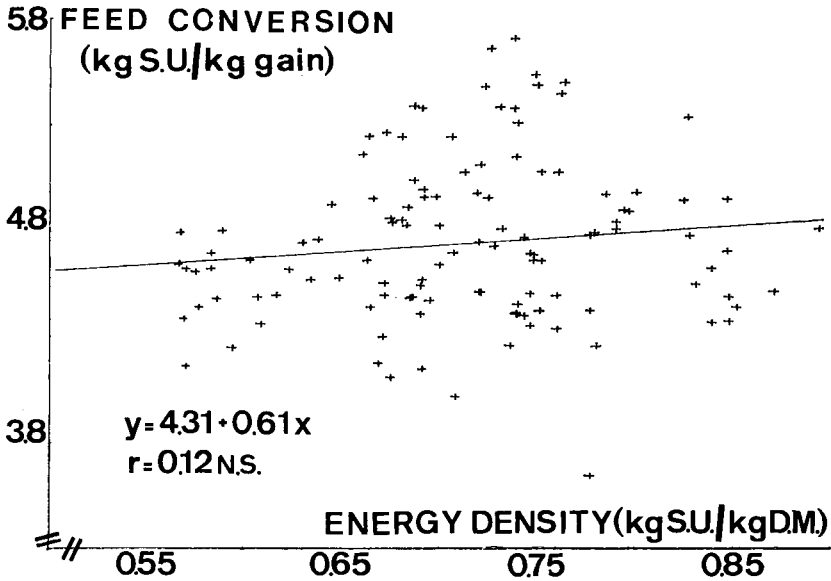


FIG. 5. — Relationship energy density and energy utilization (I).

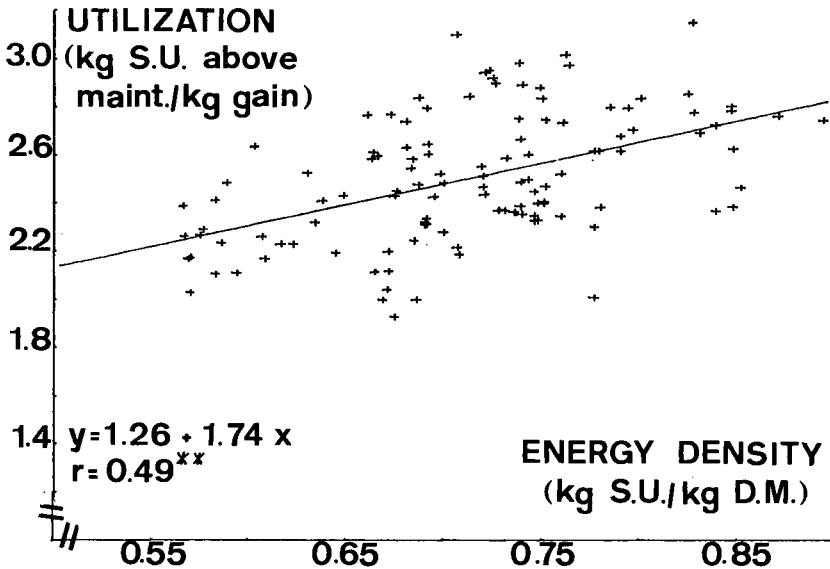


FIG. 6. — Relationship energy density and energy utilization (I).

1977). Certainly there exists a genotype-nutrition interaction (GEAY and ROBELIN, 1979). Rations with increasing energy density resulted in an unfavourable feed conversion of Salers bulls, while there was no influence on feed conversion of Charolais bulls (GEAY *et al.*, 1976a).

LANARI and SUSMEL (1979) concluded that there was no modification in efficiency due to energy concentration with beef breed bulls ( $r = 0.10$ ), but the efficiency declined clearly with dairy breed bulls ( $r = 0.44$ ), light steers ( $r = 0.71$ ) and heavy steers ( $r = 0.68$ ). When we took the liveweight ( $x_2 = \text{kg LW}$ ) into account (beside the energy density  $x_1$ ), we obtained the following multiple linear regression :

$$\text{Group I : } y = 1.75 + 0.27 x_1 + 0.0063 x_2; R^2 = 0.31; \text{SD} = 0.31.$$

$$\text{Group II : } y = 1.06 + 1.41 x_1 + 0.0060 x_2; R^2 = 0.31; \text{SD} = 0.34.$$

$$\text{Group III : } y = 1.83 + 0.69 x_1 + 0.0050 x_2; R^2 = 0.19; \text{SD} = 0.20.$$

The partial regression coefficients between liveweight ( $x_2$ ) and energy conversion ( $y$ ) are 0.56, 0.40 and 0.45 respectively.

Assuming that the maintenance requirements are constant, the energy intake *above maintenance* per kg liveweight gain ( $y = \text{kg SU/kg gain}$ ) follows a more uniform pattern compared to the total energy consumption per kg gain (Figure 6 vs 5). In that case, there is a closer relationship with the energy concentration ( $x$ ).

$$\text{Group I : } y = 1.26 + 1.74 x; r = 0.49^{**}; \text{SD} = 0.23$$

$$\text{Group II : } y = 0.73 + 1.90 x; r = 0.44^{**}; \text{SD} = 0.28$$

$$\text{Group III : } y = 1.02 + 1.36 x; r = 0.36^*; \text{SD} = 0.21$$

Taking the average liveweight ( $x_2$ ) into account, the following multiple linear regressions were calculated :

$$\text{Group I : } y = 0.07 + 1.58 x_1 + 0.00292 x_2; R^2 = 0.37; \text{SD} = 0.23.$$

$$\text{Group II : } y = 0.71 + 1.89 x_1 + 0.00006 x_2; R^2 = 0.19; \text{SD} = 0.28.$$

$$\text{Group III : } y = -0.10 + 1.63 x_1 + 0.00289 x_2; R^2 = 0.19; \text{SD} = 0.21.$$

The multiple regressions did not improve the relationship to any considerable extent. The relationship between the *total energy intake* (for maintenance and growth together) *per kg liveweight gain* ( $y$ ) and the daily gain ( $x$ ) demonstrates the beneficial effect of rapid growing animals :

$$\text{Group I : } y = 6.55 - 0.00143 x; r = -0.46^{**}; \text{SD} = 0.34$$

$$\text{Group II : } y = 6.81 - 0.00218 x; r = -0.51^{**}; \text{SD} = 0.35$$

$$\text{Group III : } y = 4.14 - 0.00016 x; r = -0.05 \text{ NS}; \text{SD} = 0.22$$

The low  $r$  value for group III can be explained by the smaller range of liveweight gain (1 009 to 1 333 g) compared to group I (1 010 to 1 576 g) and II (899 to 1 397 g). Considering the *energy intake above maintenance* per kg liveweight gain ( $y$ ) in function of the growth rate ( $x$ ), the increase of energy consumed per unit of liveweight gain is generally rather low (except for group III) :

$$\text{Group I : } y = 2.27 + 0.00018 x; r = 0.08 \text{ NS}; \text{SD} = 0.27$$

$$\text{Group II : } y = 1.90 + 0.00012 x; r = 0.03 \text{ NS}; \text{SD} = 0.31$$

$$\text{Group III : } y = 0.44 + 0.00136 x; r = 0.46^{**}; \text{SD} = 0.20$$

### 3.3.2. Different energy levels

When a particular ration is fed at different levels one could expect the same result as when giving rations with different energy concentration to appetite. However, energy utilisation is more dependent on levels than on concentrations. The data in Table 3 mostly indicate a more favourable feed conversion at 80

TABLE 3  
INFLUENCE OF ENERGY LEVEL ON FEED CONVERSION BY BULLS

Ref.	Breed	Liveweight interval (kg)	Energy level (%)	Unit	Feed conversion Units	Feed conversion %
1	Red Danish	95 - 200	ad lib. = 100	Sc.f.u.	2.97	100
			85		2.98	100
			70		3.15	106
			55		3.38	114
		95 - 250	100		3.20	100
			85		3.17	99
			70		3.30	103
			55		3.54	111
		95 - 300	100		3.52	100
			85		3.39	96
			70		3.48	99
			55		3.79	108
		95 - 350	100		3.85	100
			85		3.65	95
			70		3.73	97
			55		4.07	106
		95 - 400	100		4.15	100
			85		3.95	95
			70		4.02	97
			55		4.43	107
		95 - 450	100		4.48	100
			85		4.27	95
			70		4.35	97
			55		4.83	108
		95 - 500	100		4.84	100
			85		4.61	95
			70		4.70	97
			55		5.28	109

TABLE 3 (Continued)

Ref.	Breed	Liveweight interval (kg)	Energy level (%)	Unit	Feed conversion Units	%
21	MRY	249 - 427	100 (standard)	g S.U.	4200	100
		251 - 414	80			
		251 - 443	120			
		251 - 454	130			
31	Limousin	306 - 653	ad lib. = 100	Mcal ME	15.2	100
		304 - 654	81	Mcal ME	13.3	88
34	Salers x Charolais	9-17 months	ad lib. = 100	Mcal ME	17.43	100
			97	Mcal ME	17.74	102
			high = 100	Mcal ME	15.78	100
			moderate : 93		14.65	93
43	Friesian	240 - 489	high = 100	Mcal ME	22.45	100
			moderate : 93			
			high = 100			
			moderate : 93			
45	Friesian	238 - 482	ad lib. = 100	Mcal ME	19.79	88
			85			
			70			
			ad lib. = 100			
			85			
			70			
52	Friesian	150 - 550	ad lib. = 100	Mcal ME	19.20	100
			80			
			100			
			80			
57	Friesian	96 - 555	3700	g S.U.	4325	100
			4400			
			3700			
			4400			
57	Friesian	96 - 514	LW x 10 + 800	g S.U.	3771	100
			LW x 10 + 200			
					3372	89

to 85 per cent of the *ad libitum* intake. Some investigations assume an interaction between energy level and energy concentration in the ration (LEVY *et al.*, 1974 ; ROHR and DAENICKE, 1978). Severe restriction (ANDERSEN, 1975) resulted in a pronounced unfavorable feed conversion. These statements can be explained by a less efficient energy utilisation at high energy levels due to a higher fat deposition (BERGEN, 1974) and higher energy requirements (VAN ES, 1976) on the one side, and to a relatively higher maintenance requirement at low densities on the other hand. ELSLEY (1976) also established this phenomenon for pigs. The genotype-nutrition-interaction was demonstrated by GEAY and ROBELIN (1979).

#### 4. — Conclusion

Diets with increasing *energy densities*, fed *ad libitum* to intensively fattened bulls of Belgian dual purpose breeds generally resulted in a decreased daily dry matter and an increased energy intake. The positive effect on growth rate was only significant for the loose housed store bulls and the tied baby-beef bulls. For these two groups the energy density of the diet did not modify the feed conversion to any considerable extent. For the tied store bulls however, higher energy diets resulted in a less favourable feed conversion due to a negligible growth response to increased energy intake.

When different *energy levels* are applied, generally lower growth rates were obtained which in many cases resulted in a better feed efficiency. Following many literature data, the most favourable feed conversion was obtained when bulls were fed at 80 to 85 per cent of *ad libitum* intake.

Besides the study of parameters related to energy content of the diet, our investigation emphasized the beneficial effect of high growth rates on feed conversion.

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#### References

- ANDERSEN H.R., 1975. The influence of slaughter weight and level of feeding on growth rate, feed conversion and carcass composition of bulls. *Livest. Prod. Sci.*, **2**, 341-356.
- BAUMGARDT B.R., 1970. Control of feed intake in the regulation of energy balance In : *Physiology of digestion and metabolism in the ruminant*. Ed. A.T. PHILLIPSON. Oriel Press, Newcastle upon Tyne. 235-253.
- BERGEN W.G., 1974. Protein synthesis in animal models. *J. Anim. Sci.*, **38**, 1079-1091.
- BOND J., HOOVEN Jr, N.W., WARICK E.J., HINER R.L., RICHARDSON G.V., 1972. Influence of breed and plane of nutrition on performance of dairy, dual-purpose and beef steers. II. From 180 days of age to slaughter. *J. Anim. Sci.*, **34**, 1046-1053.
- BOUCQUE Ch.V., COTTYN B.G., BUYSSE F.X., 1971a. *Effects of varying haypellets barley rations on performance of beef cattle*. Atti del VI Simposio Internazionale di Zootecnia, Milano 15-17 Aprile, p. 361-376.

- BOUCQUE Ch.V., COTTYN B.G., BUYSSE F.X., 1971b. Maïs déshydraté et orge aplatie dans les rations complètes pour taurillons à l'engrais. *Revue Agric., Brux.* **24**, 1295-1305.
- BOUCQUE Ch.V., COTTYN B.G., BUYSSE F.X., 1972. Valeur comparée d'agglomérés de maïs pâteux déshydraté et de farine de maïs dans des rations sèches complètes pour taurillons à l'engrais. *Revue Agric., Brux.* **25**, 1273-1292.
- BOUCQUE Ch.V., COTTYN B.G., BUYSSE F.X., 1978. Bull fattening with dehydrated whole-corn-plant pellets compared with corn silage and high-moisture corn grain. Proc. 2nd Intern. *Green Crop Drying Congr.* University of Saskatchewan, Saskatoon, Canada. 20 - 25 August, p. 327-33.
- BOUCQUE Ch.V., FIEMS L.O., COTTYN B.G., BUYSSE F.X., 1978. Utilisation of some industrial by-products in beef production. Proc. *European Congress for Improved Beef Productivity* Paris, 28-29 September 1978, Eli Lilly, Saint Cloud, France.
- BOUCQUE Ch.V., 1979. Unpublished data.
- BOUCQUE Ch.V., FIEMS L.O., COTTYN B.G., BUYSSE F.X., 1979. The effect of straw bedded loose houses or tie stalls on the performance of finishing bulls. *Livest. Prod. Sci.*, **4**, 369-378.
- BUYSSE F.X., 1969. Intensive beef production. *Proc. 8th Intern. Congr. Nutrition.* Prague, August 28th - September 5th, 1969. Ed. by Excerpta Medica, Amsterdam, 1970, p. 747-749.
- BUYSSE F.X., 1974. *Nieuwe inzichten omtrent de energetische voederevaluatie en daarmede aansluitende voedernormen.* Communication of the Institute nr. 304.
- BUYSSE F.X., BOUCQUE Ch.V., 1975. Present and future beef production systems in Belgium. In : *Improving the Nutritional Efficiency of Beef Production.* Com, Eur. Com. 5488<sup>e</sup> Theix 14 - 17 October, 1975. Ed. by J.C. TAYLER and J.M. WILKINSON, UK, p. 15-35.
- CALLOW E.H., 1961. Comparative studies of meat. VII. A comparison between Hereford, Dairy Shorthorn and Friesian steers on four levels of nutrition. *J. Agric. Sci.*, **56**, 265-282.
- CONRAD H.R., 1966. Symposium on factors influencing the voluntary intake of herbage by ruminants : physiological and physical factors limiting feed intake. *J. Anim. Sci.*, **25**, 227-234.
- COTTYN B.G., BOUCQUE Ch.V., 1969. Digestibilité et valeur alimentaire de pulpes séchées de betteraves sucrières. *Revue Agric., Brux.* **22**, 1101-1109.
- COTTYN B.G., BOUCQUE Ch.V., AERTS J.V., BUYSSE F.X., 1978. L'utilisation de maïs-grain humide ou sec dans des rations destinées à la production intensive de viande bovine. *Revue Agric., Brux.* **31**, 295-306.
- COTTYN B.G., BOUCQUE Ch.V., BUYSSE F.X., 1971. Influence de la mouture, de la finesse de mouture et de la mise en agglomérés de foin de prairie sur la production de viande bovine. *Revue Agric., Brux.* **24**, 975-991.
- COTTYN B.G., BOUCQUE Ch.V., BUYSSE F.X., 1973. Possibilités d'utilisation de fanes et cosses de pois déshydratées et agglomérées pour la production de viande bovine. *Revue Agric., Brux.* **26**, 813-827.
- DE BOER F., SMITS B., DIJKSTRA K.T.J., 1971. Voederhoeveelheid, groei en slachtkwaliteit bij jonge vleesstieren. *Landbouwk. Tijdschr.* **83**, 354-359.
- DE BRABANDER D.L., AERTS J.V., BOUCQUE Ch.V., BUYSSE F.X., 1978. Intake of preserved grassland products by dairy cattle. *Proc. 7th General Meeting Europ. Grassld Fed. Constraints to Grass Growth and Grassland Output.* Ed. by Government Agric. Res. Centre Gent, Merelbeke, Belgium, p. 6.87-6.94.
- DINIUS D.A., BAUMGARDT B.R., 1970. Regulation of food intake in Ruminants. 6. Influence of caloric density of pelleted rations. *J. Dairy Sci.*, **53**, 311-316.
- DRAPER N.R., SMITH H., 1966. *Applied regression analysis.* Ed. J. WILEY, New York. 407 pp.
- ELSLEY F.W.H., 1976. Limitations to the manipulation of growth. *Proc. Nutr. Soc.* **35**, 325-337.
- FLACHOWSKY G., LÖHNERT, H.J., 1977. Pelletierte Fertigfuttermittel mit unterschiedlichen Strohanteilen in der Rindermast. 2. Futteraufnahme und Lebendmasseentwicklung. Tierernährung und Fütterung - *Erfahrungen, Ergebnisse, Entwicklungen.* **10**, 81-87.
- FLACHOWSKY G., LÖHNERT H.J., HENNIG A., 1977. Pelletierte Fertigfuttermittel mit unterschiedlichen Strohanteilen in der Rindermast. 1. Versuchsanstellung und Pansenphysiologische Kennwerte. Tierernährung und Fütterung - *Erfahrungen, Ergebnisse, Entwicklungen* **10**, 73-80.



- FLACHOWSKY G., 1979. Untersuchungen zum Einfluss einer unterschiedlichen Energiekonzentration in Rationen von Mastrindern verschiedener Genotypen auf Schlachtkörperzusammensetzung und Ansatzkriterien. 1. Protein-, Fett- und Energiegehalt in Schlachtkörper. *Arch. Tierernähr.* **29**, 17-26.
- FREER M., CAMPLING R.C., 1963. Factors affecting the voluntary intake of food by cows. 5. The relationship between the voluntary intake of food, the amount of digesta in the reticulo-rumen and the rate of disappearance of digesta from the alimentary tract with diets of hay, dried grass and concentrates. *Br. J. Nutr.* **17**, 79-88.
- GARRIGUS R.R., JOHNSON H.R., THOMAS N.W., FIRTH N.L., HARRINGTON R.B., JUDGE M.D., 1969. Dietary effects on beef composition. I. Quantitative and qualitative carcass traits. *J. Agric. Sci., Camb.* **72**, 289-295.
- GEAY Y., MALTERRE C., 1973. Croissance, rendement et composition des carcasses de jeunes bovins de différentes races. *Bull. Techn. du CRZV Theix* No. 14, 17-20.
- GEAY Y., 1975. Fitting the diet to the potential of the animal. In : *Improving the Nutritional Efficiency of Beef Production*. Com. Eur. Com. 5488°, Theix, 14-17 October 1975. Ed. by J.C. TAYLER and J.M. WILKINSON, UK, p. 333-347.
- GEAY Y., ROBELIN J., BERANGER C., 1976a. Influence du niveau alimentaire sur le gain de poids vif et la composition de la carcasse de taurillons de différentes races. *Ann. Zootech.* **25**, 287-298.
- GEAY Y., ROBELIN J., JARRIGE R., 1976b. *The influence of the metabolisable energy content of the diet on the efficiency of energy utilisation for young fattening bulls*, Proc. 7th Energy symposium - EAAP Publ. No. 19. Ed. M. VERMOREL and G-DE BUSSAC, Clermont-Ferrand, 1976, p. 225-228.
- GEAY Y., ROBELIN J., 1979. Variation of meat production capacity in cattle due to genotype and level of feeding : genotype - nutrition interaction. *Livest. Prod. Sci.* **6**, 263-276.
- GUENTHER J.J., BUSCHMANN D.H., POPE L.S., MORRISON R.D., 1965. Growth and development of the major carcass tissues in beef calves from weaning to slaughter weight, with reference to the effect of plane of nutrition. *J. Anim. Sci.* **24**, 1184-1191.
- HENRICKSON R.L., POPE L.S., HENDRICKSON R.F., 1965. Effect of rate of gain of fattening beef calves on carcass composition. *J. Anim. Sci.* **24**, 507-513.
- KAY M., MACDEARMID A., MASSIE R., 1970. Intensive beef production. 11. Replacement of cereals with ground straw. *Anim. Prod.* **12**, 419-424.
- KAY M., MASSIE R., MACDEARMID A., 1971. Intensive beef production. 12. Replacement of concentrates with chopped dried grass. *Anim. Prod.* **13**, 101-106.
- LANARI D., SUSMEL P., 1979. Feed-lot beef production from maize silage. *Euromais, European Maize Congress*, Cambridge, 3 - 7 September.
- LEVY D., HOLZER Z., VOLCANI R., 1968. The effect of age and liveweight on feed conversion and yield of saleable meat of intact Israeli-Friesian male calves. *Anim. Prod.* **10**, 325-330.
- LEVY D., HOLZER Z., VOLCANI R., 1970. Concrete slatted floors vs bedding for fattening Israeli-Friesian bull calves. *J. Anim. Sci.* **31**, 815-820.
- LEVY D., HOLZER Z., NEUMARK H., AMIR S., 1974. The effects of dietary energy content and level of feeding on the growth of Israeli-Friesian intact male cattle. *Anim. Prod.* **18**, 67-73.
- LEVY D., HOLZER Z., FOLMAN Y., 1975. Effect of concentrate roughage ratio on the production of beef from Israeli-Friesian bulls slaughtered at different liveweights. *Anim. Prod.* **20**, 199-205.
- LEVY D., HOLZER Z., FOLMAN Y., 1976. Effect of plane of nutrition, diethylstilboesterol implantation and slaughter weight on the performance of Israeli-Friesian intact male-cattle. *Anim. Prod.* **22**, 55-59.
- MEYER J.H., HULL J.L., WEITKAMP W.H., BONILLA S., 1965. Compensatory growth responses of fattening steers following various low energy intake regimes on hay or irrigated pasture. *J. Anim. Sci.* **24**, 29-37.
- MONTGOMERY M.J., BAUMGARDT B.R., 1965. Regulation of food intake in ruminants. 1. Pelleted rations varying in energy concentration. *J. Dairy Sci.* **48**, 569-579.
- PICKARD D.W., SWAN H., LAMMING G.E., 1969. Studies on the nutrition of ruminants. 4. The use of ground straw of different sizes for cattle from twelve weeks of age. *Anim. Prod.* **11**, 543-550.
- PIRIE R., GREENHALGH J.F.D., 1978. Alkali treatment of straw for ruminants. I. Utilization of complete diets containing straw by beef cattle. *Anim. Feed Sci. Technol.* **3**, 143-154.

- PRIOR R.L., KOHLMEIER R.H., CUNDIFF L.V., DIKEMAN M.E., CROUSE J.D., 1977. Influence of dietary energy and protein on growth and carcass composition in different biological types of cattle. *J. Anim. Sci.*, **45**, 132-146.
- RICHARDSON D., SMITH E.F., BAKER F.H., COX R.F., 1961. Effects of roughage-concentrate ratio in cattle fattening rations on gains, feed efficiency, digestion and carcass. *J. Anim. Sci.* **20**, 316-318.
- ROHR K., DAENICKE R., 1978. Untersuchungen über den Einfluss des Fütterungsniveaus und der Energieconcentration der Ration auf Pansenfermentation, Gewichtszuwachs und Schlachtkörperzusammensetzung schwarzbunter Mastbullen. *Züchtungskunde*, **50**, 67-77.
- SWAN H., LAMMING G.E., 1970. Studies on the nutrition of ruminants. 5. The effect of diets containing up to 70 per cent ground barley straw on the liveweight gain and carcass composition of yearling Friesian cattle. *Anim. Prod.* **12**, 63-70.
- VAN ES A.J.H., 1976. Meat production from ruminants. *Proc. Symp. on Growth and Productivity of Meat Animals*. Eds. D. LISTER, D.N. RHODES, V.R. FOWLER, H.F. FULLER, Plenum Press, Prestbury, p. 391-401.
- WALDMAN R.C., TYLER W.J., BRUNGARDT V.H., 1971. Changes in carcass composition of Holstein steers associated with ration energy level and growth. *J. Anim. Sci.* **32**, 611-619.
- WEISS R.L., BAUMGARDT B.R., BARR G.R., BRUNGARDT V.H., 1967. Some influences on rumen volatile fatty acids upon carcass composition and performance in growing and fattening steers. *J. Anim. Sci.* **26**, 389-393.
- WITT M., ANDREAE U., KALLWEIT E., 1971. Einfluss unterschiedlicher Fütterungsintensität auf Wachstum und Fettsatz beim Rind, untersucht an eineiigen Zwillingsbullen. *Züchtungskunde* **43**, 173-186.
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