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SELF FEEDING DAIRY COWS: FREE CHOICE INTAKES OF CONCENTRATES AND HAY GROUND THROUGH DIFFERENT SIZED SCREENS

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OPSOMMING: SELFVOEDING VAN MELKKOEIE: VRYE-KEUSE INNAMES VAN 'N KRAGVOERMENGSEL EN HOOI WAT DEUR SIWWE VAN VERSKILLENDE GROOTTES GEMAAL IS.

Twaalf Frieskoeie is vanaf die einde van die tweede maand van laktasie in 'n latynse-vierkant proefontwerp met 42 dae behandelingsperiodes, onderwerp aan 3 voedingsprosedures nl. 'n konvensionele voedingstelsel waarin kuilvoer, hooi en kragvoer gerantsoeneer is volgens liggaamsgrootte en produksie, 'n *ad lib.* aanbieding van 'n volledige dieet en 'n vrye-keuse aanbieding van 'n kragvoermengsel en hooi wat deur 2 verskillende sifgroottes gemaal is. Hoewel daar geen statisties betekenisvolle verskille was in die hoeveelhede 4 %vetgekorrigeerde melk daagliks geproduseer op die 3 behandelings nie, het die koeie op die derde behandeling 'n opmerklike konstante voorkeur aan die verskillende voere gegee en het hulle betekenisvol meer melk geproduseer maar met 'n laer bottervetpersentasie.

SUMMARY:

Twelve Friesland cows, in a Latin Square experimental design with 4 blocks and 42-day treatment periods, were subjected from the end of the second month of lactation, to 3 dietary treatments viz. a conventional system of roughage fed according to body size and concentrates according to production, an *ad lib.* offering of a complete diet and a free choice *ad lib.* offering of a concentrate mixture and hay, ground through screens of 2 different sizes. There were no statistically significant differences in the mean daily production of 4 %fat corrected milk (FCM) on the 3 treatments, but cows on the third treatment showed a remarkably constant preference for the different dietary components while they produced significantly more milk but with a lower percentage of butterfat.

In the grain producing areas of the Western Cape Province, drylot dairying has become almost a traditional system of city-milk production. Over the past years the feeding programme in these intensive units has developed a fairly characteristic pattern. A typical diet for in-milk cows consists of a roughage component which comprises silage (winter grown oats or barley with sweet lupins), oat hay, lucerne hay and small quantities of grain straw. This is usually fed between milkings when the cows are in open loafing yards. Where stanchion barns are used hay and/or silage is fed in the barn with concentrates. The daily concentrate allowance is fed at levels of 0,35 to 0,45 kg per kg milk produced.

Machine milking in walk-through parlours is rapidly gaining favour and labour is an ever-rising cost factor. Under these circumstances group feeding of concentrates in the loafing yard, or of at least part of the daily concentrate allowance, and self feeding of complete diets, hold attractive possibilities. These systems present various problems with regard to management, balancing of rations and factors involved in the voluntary intake of roughage and concentrates. In view of this it was decided to initiate trials to compare the conventional feeding method with two experimental methods viz. limited self feeding of a complete diet and free choice offering of concentrates and hay which is either coarsely or finely ground. In this paper the intakes by in-milk cows of the different diets and dietary components and milk production are presented. In a further paper results pertaining to the different methods used to determine digestibility of the diets and estimated utilization of metabolizable energy will be presented.

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Procedure

Twelve Friesland cows, which were completing the second month of lactation, were assigned to 4 blocks of a 3 x 3 Latin Square design. With this type of experimental design it is, according to Patterson & Lucas (1962), possible to eliminate the error variance due to animal variability and also to effectively increase the number of degrees of freedom where relatively small numbers of experimental animals are available. Furthermore, the completely balanced model makes it possible to adequately separate treatment effects and carry-over effects.

The 3 dietary treatments imposed for 42-day periods were:

A – a diet of oat-lupin silage, lucerne hay and concentrates fed in the conventional manner i.e. 13,6 kg silage per cow per day with 0,84 kg lucerne hay per 100 kg live body mass and 0,4 kg concentrates per kg milk produced daily during the previous week; the concentrate mixture consisted of 80% maize meal, 15% wheaten bran, 3% fish meal and 2% minerals; the cows were allowed 5,5 hr eating time per day in the stanchion barn;

B – a complete diet which consisted of 56,0% maize meal, 10,5% wheaten bran, 2,1% fish meal, 1,4% minerals and 30,0% lucerne hay, ground through a 32 mm screen, was offered *ad libitum* for 5,5 hr per day at a 5% refusal level in the stanchion barn;

C – a free choice offering to cows housed individually in free stalls, of milled lucerne hay ground through either a 12,5 mm or a 32,0 mm screen and a concentrate mixture with the same composition as that used in Treatment A; the cows had access to the food for 18,5 hr per day.

Daily feed intakes were recorded and all diets and dietary components were chemically analysed. Digestibility of the diets were estimated from data obtained in digestibility studies with sheep and also from data obtained in *in vitro* studies (McDonald, 1972). Daily milk production was recorded and 24 hr milk samples were analysed twice weekly.

Results

The condition and over-all appearance of the cows was excellent. On the complete diet (B) bloat occurred occasionally and on the free choice diet (C) the cows gained in body mass. In Table 1 the mean values for chemical composition of the dietary components are presented while mean daily feed intakes per cow and per unit metabolic body size, as well as the mean nutrient contents of the total diets as eaten, are set out in Table 2.

Table 2 shows a remarkable correspondence in the total dry matter (DM) intakes of the cows on Diets A and B while on Diet C, DM intake increased by 25,3%. The mean concentrate:roughage ratios as ingested were 41:59, 70:30 and 59:41, for Diets A, B and C respectively. Although mean DM intakes were similar on Diets A and B, cows on Diet B had a 15% higher DE-intake as a result of the higher digestibility of Diet B while cows on Diet C ingested 34% more DE than those on Diet A and 16% more than those on Diet B. While the mean crude protein content of the 3 diets showed little variation and the mean calcium and phosphorus contents as well as their ratios were both within the presently accepted limits, the crude fibre percentage showed a fairly wide difference between Diet B and the other two.

In Table 3 the mean weekly intakes of dietary components, expressed as a percentage of the total DM intake, by cows on Diets A and C are presented. Diet B (complete diet) had a fixed concentrate:roughage ratio. All cows were in the declining phase of the lactation curve and because the concentrate allowances on Diet A were fed according to production, the concentrate intake on this diet declined as the experimental period progressed. However, on Diet C, where the cows had free access to concentrates, coarse lucerne and fine lucerne, a remarkably constant pattern of preference was established from about the second week of the experiment. On the average this resulted in a 60% concentrate-DM intake and a 40% hay-DM intake. Similarly the proportionate intake of coarsely and finely ground hay was also remarkably constant at about 27% and 13%, respectively, of the total DM intake.

The mean values for changes in body mass, milk production, milk composition as well as estimated gross efficiency of utilisation of digestible energy (DE) for milk production (g 4% FCM per mJ DE), are presented in Table 4. Except for daily milk production and mean change in live mass on Diet C, which differed significantly from those on Diets A and B, there were no significant differences in the production parameters listed in Table 4. However, it is interesting to note the progressive decrease in butterfat percentage from Diet A to Diet C and the tendency for protein percentage to be higher on Diets B and C. The estimated gross efficiency of utilisation of DE was lowest with Diet C and highest with Diet A.

Discussion

In this study, the cows on the complete diet (B) were, for practical reasons, allowed the same feeding time (5,5 hr/24 hr) as those on the conventional diet (A), but whereas the latter were rationed according to body size and production, the complete diet was offered on an *ad lib.* basis. Despite this, feed intake, change in live mass and quantity of milk produced on Diets A and B were remarkably similar. The highest energy intake was achieved on Diet C and this resulted in a significantly higher milk production but, as result of compositional changes, FCM production was the highest on Diet B followed by C and A in that order.

Cows on Treatment C selected a diet with crude protein and crude fibre percentages very similar to the conventionally rationed Diet A. However, on Diet C, energy intake was considerably higher and despite the 18% crude fibre in the diet, as ingested, fat percentage dropped lower than on Diet B with only 12% crude fibre. The control diet (A) with 21% crude fibre, maintained the highest fat

Table 1

Mean chemical composition of the diet components (moisture free basis)

	Diet A			Diet B	Diet C		
	Concentrates	Silage	Lucerne hay	Complete diet	Concentrates	Fine lucerne	Coarse lucerne
Crude protein (%)	12,9	11,1	14,8	13,7	12,9	14,6	14,4
Crude fibre (%)	4,6	34,9	31,9	12,4	4,6	32,6	34,1
Ether extract (%)	4,7	6,2	3,0	4,3	4,7	2,7	2,8
Ash (%)	4,0	8,2	6,9	4,8	4,0	6,4	6,5
N.F.E. (%)	73,8	39,5	43,4	64,8	73,8	43,6	42,2
Gross energy (MJ/kg)	18,4	18,8	18,4	18,4	18,4	18,6	18,4
Ca (%)	0,4	1,0	1,7	0,8	0,4	1,4	1,3
P (%)	1,0	0,3	0,3	0,7	0,9	0,3	0,3

Table 2

Mean values for daily dry matter intake (per cow and per kg $W^{0,75}$), daily DE intakes and nutrient concentrations of the total diets as eaten (moisture free basis)

Intakes	Diet A	Diet B	Diet C
Concentrates (kg/cow/day)	5,74	–	10,45
Silage (kg DM/cow/day)	3,41	–	–
Lucerne hay* (kg/cow/day)	4,87	–	4,82
Lucerne hay** (kg/cow/day)	–	–	2,31
Complete diet (kg/cow/day)	–	14,23	–
Total DM (kg/cow/day)	14,02 ± 0,56	14,23 ± 0,53	17,58 ± 0,54
Total DM (g/kg $W^{0,75}$/day)	117	118	146
DE (MJ/cow/day)	174	200	233
Nutrient concentrations:			
DE (MJ/kg)	12,43	14,11	13,27
Crude protein (%)	13,1	13,7	13,5
Crude fibre (%)	21,4	12,4	18,0
Ca (%)	1,00	0,80	0,75
P (%)	0,60	0,70	0,65

* Lucerne hay ground through a 32 mm screen
** Lucerne hay ground through a 12,5 mm screen

Table 3

Mean values for proportionate intakes of diet components (moisture free) by cows on the conventional diet (A) and the free choice diet (C)

Week	Diet A			Diet C		
	Concentrates	Silage	Lucerne	Concentrates	Coarse lucerne	Fine lucerne
1	46	23	31	50	28	22
2	43	24	33	57	30	13
3	41	24	35	61	27	12
4	39	24	37	62	28	10
5	39	25	36	62	26	12
6	38	25	37	63	25	12

Note: Diet B had a fixed concentrate:roughage ratio of 70:30

test and was utilised more efficiently (in terms of g FCM produced per MJ DE ingested) than both the complete Diet B and the free choice Diet C. Butterfat percentage was lower on Diet B and lowest on C while solids-not-fat (SNF) percentage increased (although statistically non-significantly) as digestible energy intake increased from 174 MJ to 200 and 233 MJ per cow per day on Diets A, B and C respectively. This is in accordance with results obtained by Holmes, Reid, MacLusky, Waite & Watson (1957), Rook & Line (1961) and Huber & Bowman (1966) who found that increased energy intake resulted in an increase in the SNF percentage.

In considering the composition of complete diets for self-feeding of dairy cows, not only the nutrient content of the diet but also its physical characteristics and possible effects on milk composition should be taken into account. Energy intake can be increased by reducing physical size of roughages thus increasing rate of passage or, as is more commonly done, by increasing concentrate intakes, thus lowering crude fibre percentage of the diet. Both procedures may have profound effects on the nature of the end products of digestion which become available as substrates for the metabolic products of the mammary gland. In a recent study Cowan, Oliver & Elliot (1970) compared com-

Table 4

Mean values for changes in body mass, production and composition of milk and estimated gross efficiency of utilisation of DE for the production of fat corrected milk.

	Diet A	Diet B	Diet C
Change in live mass (kg/day)	- 0,03	- 0,04	0,43
Milk (kg/day)	15,12	15,95	16,59
Butterfat (%)	3,90	3,76	3,64
Total solids (%)	13,03	12,90	12,60
Solids-not-fat (%)	9,13	9,15	9,16
Protein (%)	3,37	3,64	3,62
Fat-corrected milk (kg/day)	14,84	15,37	15,13
FCM/MJ DE (g)	85	77	65
FCM/kg DM (g)	1060	1080	860

plete diets with 5, 20, 35 and 50% roughage and found that molar percentage acetic acid in rumen fluid changed from 42,7% on the 5% roughage diet to 59,6% on the 50% roughage diet. They obtained a definite lowering of butterfat percentage only on the diet with 5% roughage and concluded that gross efficiency of utilisation of metabolizable energy for milk production was highest on the 50% roughage diet. Coppock, Flatt, Moore & Stewart (1964) compared diets supplying 100, 75 and 50% of estimated net energy in the form of roughage and found that the metabolizable energy of the 50% diet with a molar percentage of 65% acetic acid in rumen fluid, was utilised with highest efficiency for milk production.

In the present study rumen concentrations of volatile fatty acids were not determined, therefore it is difficult to comment on the apparent paradox that butterfat percentage dropped lower on Diet C, with 18% crude fibre, than on Diet B with only 12%. According to live mass changes, cows on Diets A and B were probably catabolizing body tissue while those on C gained in mass and, presumably, in body fat. As the long chain acids of milk fat are derived from triglycerides of beta-lipoproteins, which should be more abundant in the blood plasma of cows in the process of losing body mass, the answer might lie not only in the type of rumen fermentation on a particular diet, but also in the type of metabolism resulting from a particular level of energy intake in relation to the cow's genetic potential for milk production. In the present study it is obvious that the level of energy intake achieved on Diet C, exceeded the experimental cows' potential for milk production and that this resulted not only in a gain in body mass but also in the production of milk of lower butterfat content, both of which are economically undesirable. However, the remarkably constant pattern of diet selection shown by cows on the free choice diet (C) might be of value in further work on complete diets for dairy cows.

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