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THE NUTRITIVE VALUE OF SORGHUM HAY, SUPPLEMENTED BY CONCENTRATES IN DIFFERENT RATIOS, AND FED TO HIGH AND LOW PRODUCING FRIESLAND COWS AND FIRST CALF HEIFERS

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OPSOMMING: DIE VOEDINGSWAARDE VAN SORGHUMHOOI WAT IN VERSKILLENDE VERHOUDINGS DEUR KRAGVOER AANGEVUL WORD, VIR MELKPRODUKSIE VAN HOOG- EN LAAGPRODUSERENDE FRIESKOEIE EN EERSTEKALF-VERSE

Die gebruik van sorghumhooi vir die produksie van melk by hoog- en laagproduserende Frieskoeie en eerstekalf-verse, en die invloed daarvan op die samestelling van die melk van die proefdiere, is ondersoek. Die proefdiere is in vier produksiegroepe geplaas en 12 lakterende koeie en 12 eerstekalf-verse onderwerp aan 'n proef met 'n ekstra-periode Latynse Vierkant roterende oorslaanontwerp. Drie volledige rantsoene met wisselende verhoudings van sorghumhooi (S) tot kragvoer (K) naamlik 20S : 80K, 40S : 60K en 60S : 40K, is gevoer. Waar 'n hoër produksie bewerkstellig kon word deur die verhouding van sorghumhooi tot kragvoer te verminder van 60S : 40K na 40S : 60K, is geen ooreenkomstige verbetering in produksie behaal deur 'n verdere vermindering na 20S : 80K nie. Oorvoorsiening van metaboliseerbare energie (ME) met 20S : 80K en 40S : 60 K rantsoene het vermeerder namate die produksie gedaal het. Vanuit 'n oogpunt van ME-inname en produksie, kan die 20S : 80K rantsoen nie vir hoog- en laagproduserende koeie en eerstekalf-verse aanbeveel word nie.

SUMMARY:

The possible use of sorghum hay in the production of milk by high and low yielding Friesland cows and first calf heifers was investigated and its influence on milk composition was determined. The animals were divided into four production groups, and 12 lactating cows and 12 first calf heifers were subjected to a trial having an extra period Latin Square rotating changeover design. Three complete rations with varying sorghum hay (S) to concentrate (C) ratios were fed, viz. 20S : 80C, 40S : 60C and 60S : 40C. Whereas a higher milk production was obtained by decreasing the ratio of sorghum hay to concentrate from 60S : 40C to 40S : 60C, similar improvement could not be obtained by decreasing the ratio further to 20S : 80C. An overprovision of metabolisable energy (ME) from the 20S : 80C and 40S : 60C ratios was aggravated by decreased production. Viewed from an ME intake and production point of view, the 20S : 80C ration cannot be recommended for high and low yielding cows and first calf heifers.

Voluntary feed intake is the most important factor influencing total energy intake by ruminants (Blaxter, 1967). Therefore it is important to restrict the intake of low energy feeds for high yielding cows in order to conserve rumen space. Roughages such as sorghum hay have relatively low ME values, necessitating the intake of large quantities in order to supply sufficient nutrients.

Conrad, Pratt & Hibbs (1964) point out that it is not economic to increase the ration quality for ruminants further than a digestibility of 67% on a dry matter basis. With such a high digestibility, feed intake of ruminants is no longer restricted by rate of digestion, but by physiological factors as in the case of the non-ruminant. The latter reacts to the increase of nutrient concentration in the ration by eating less, maintaining a constant nutrient intake at a specific level. Flatt, Moe, Moore, Hooven, Lehmann, Ørskov & Hemken (1966) and Neitz (1974) found a virtually constant net energy or ME intake after *ad libitum* feeding of 60L : 40C, 40L : 60C and 20L : 80C lucerne: concentrate rations. The significant difference in roughage intake when sorghum or lucerne is used with concentrates stays unexplained. Crowley (1970) mentioned that the feeding of up to 4,5 kg of grain does not decrease roughage intake. If more grain is fed, each additional kilogram causes a decrease in roughage intake of 0,5 kg.

Dickson & Kopland (1934) found that the amount of milk produced from roughage only, roughage plus limited concentrate and roughage plus sufficient concentrate, amounted to 6194, 7642 and 8097 kg per cow per

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Table 1

Composition of experimental rations fed to cows and first-calf heifers

Composition	Rations		
	A 20S:80C* %	B 40S:60C %	C 60S:40C %
Sorghum hay	20,0	40,0	60,0
Yellow maize meal	62,0	41,0	22,0
Wheaten bran	6,0	4,5	2,0
Sunflower cake meal	5,0	8,0	8,0
H.P.C. '60'	5,0	5,0	7,0
Dicalcium phosphate	1,5	1,0	0,5
Salt	0,5	0,5	0,5
Dry matter	89,57	90,55	90,76
Crude protein	13,52	12,94	13,84
Cellulose	12,5	20,3	24,6

*S = sorghum hay
C = concentrate dairy meal

lactation respectively. The calculated TDN required to produce 100 kg of milk for the three feeding levels was 53,4; 55,5 and 68,9 kg respectively.

Procedure

Twelve lactating Friesland cows and twelve first calf heifers were used in an extra period Latin Square rotating changeover design having two blocks, four periods and six animals per block (Lucas, 1957). The grouping was done on the basis of daily milk production as registered during the first month of lactation.

The four production groups, in the case of the cows, were:

group 1 25,0 ℓ and higher
group 2 22,0 ℓ to 24,9 ℓ
group 3 19,0 ℓ to 21,9 ℓ
group 4 18,9 ℓ and lower

and in the case of the first calf heifers:

group 1 18,0 ℓ and higher
group 2 15,0 ℓ to 17,9 ℓ
group 3 12,0 ℓ to 14,9 ℓ
group 4 11,9 ℓ and lower

In both cases groups 1 and 2 were considered the high production group (block A) and groups 3 and 4 the low production group (block B).

The animals were fed individually and *ad lib.* from 30 to 150 days *post partum* in four periods of 30 days each. The experimental rations were three complete rations having varying ratios of sorghum hay to concentrate, viz. 20S:80C, 40S:60C and 60S:40C.

In addition three lactating Friesland cows were subjected to a metabolic trial for each of the experimental rations (3 x 3 Latin Square design) in order to determine the digestibility of the components of each ration.

Results and discussion

Metabolisable energy (ME) values (MJ/kg) were 9,68; 8,51 and 7,63 respectively. The crude protein content of the three rations varied from 12,94 to 13,84 per cent. The composition of the experimental rations is given in Table 1. The cellulose percentages increased significantly with an increase in the sorghum portion in the ration.

The digestibility of the components of each ration is given in Table 2.

Table 2

Average digestibility coefficients of the components of the experimental rations consumed by the lactating cows during the digestion trial

Component	Unit	Ration treatment			
		A 20S:80C	B 40S:60C	C 60S:40C	Difference[1]
Dry matter	%	64,63	57,29	53,03	NS
Energy	%	64,76	58,16	53,69	NS
Nitrogen	%	70,75	64,37	64,80	NS
Crude protein	%	70,75	64,37	64,80	NS
Cellulose	%	42,59	48,21	50,01	NS
Organic material	%	66,55	59,93	56,01	NS

[1] Differences: NS: not significant ($P > 0,05$)

Table 3

Average digestible nutrients of the rations consumed by the lactating cows during the digestibility trial

Component	Unit	Ration treatment		
		A 20S:80C	B 40S:60C	C 60S:40C
Digestible energy	MJ/kg	11,51[a]	10,24[a, b]	9,31[b]
Metabolisable energy	MJ/kg	9,68[a]	8,51[a, b]	7,63[b]
Digestible protein	%	9,50	8,33	9,15

a, b : Averages in a line having the same superscript do not differ significantly at the 5% significance level

Except in the case of cellulose, the digestibility of all the components increased as the sorghum hay content of the rations decreased. Differences were however, not significant.

Table 3 indicates the digestible nutrient content of the rations; viz. digestible energy (DE), metabolisable energy (ME) and digestible protein (DP).

Both DE and ME values of the rations increased significantly as the sorghum hay content in the rations decreased. Difference in DP between rations were not significant.

The average daily feed intake of the first calf heifers and the cows in this study is given in Table 4.

Table 4

Average daily intake of sorghum: concentrate rations by first calf heifers and cows

Variable description	Unit	First-calf heifers			Cows		
		Ration treatment			Ration treatment		
		A 20S:80C	B 40S:60C	C 60S:40C	A 20S:80C	B 40S:60C	C 60S:40C
High Production group							
Dry matter	kg	18,04	17,17	13,65	20,61	19,88	16,58
Metabolisable energy	MJ	174,65	146,09	104,35	199,69	169,30	127,03
ME intake/kg milk	MJ	11,29[a, b]	9,12[a]	7,85[b]	7,93[a, b, 1]	7,49[a, 1, 2]	6,20[b, 2]
DM intake as % of body mass	%	3,90	3,64	2,97	3,91	3,76	3,21
Low Production group							
Dry matter	kg	16,80	16,58	12,14	19,32	18,66	15,10
Metabolisable energy	MJ	162,50	141,17	92,52	187,27	158,94	115,22
ME intake/kg milk	MJ	12,03[a, 1]	10,89[b, 1]	7,89[a, b, 2]	10,84[a, 1]	9,48[b, 1]	7,43[a, b, 2]
DM intake as % of body mass	%	3,75	3,80	2,79	3,63	3,56	2,95
Overall average							
Dry matter	kg	17,42[1]	16,87[1]	12,89[2]	19,96[1]	19,27[1]	15,84[2]
Metabolisable energy	MJ	168,57[1]	143,63[2]	98,44[3]	193,47[1]	164,12[2]	121,12[3]
ME intake/kg milk	MJ	11,66	10,00	7,86	9,39	8,49	6,82
DM intake as % of body mass	%	3,82[1]	3,71[1]	2,87[2]	3,77[1]	3,66[1]	3,08[2]

Averages in a line having the same superscript, do not differ significantly: a, b – 5% level of significance

1, 2, 3 – 1% level of significance

Overall, both cows and first calf heifers consumed more of the high concentrate rations A and B, than of ration C. When the cow production groups are viewed separately, the differences in intake are not significant.

Between A and B differences in intake were not significant. In other words, whereas a higher DM intake resulted from altering the sorghum-concentrate ratio from 60S:40C to 40S:60C no further increase resulted from decreasing the ratio still further to 20S:80C.

Dry matter intake expressed as percentage of body mass produced non-significant differences between treatments when the production groups were viewed separately. Viewed jointly, highly significant differences occurred, namely A > C ($P < 0,01$) and B > C ($P < 0,01$). This applies to both cows and first calf heifers.

Differences in ME intake occurred, being non-significant for the low and high producers separately, but highly significant for the two groups viewed jointly. As DM digestibility increased, so did ME intake.

The higher the ME content of the rations, the more ME was taken in per kg of milk produced.

Table 5 indicates the average composition of the milk and the daily milk production of the first calf heifers and the cows respectively.

The overall milk production of the first calf heifers receiving rations A and B was highly significantly better than those receiving ration C, but there was no significant difference between rations A and B.

The largest quantity of milk was produced by the cows of the high production groups, fed ration A, followed by the cows fed rations B and C. The cows belonging to the low production group produced more milk on rations A and B than on C.

Table 5

Average composition of the milk and daily milk yield of the first calf heifers and cows

Variable description	Unit	First-calf heifers			Cows		
		Ration treatment			Ration treatment		
		A 20S:80C	B 40S:60C	C 60S:40C	A 20S:80C	B 40S:60C	C 60S:40C
High Production group							
Daily milk production	kg	15,68	16,37	13,56	25,11 [1]	22,75 [2]	20,59 [3]
4 % FCM	kg	15,03	15,42	13,13	22,13	22,16	20,08
Butterfat	kg	0,58	0,59	0,52	0,81	0,87	0,79
Chemical composition of milk:							
Butterfat	%	3,72	3,66	3,78	3,22	3,84	3,85
Solids-not-fat	%	8,93	8,84	8,44	8,72	8,79	8,46
Low Production group							
Daily milk production	kg	13,52	13,48	11,73	17,68 [a, b, 1]	17,17 [a, 1, 2]	15,67 [b, 2]
4 % FCM	kg	12,31	12,25	11,65	15,58	16,09	15,03
Butterfat	kg	0,45	0,47	0,46	0,57	0,61	0,58
Chemical composition of milk:							
Butterfat	%	3,37	3,50	3,94	3,22	3,56	3,73
Solids-not-fat	%	9,09	8,95	8,59	8,87	8,77	8,47
Overall average							
Daily milk production	kg	14,60 [1]	14,93 [1]	12,64 [2]	21,39	19,96	18,13
4 % FCM	kg	13,67 [1]	13,83 [1]	12,39 [2]	18,86 [a, b]	19,13 [a]	17,55 [b]
Butterfat	kg	0,52	0,53	0,49	0,69	0,74	0,69

Averages in a line having the same superscript, do not differ significantly: a, b – 5 % level of significance

1, 2, 3 – 1 % level of significance

Flatt, Moe, Munson & Cooper (1969) found that the pattern of energy distribution between the production functions of the body changed as the roughage content of rations fed *ad lib.* decreased, so that more energy was used for body tissue production. The cows receiving the two high concentrate rations in the present study probably had more feed energy available for milk secretion than the cows receiving the 60S:40C ration, because they did not use body reserves to supplement the feed energy.

Although body mass changes do not necessarily reflect changes in body reserves, Table 6 does indicate that the cows which received the two high concentrate rations had a higher body mass than those which received the low concentrate ration.

The ME intake per kg of milk produced by heifers increased as the ME content of the ration increased. These differences in ME intake per kg of milk produced are reflected in the body mass of the first calf heifers, which received the two high concentrate rations. The body mass of these groups is significantly higher than that of the heifers on the low concentrate ration. It is a striking fact that within each treatment and production group the first calf heifers showed a higher ME intake per kg of milk produced than the cows. These differences may be ascribed to the greater utilization of body reserves by older cows in comparison to the first calf heifers. These heifers gained substantially in body mass during first lactation. Neitz (1974) found that cows gained only 9,9 kg body mass during a 300 day lactation, compared to 80,4 kg by first calf heifers.

Within each treatment, the first calf heifers in the high production group exhibited a lower ME intake per kg of milk produced than the heifers in the low production group. The higher producer seems to be more efficient because virtually no differences in body mass occurred between the two production groups.

Within all the treatment groups the cows in the high production group exhibited a lower ME intake per kg of milk produced than the cows of the lower production group. This points to a greater efficiency of the high producer.

Table 6

Average body mass of the cows and the first calf heifers during the experimental period

Body mass (kg)	Ration treatment		
	A 20S:80C	B 40S:60C	C 60S:40C
Cows			
(a) High production group	545 [1]	538 [1]	509 [2]
(b) Low production group	568 [a, 1]	539 [b, 1, 2]	492 [a, b, 2]
(c) Overall average	557 [1]	538 [1]	501 [2]
First calf heifers			
(a) High production group	471	482	459
(b) Low production group	476	471	458
(c) Overall average	474 [a]	476 [a]	459 [b]

Averages in a line having the same superscript do not differ significantly : a, b – 5% level of significance
1, 2 – 1% level of significance

With reference to the butterfat yield, non-significant differences occurred in the case of both cows and first calf heifers. However, highly significant differences in butterfat percentage occurred in the milk of the cows, and non-significant differences in the butterfat percentage in the milk of the first calf heifers, when the production groups are viewed jointly. The butterfat percentage increased with an increase of the sorghum hay content of the ration. Neitz (1974) mentioned that the butterfat percentage increased when the lucerne content of the ration was increased from 20 to 80 percent. The prediction can be made that when rations contain as low as 20 per cent roughage, milk having a relatively low fat percentage will be produced (Emery, Brown & Thomas, 1964 and Leighton & Rupel, 1964).

With reference to the solids-not-fat content of the milk, highly significant overall differences occurred in both cows and first calf heifers. The expected pattern of an increase in solids-not-fat as a result of an increase in the energy content of the ration (Hoogendoorn & Grieve, 1970) was experienced in the current trial.

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