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FINENESS AND CONCENTRATE TO LOW QUALITY ROUGHAGE RATIO OF COMPLETE DIETS FOR DAIRY COWS. 2. MILK PRODUCTION AND COMPOSITION

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OPSOMMING: FYNHEID EN KRAGVOER TOT LAE KWALITEIT RUVOER VERHOUDING VAN VOLLEDIGE RANTSOENE VIR MELKKOEIE. 2. MELKPRODUKSIE EN SAMESTELLING

Ses-en-dertig lakterende koeie is gebruik in 'n proef waar lae gehalte mieliestrooi as ruvoerbron in volledige diëte gebruik is. Die effek van fynheid van ruvoer en kragvoerpersentasie op melkproduksie en melksamestelling is bepaal. 'n Verhoging in die kragvoer tot ruvoer verhouding (35 – 65 persent) en 'n kleiner sifopeninggrootte (19 – 6 mm) het gelei tot verhoogde melkproduksie. Verskillende hoeveelhede melk is geproduseer vir elke kragvoer tot ruvoer verhouding en sifopeninggrootte-kombinasie.

'n Verhoging vanaf 35 tot 50 persent kragvoer het gelei tot 11 persent verhoging in melkvetproduksie. Sifopeninggrootte het geen invloed gehad op melkvetproduksie met diëte wat 35 persent kragvoer gehad het nie. Indien sifopeninggrootte verklein is vanaf 19 na 13 mm het melkvetproduksie verhoog met diëte wat 50 en 65 persent kragvoer gehad het.

Melk DM en melkproteïenproduksies was verskillend vir elke kragvoerpersentasie en sifopeninggrootte. Die gemiddelde DM-, vet- en proteïenpersentasie van die melk was 12,3, 3,7 en 3,1 onderskeidelik. Kragvoer tot ruvoer verhouding en sifopeninggrootte van die diëte het geen betekenisvolle effek op melk DM en melkproteïenpersentasies gehad nie.

SUMMARY:

Thirty six lactating cows were used in a trial where low quality maize straw was used as a roughage source in complete diets. The effects of fineness of roughage and concentrate to roughage ratio on milk production and milk composition were studied. An increase in concentrate percentage (35 – 65 per cent) and a decrease in screen size (19 – 6 mm) increased milk production. Different quantities of milk were produced for each concentrate to roughage ratio and screen size combination. Butterfat production increased by 11 per cent when the concentrate in the diet was increased from 35 to 50 per cent. Screen size had no effect on butterfat production at the 35 per cent concentrate level. At 50 and 65 per cent concentrate, butterfat, production increased with a decrease in screen size from 19 to 13 mm. Milk DM and milk protein production were distinctly different for each specific treatment. The mean DM-, fat- and protein percentages of the milk were 12,3, 3,7 and 3,1, respectively. Treatment had little effect on milk DM and milk protein percentages.

To produce large quantities of milk, especially early in lactation, the dairy cow needs high energy intake (Broster & Smith, 1969). Factors like concentrate to roughage ratio and fineness of diet are important in ensuring maximum energy intake. The adverse effects of too high concentrate or too fine diets on milk production and composition have been described (Rodrique & Allen, 1960; Storry & Rook, 1965; Mc Coy, Thurmon, Olsen & Reed, 1966; O'Dell, King & Cook, 1968; Storry & Sutton, 1969; Cowan, Oliver & Elliot, 1970; Armstrong & Prescott, 1971; Annison, 1973).

The use of a low quality inexpensive and abundantly produced roughage such as maize straw reduces the costs involved in producing milk. It is possible to increase the intake of low quality roughage complete diets by 44 per cent (Liebenberg, 1979) by reducing the fineness of the diet through milling (19 to 6 mm) and simultaneously increasing the concentrate content (35 to 65 per cent) of the diet.

This paper describes the influence of fineness and concentrate to roughage ratio of complete diets based on maize and maize straw on milk production and milk composition.

Procedure

Thirty six lactating cows were fed 9 different complete diets. The diets were obtained by different combination of concentrate to roughage (65 : 35; 50 : 50; 35 : 65) and milled through 6, 13 or 19mm screens. The diets were offered *ad libitum* to the cows from 10 days to 130 days *post partum* in three periods of 40 days each. The maize straw used was of low quality and the complete diets were fed in an unpelleted form. A partially balanced change-over design was chosen as statistical model (Patterson & Lucas, 1962). More detailed information on diets, statistical model, animals, diet preparation and experimental routine have been reported elsewhere (Liebenberg, 1979).

Milk production for every cow was recorded with each milking. Composite milk samples as a constant proportion (1 per cent) of total milk production were taken after each milking for individual cows. These samples were preserved with formalin (1 mℓ 10 per cent formalin/150 mℓ milk) and analysed within 3 weeks after collection for DM, butterfat, nitrogen and ash.

Results and Discussion

Milk Production

The mean milk production (Table 1) was calculated by adding the overall mean to the estimated constants as determined by the model of Patterson & Lucas (1962). At a 6 mm screen size milk production increased from 16,1 to 17,0 kg with an increase in concentrate from 35 to 65 per cent. At a 13 mm screen size an increase in concentrate from 35 to 50 per cent increased milk production significantly ($p \leqslant 0{,}01$) from 15,1 to 16,6 kg. A further increase in concentrate to 65 per cent did not increase milk production significantly. On diets with roughage milled through a 19 mm screen milk production increased significantly ($p \leqslant 0{,}01$) from 14,9 to 15,8 kg with an increase in concentrate from 35 to 50 per cent, but no further significant increase when concentrate was increased to 65 per cent.

Table 1

Mean daily fat corrected milk production by cows on diets with different concentrate : roughage ratios and screen sizes

Screen size (mm)	Daily fat corrected milk production (kg) Concentrate percentage 35	50	65	Mean
6	*16,1^{abcdef}	16,7^{abc}	17,0^{a}	16,6
13	15,1^{efgh}	16,6^{abcd}	16,8^{ab}	16,2
19	14,9^{fgh}	15,8^{abcdefg}	16,3^{abcde}	15,7
Mean	15,4	16,4	16,7	16,2

*Means with different superscripts differ significantly ($p \leqslant 0{,}01$)

At 35 per cent concentrate a decrease in screen size from 19 mm to 6 mm increased milk production from 14,9 to 16,1 kg. At 50 and 65 per cent concentrate milk production increased from 15,8 and 16,3 to 16,7 and 17,0 kg, respectively with a decrease in screen size from 19 mm to 6 mm. These increased milk productions were, however, non-significant.

From Table 1 it is clear that an increase in concentrate and a decrease in screen size resulted in an increase in milk production. It is further shown that different quantities of milk were produced for each combination of screen size and concentrate percentage. The mean values between screen sizes indicated a significant ($p \leqslant 0{,}01$) increase in milk production from 15,7 kg at 19 mm to 16,6 kg at 6 mm. The mean values for concentrate to roughage ratios indicated a significant ($P \leqslant 0{,}01$) increase in milk production from 15,4 kg at 35 per cent concentrate to 16,4 and 16,7 kg at 50 and 65 per cent respectively. The average daily fat corrected milk production of 16,2 kg obtained for the first 130 days *post partum*, was not optimal, but acceptable when diets with low quality roughage, like maize straw are the only available roughage source.

The means for milk production in each period are given in Table 2.

Table 2

Daily fat corrected milk production for each experimental period

No.	Experimental period: Days *post partum*	Daily fat corrected milk production (kg)
I	10 - 50	18,1
II	50 - 90	16,0
III	90 - 130	14,3

The means in Table 2 differed significantly ($p \leqslant 0{,}01$). From Table 2 it can be seen that maximum milk production was recorded during the first 50 days of lactation. Milk production decreased, on average, by 10 per cent for each successive 40 day period.

Butterfat-, DM- and protein production

The differences in butterfat production as shown in Table 3 were not significant. Nevertheless, from the concentrate means it is clear that daily butterfat production increased from 600 to 634 g with an increase in concentrate from 35 to 50 per cent. At 35 per cent concentrate daily butterfat production increased from 582 to 628 g with a decrease in screen size from 19 to 6 mm. The screen size means indicate a small increase in daily butterfat production from 626 to 639 g as screen size decreased from 19 to 6 mm.

Table 3

Daily butterfat production on the diets with different concentrate : roughage ratios and screen sizes

Screen size (mm)	Daily butterfat production (g) Concentrate percentage			Mean
	35	50	65	
6	628	641	647	639
13	591	649	648	629
19	582	613	623	626
Mean	600	634	639	625

The results on butterfat production for each experimental period showed a significant ($p \leqslant 0{,}01$) decline from period I to III. The daily butterfat production for each period was 702, 616 and 556 g for periods I, II and III, respectively.

At a 6 mm screen daily DM production increased from 2 068 g to 2 255 g with an increase in concentrate from 35 per cent to 65 per cent (Table 4). At a 13 mm screen daily DM production increased significantly ($p \leqslant 0{,}01$) from 1 915 to 2 117 g with an increase in concentrate from 35 per cent to 50 per cent. A further increase in concentrate had no further significant effect on DM production at a 13 mm screen size. At a 19 mm screen an increase in concentrate from 35 per cent to 65 per cent, increased daily DM production significantly ($p \leqslant 0{,}01$) from 1 877 to 2 149 g. At 35 per cent concentrate a decrease in screen size from 19 mm to 6 mm, significantly ($p \leqslant 0{,}01$) increased daily DM production from 1 877 to 2 068 g.

Table 4

Daily DM production on the diets with different concentrate : roughage ratio's and screen sizes

Screen size (mm)	Daily DM production Concentrate percentage			Mean
	35	50	65	
6	*2 068^{bcdef}	2 188^{abc}	2 255^{a}	2 170
13	1 915^{fgh}	2 117^{abcde}	2 197^{ab}	2 076
19	1 877^{gh}	2 042^{bcdefg}	2 149^{abcd}	1 989
Mean	1 953	2 116	2 200	2 090

*Means with different superscripts differ significantly ($p \leqslant 0{,}01$)

The results on DM production for each experimental period showed a significant ($p \leqslant 0{,}01$) decline from period I to III. Daily DM production were 2 327, 2 075 and 1 867 g for periods I, II and III, respectively.

At a 6 mm screen daily protein production (Table 5) increased significantly ($p \leqslant 0{,}01$) from 520 to 577 g with an increase in concentrate from 35 to 65 per cent. At a 13 mm screen daily protein production increased significantly ($p \leqslant 0{,}01$) from 463 to 529 g with an increase in concentrate from 35 to 50 per cent. At a 19 mm screen daily protein production also increased significantly ($p \leqslant 0{,}01$) with an increase in concentrate from 35 to 50 per cent. The concentrate means show a significant ($p \leqslant 0{,}01$) increase in daily protein production from 479 to 532 g with an increase in concentrate from 35 to 50 per cent. The increase in protein production from 532 to 554 g with an increase in concentrate from 50 per cent to 65 per cent was non-significant.

Table 5

Daily protein production on the diets with different concentrate : roughage ratios and screen sizes

Screen size (mm)	Daily protein production Concentrate percentage			Mean
	35	50	65	
6	*520^{bcdef}	561^{ab}	577^{a}	523
13	463^{gh}	529^{abcde}	544^{abc}	512
19	454^{h}	506^{cdefg}	541^{abcd}	500
Mean	479	532	554	517

*Means with different superscripts differ significantly ($p \leqslant 0{,}01$)

At 35 per cent concentrate a decrease in screen size from 19 to 6 mm increased daily protein production significantly ($P \leqslant 0{,}01$) from 454 to 520. At 50 per cent concentrate daily protein production also increased significantly ($p \leqslant 0{,}01$) from 506 to 561 g with a decrease in screen size from 19 to 6 mm. The screen size means for protein production show a significant ($p \leqslant 0{,}01$) increase in daily protein production from 500 to 523 g with a decrease in screen size from 19 to 6 mm.

The results on protein production for each experimental period showed a significant decline from period I to III. Daily protein production declined from 573 g in period I to 513 g in period II and 478 g in period III.

From the results it is clear that an increase in concentrate content and a decrease in screen size led to an increase in milk DM and milk protein production.

Milk composition

Milk composition, expressed as percentage of total milk production was calculated from the means for daily milk, butterfat, DM- and protein productions. Milk DM and milk protein did not differ conspicuously and varied from 12,1 per cent to 12,4 per cent for milk DM and from 2,9 per cent to 3,2 per cent for milk protein. The overall means for milk DM and milk protein were 12,3 and 3,1 per cent respectively.

The results on butterfat percentage are given in Table 6.

Table 6

Butterfat percentage on the diets with different concentrate : roughage ratios and screen sizes

Screen size (mm)	Butterfat percentage: Concentrate percentage 35	50	65	Mean
6	3,8	3,6	3,5	3,6
13	3,8	3,8	3,7	3,8
19	3,8	3,7	3,6	3,7
Mean	3,8	3,7	3,6	3,7

The concentrate means in Table 6 indicate a decrease in butterfat percentage from 3,8 to 3,6 per cent with an increase in concentrate from 35 to 65 per cent. The screen size means show that diets milled through 6, 13 and 19 mm screen produced butterfat percentages of 3,6; 3,8 and 3,7 per cent respectively. Table 6 also shows that at a 13 mm screen, concentrate had little effect on butterfat percentage and screen size had no effect at 35 per cent concentrate.

The mean butterfat-, milk DM-, and milk protein percentages for each experimental period showed very little difference. Butterfat, milk DM and milk protein percentages for periods I, II and III were 3,7; 3,6; 3,7; 12,3; 12,3; 12,4; 3,0; 3,0 and 3,2 per cent respectively.

Conclusions

The amounts of milk produced by dairy cows on diets with different concentrate levels and milled through different screen sizes are tabulated in Table 7. The diets were fed as complete diets at *ad libitum*. Milk production for cows weighing 400, 500 or 600 kg were calculated from experimental figures measured as fat corrected milk/kg live mass.

Table 7

Estimated amounts of milk produced on the complete diets with different screen sizes and concentrate combinations

Screen size (mm)	Concentrate (%)	Fat corrected milk production kg/day: 400 kg cow	500 kg cow	600 kg cow
6	35	13,1	14,8	17,8
6	50	13,8	16,3	18,7
6	65	13,9	16,5	18,9
13	35	12,5	14,8	17,0
13	50	13,8	16,3	18,7
13	65	13,8	16,3	18,7
19	35	12,4	14,7	16,8
19	50	13,1	15,5	17,8
19	65	13,4	15,9	18,2

Fat corrected milk production increased by only 8 per cent when the concentrate content in these complete diets increased from 35 to 65 per cent. The increase was significant ($p \leqslant 0{,}01$) between 35 to 50 per cent and non-significant between 50 and 65 per cent concentrate content. Decreasing particle size of these complete diets increased fat corrected milk production on average, by 5 per cent.

Overall mean butterfat-, milk DM- and milk protein percentages of 12,3; 3,7 and 3,1 respectively showed that within treatment limits, diets had no adverse effects on milk composition. Daily butterfat production (g) increased by 11 per cent if the concentrate content in the diet increased from 35 to 50 per cent and levelled off if concentrate was further increased to 65 per cent (Table 3). This is because of the negative influence of concentrate content on butterfat percentage (Table 6). Milk with a lower, but still acceptable butterfat was produced if the concentrate content of these diets exceeded 50 per cent. Screen size *per se* had no influence on butterfat percentage at the 35 per cent concentrate level (Table 6) so that butterfat production at this level kept increasing with a decrease in particle size (Table 3) because of an increase in total milk production. At higher levels of concentrate butterfat production increased up to a 13 mm screen with a decrease in screen size (Table 3). This was because of an increase in butterfat percentage (Table 5) and on increase in milk production (Table 1). The levelling off of butterfat production with diets with higher concentrate is because of the negative influence of particle size (13mm screen) and concentrate on butterfat percentage.

Milk DM and milk protein production increased by 20 and 26 per cent respectively from the highest to the lowest concentrate and smallest screen size. These productions were distinctly different for each specific treatment. Furthermore these differences were caused by milk production level, since the treatments (i.e. concentrate to roughage ratio and screen size) had little effect on the milk DM and milk protein percentages.

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References

ANNISON, E.F., 1973. Studies on the low milk fat syndrome in the cow, induced by low roughage diets. In, *Production disease in farm animals*, pp. 115–121. Ed. J.M. Payne, K.B. Hibbit and B.F. Sansom. London: Bailliére, Tindall.

ARMSTRONG, D.G. & PRESCOTT, J.H.D., 1971. Amount of physical form and composition of feed and milk secretion in the dairy cow. In, *Lactation*, pp 349–377. Ed. by I.R. Falconer. London: Butterworths.

BROSTER, W.H., BROSTER, V.J. & SMITH, T., 1969. Experiments on the nutrition of the dairy heifer. VIII. Effect on milk production of level of feeding at two stages of lactation. *J. of Agric. Sci. Cambridge,* 72, 229.

COWAN, E.D., OLIVIER, J. & ELLIOT, R.C., 1970. Complete diets for dairy cows. 2. The effect of dietary roughage content on some by-products of rumen composition of cows fed with complete diets throughout lactation. *Rhod. J. agric. Res.* 8, 23.

LIEBENBERG, L.H.P., 1979. Concentrate to low quality roughage ratio and fineness of complete rations for dairy cows. 1. Intake- and digestibility under ad libitum feeding conditions. *S. Afr. J. Anim. Sci.*

Mc COY, G.C., THURMON, H.S., OLSON, H. & REED, A., 1966. Complete feed rations for lactating dairy cows. *J. Dairy Sci.* 49, 1058.

O'DELL, G.D., KING, W.A. & COOK, W.C., 1968. Effect of grinding, pelletting and frequency of feeding of forage on fat percentage of milk and milk production of dairy cows. *J. Dairy Sci.* 51, 50.

PATTERSON, T. & LUCAS, H.L., 1962. Change over designs. *N.Z. Agric. Exp. Sta. Techn. Bull* 147.

RODRIQUE, C.B. & ALLEN, N.N., 1960. The effect of fine grinding of hay on ration digestibility, rate of passage and fat content on milk. *Can. J. Anim. Sci.* 40, 23.

STORRY, J.E. & SUTTON, J.D., 1969. The effect of change from low roughage to high roughage diets on rumen fermentation blood composition and milk fat secretion in the cow. *Br. J. Nutr.* 23, 511.

STORRY, J.E. & ROOK, J.A.F., 1965. The effect of a diet low in hay or high in flaked maize on milkfat secretion and on the concentration of certain constituents in the blood plasma of the cow. *Br. J. Nutr.* 19, 101.