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DRY MATTER, PROTEIN, ENERGY AND FIBRE INTAKE BY DAIRY HEIFERS GRAZING A RHODES GRASS *(CHLORIS GAYANA)* PASTURE[1]

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ABSTRACT

Abate, A., Kayongo-Male, H. and Karue, C.N., 1981. Dry matter, protein, energy and fibre intake by dairy heifers grazing a Rhodes grass (*Chloris gayana*) pasture. Anim. Feed Sci. Technol., 6: 15—26.

Dry matter (DM), protein, energy and fibre (ADF) intakes of Friesian and Ayrshire dairy heifers grazing a Rhodes grass pasture in Central Kenya were studied by indicator techniques for ten 22-day periods, each comprising 10 preliminary days and 12 collection days.

Digestibility coefficients of DM, CP, GE and fibre were higher ($P < 0.05$) in the wetter periods and generally declined during the drier periods, as pasture matured. Intakes of DM, DCP and DE decreased ($P < 0.05$) as herbage matured. Average daily intake per $kgW^{0.75}$ was 73.9-g DM, 4.1-g DCP, 31.8-g ADF and 167-kcal DE. Average daily gain (ADG) also varied ($P < 0.05$) with period and was positively related to intake of digestible dry matter, protein and energy. When conditions were wet, ADG was satisfactory at 480 g. In dry conditions, the heifers ingested 26.1-g DDM, 1.6-g DCP and 110-Kcal DE per $kgW^{0.75}$ daily and gained at 200 g/day, and supplementation was deemed necessary to sustain an optimum ADG of 550 g. The factors which may have limited pasture intake by the grazing heifers are discussed. In general, a *Chloris gayana* pasture, grazed at an appropriate stocking-rate, will meet the requirements of dairy heifers for maintenance and, to a variable degree, those for growth in areas of Kenya with an annual rainfall of 1400 mm and with a high potential for increased cattle production.

INTRODUCTION

In the humid tropics, the dry matter (DM) content of both mature and immature forages is relatively low (Alim, 1975; Musangi and Soneji, 1967), and their nutritive value, in terms of digestible crude protein (DCP) and total digestible nutrients (TDN), is also low for most of the year (Bredon and Horrell, 1961; Kidner, 1966; Karue, 1974). As a result, animal production tends to follow the seasonal variability in quality and quantity of pastures

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(French, 1956; Dougall, 1963; Elliot and Topps, 1963; Kayongo-Male et al., 1978) mainly because of low intake of DM and available energy (Corbett et al., 1963; Musangi, 1969, Mugerwa et al., 1974).

Increased animal output from pastures can be obtained by use of supplementary concentrates to balance the DM, protein and energy levels of the grazed pastures (Kidner, 1966). A realistic, supplementary feeding programme requires knowledge of the quality and quantity of nutrients obtained from pasture by the grazing animal.

This study was, therefore, carried out to determine DM, CP, energy and fibre (ADF) intakes of dairy heifers grazing a predominantly *Chloris gayana* pasture.

MATERIALS AND METHODS

Three Friesian and three Ayrshire heifers, averaging 11.0 months of age and 167.0-kg liveweight, were grazed continuously from 07.00—15.00 h on a weed-free, *Chloris gayana* pasture at a stocking rate of two livestock units/ha. Mineral licks and water were provided *ad libitum* on pasture.

Chromic oxide (10 g), premixed in maize meal carrier (200 g), was given daily in equal portions to each heifer at 07.00 and 15.00 hours, for 10 preliminary days and 12 collection days of each period. Carrier refusals for every three consecutive days (sub-period) were collected for Cr_2O_3 analysis. Faecal sampling was done during each collection period. Faeces (~500 g) were obtained rectally from each heifer at the dosing times each day. From each day's collection, a 500-g sub-sample was preserved in toluene at −10°C. Faeces for every sub-period were bulked; a 200-g sample in fresh condition was taken for protein analysis and a 600-g sample was processed for other analyses.

Pasture was randomly sampled at the beginning and end of each collection period by standard procedures (Mugerwa et al., 1973). Clipped grass-samples were weighed and dried at 60°C for 72 h. The dry samples were allowed to equilibrate to room conditions, weighed and ground in a Wiley mill through a 1-mm sieve for analysis.

Climatic data were collected throughout the study period. Potential transpiration (E_{to}) and effective rainfall (P/E_{to}) were calculated from the equations of Doorenbos and Pruitt (1975) and Stanley-Price (1977). Heifers were de-wormed with thiobenzadole once every three months, sprayed weekly with Gammatox, and weighed at the beginning and end of each collection period.

Faecal material and pasture grass samples were analysed for dry matter (DM), crude protein (CP) and gross energy (GE) (Association of Official Analytical Chemists, 1975) and fibre (ADF) and lignin (Van Soest, 1963). Carrier- and faecal-material were analysed for Cr_2O_3 (Kimura and Miller, 1957). Faecal Cr_2O_3 concentrations were corrected for incomplete recovery by a factor of 90.2% obtained from an earlier experiment (Abate, 1978).

Herbage digestibility was estimated by using lignin in the ratio technique (Crampton and Harris, 1969). Faecal output (FO), dry matter intake (DMI) and digestible dry matter intake (DDMI) were derived using the equations of Smith and Reid (1955) and Olaloku and Oyenuga (1974).

$$(1)\ \text{Digestibility (\%)} = 100 - 100\,\frac{\text{\% Indicator in feed} \times \text{\% Nutrient in faeces}}{\text{\% Indicator in faeces} \times \text{\% Nutrient in feed}}$$

$$(2)\ \text{FO (g DM/day)} = \frac{Cr_2O_3\ \text{consumed (g/day)}}{Cr_2O_3\ \text{concentration of faeces (g/g DM)}}$$

$$(3)\ \text{DMI (g/day)} = \frac{\text{FO (g DM/day)}}{\text{Indigestibility of DM (\%)}}$$

$$(4)\ \text{DDMI (g/day)} = \frac{\text{DMI (g DM/day)} \times \text{digestibility}}{100}$$

In determining protein, energy and fibre consumption, equation (*1*) was used to derive nutrient digestibility, amounts of nutrients voided were calculated from faecal output, and equations (*3*) and (*4*) were used to determine total- and digestible-intakes of nutrients.

Data were subjected to variance and regression analyses (Steel and Torrie, 1960). Differences between means were compared using Duncan's multiple range test (Duncan, 1955).

RESULTS

Pasture quality and yield

Data on pasture quality and availability are presented in Table I. There were indications that the pasture herbage was mature at the beginning and end of the experimental period and relatively young in between. Forage DM content was lowest at the peak of the rains in period 4. Crude-protein values

TABLE I

Mean values (and ranges) for composition, digestibility and yield of the grazed pasture

Component	Chemical composition (%)	Digestibility (%)	Nutrient yield (kg/ha)
Dry matter	35.7 (29.7—49.9)	47.1 (41.6—53.5)	2377 (1980—3327)
Crude protein in DM	9.8 (8.0—11.4)	54.6 (31.5—63.8)	659 (445— 759)
Acid detergent fibre in DM	39.2 (39.0—46.0)	49.9 (42.4—58.2)	—
Gross energy	4.5 (4.1—5.2)[1]	49.3 (42.2—56.4)	10701 (8633—14581)[2]

[1]Mcal/kg DM
[2]Mcal/ha.

TABLE II

Daily intakes of dry matter, protein, energy and fibre of dairy heifers grazing a *Chloris gayana* pasture as related to performance

Parameter[1]	Period										SE
	1	2	3	4	5	6	7	8	9	10	
DMI ($g/kgW^{0.75}$)	81.0^{a}[2]	75.5^{ab}	74.3^{ab}	75.2^{ab}	81.5^{a}	81.0^{a}	77.5^{ab}	70.6^{bc}	60.1^{d}	63.0^{cd}	3.1
DDMI ($g/kgW^{0.75}$)	39.1^{ab}	34.8^{bcd}	37.1^{abc}	40.3^{ab}	40.6^{a}	40.4^{ab}	34.2^{cd}	29.8^{de}	25.6^{e}	26.1^{e}	1.8
DCPI ($g/kgW^{0.75}$)	4.6	3.1	4.6	5.4	5.6	5.4	4.8	3.6	2.5	1.6	2.3
DEI ($kcal/kgW^{0.75}$)	231^{a}	204^{ab}	216.5^{a}	173.5^{cd}	178^{bc}	170^{cd}	146.5^{de}	133.5^{ef}	106.0^{fg}	110.0^{g}	9.2
ADFI ($g/kgW^{0.75}$)	30.9^{bc}	31.0^{bc}	31.8^{abc}	32.6^{abc}	35.5^{a}	35.1^{ab}	34.4^{ab}	31.4^{abc}	31.5^{abc}	28.9^{c}	1.3
ADG (g)	490^{de}	480^{de}	790^{b}	480^{de}	790^{b}	1100^{a}	600^{c}	520^{d}	420^{e}	200^{f}	25.8

[1]DMI = dry matter intake; DDMI = digestible dry matter intake; DCPI = digestible crude protein intake; DEI = digestible energy intake; ADFI = fibre intake; ADG = average daily gain.

[2]Means with different letter superscript(s), within a row, differ at $P < 0.05$.

were highest in periods 4 and 5 and fell progressively from 7—10. Energy levels declined from period 1—10. Digestibility of DM, CP, GE and fibre was higher ($P < 0.05$) in periods 4 and 6 than during other periods.

Effect of period on dry matter, protein, energy and fibre intake

Period had a significant ($P < 0.01$) effect on daily intake of dry matter (DMI) and digestible dry matter by the heifers. Heifers consumed more ($P < 0.05$) DM in periods 1, 5 and 6 than in periods 8, 9 and 10 (Table II). Intake of DDM was higher ($P < 0.05$) in periods 1, 4, 5 and 6 than in periods 7—10. Although period affected ($P < 0.01$) digestible crude-protein intake, the means were not significantly different. Period also affected ($P < 0.01$) digestible energy intake which was lower ($P < 0.01$) in the last seven periods than in the first three. Fibre consumption varied significantly ($P < 0.01$) between periods and heifers ingested more ($P < 0.05$) fibre in period 5 than periods 1, 2 and 10 (Table II).

Relationships between chemical components, digestibility and intake per kg$W^{0.75}$

Forage DM content was negatively related to CP level, DM and CP digestibility. Gross energy-digestibility was negatively correlated with ADF content. Fibre and CP content had a low, negative relationship. Fibre and DM digestibility were highly positively correlated with effective rainfall. Effective rainfall had negative relationships with DM and GE yield and a positive correlation with CP yield.

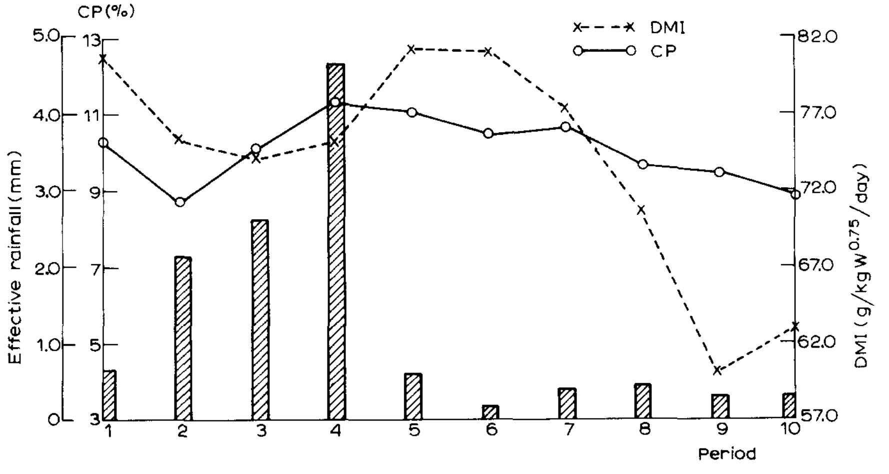

Fig. 1. Effective rainfall, CP content of the pasture and DMI by grazing dairy heifers throughout the ten periods of study.

Crude protein content (X, %) promoted DMI (Y, g/kg$W^{0.75}$ per day) through the equation

$Y = 23.52 + 5.09X$ ($r = 0.79, P < 0.01$).

Low forage DM content (X, %) depressed DCPI (Y, g/kg$W^{0.75}$ per day), the relationship being expressed by the equation

$Y = 10.11 - 0.17X$ ($r = -0.83, P < 0.01$).

High forage fibre content (X, %) reduced DEI (Y, kcal/kg$W^{0.75}$ per day) the equation being:

$Y = 1038.48 - 20.05X$ ($r = -0.78, P < 0.01$)

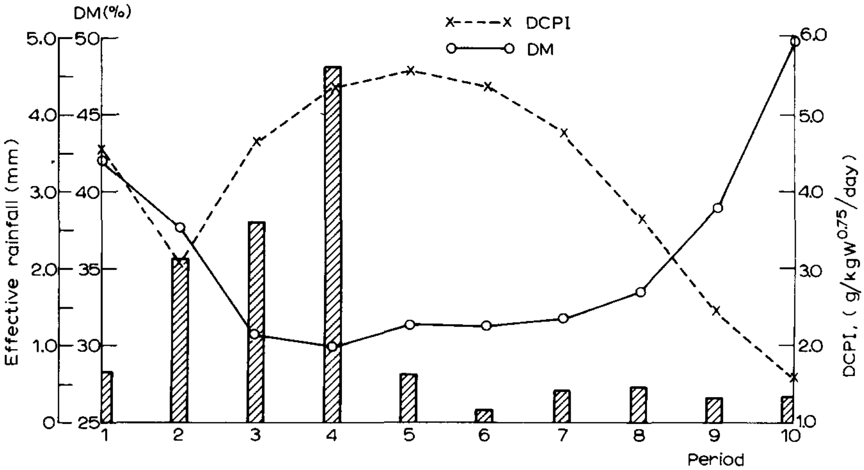

Fig. 2. Effective rainfall, DM content of the pasture and DCPI by grazing dairy heifers throughout the periods of study.

TABLE III

Simple correlations between chemical constituents, digestibility and intake

	Intake (g/kg$W^{0.75}$ per day)				
	DM	DDM	DCP	DE	ADF
Constituents (%)					
DM	−0.54	−0.60	−0.83[2]	−0.29	−0.61
CP	0.79[2]	0.85[2]	0.98[2]	0.47	0.78[2]
GE	0.39	0.42	0.14	0.89[2]	0.13
ADF	−0.61	−0.61	−0.36	−0.78[2]	−0.10
Digestibility (%)					
DM	0.69[1]	0.90[2]	0.72[1]	0.76[1]	0.47
CP	0.76[1]	0.84[2]	0.95[2]	0.60	0.62
GE	0.65[1]	0.78[2]	0.52	0.96[2]	0.22
ADF	0.62	0.84[2]	0.65[1]	0.77[2]	0.39

[1]$P < 0.05$.
[2]$P < 0.01$.

Figures 1, 2 and 3 show the variation of CP, DM, and fibre content; and DMI, and DEI coupled with effective rainfall data, throughout the ten periods of study.

Forage CP content was positively related to DDMI and ADFI ($P < 0.01$), but ADF content had low, non-significant, negative correlations with DMI, DDMI and DCPI (Table III). Higher digestibility of CP and GE increased DMI and DDMI. Digestibility of DM and fibre was associated with DCPI ($P < 0.05$); and DEI ($P < 0.05$ or $P < 0.01$). Fibre digestibility was positively correlated to DDMI ($P < 0.01$).

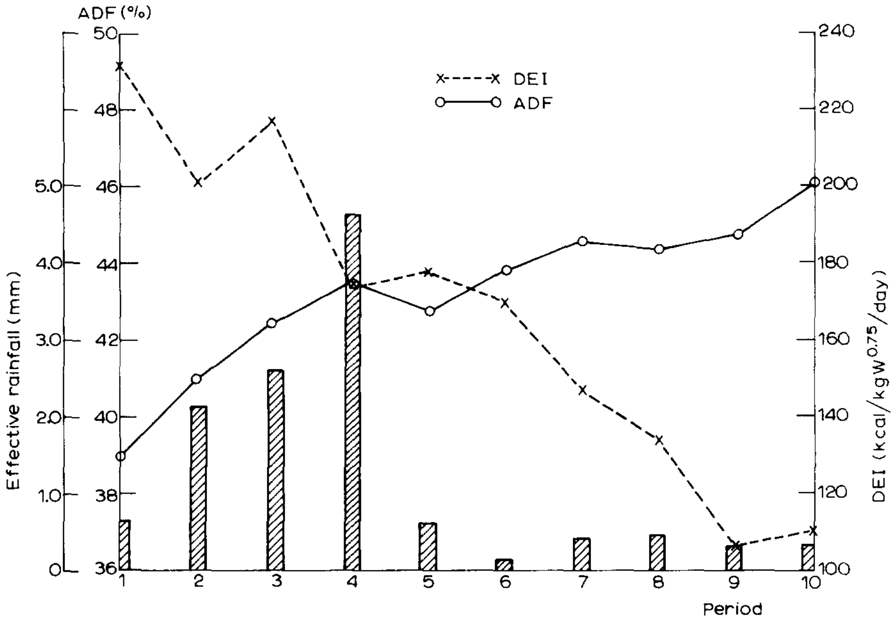

Fig. 3. Effective rainfall, fibre (ADF) content of the pasture and DEI by grazing dairy heifers during the ten periods of study.

Animal performance

Average daily gain (ADG) varied ($P < 0.05$) between periods. Heifers gained significantly more weight in period 6 and less weight in period 1C (Table II). Figure IV shows the variation of ADG, DEI and DDMI throughout the period of study and Table IV summarises the relationships between nutrient intake and average daily gain. The heifers gained 581 g/day and consumed the following quantities of DM and nutrients per day: 4.31-kg DM; 430-g CP; 1.87-kg ADF; 1.90-kg DDM; 237-g DCP; and 9.53-Mcal-DE. Average daily gain was significantly related to DCPI, DDMI, DEI and digestible fibre intake per animal per day (Table IV).

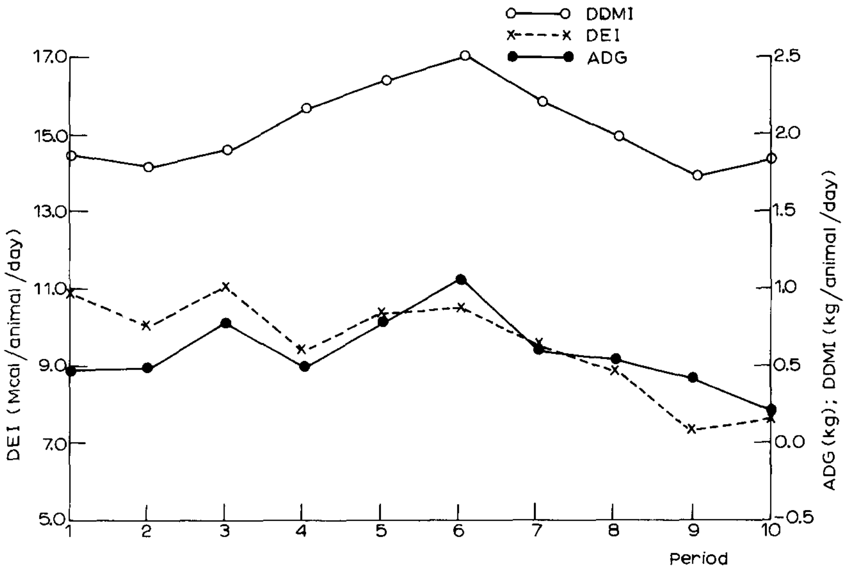

Fig. 4. The variation of ADG, DEI and DDMI by grazing dairy heifers throughout the ten periods of study.

TABLE IV

Simple regressions and correlations relating dry matter and nutrient intakes (X) to average daily gain (Y, g/day)

	Regression equation	r-Value
DMI (kg)	Y = −0.21 + 0.18X	0.38
DDMI (kg)	Y = −0.80 + 0.68X	0.73[1]
GEI (Mcal)	Y = −1.57 + 0.11X	0.67[1]
DEI (Mcal)	Y = 0.60 + 0.12X	0.66[1]
ADFI (kg)	Y = 0.20 + 0.20X	0.23
DADFI (kg)	Y = −0.53 + 1.20X	0.64[1]
CPI (g)	Y = −0.10 + 0.002X	0.37
DCPI (g)	Y = 0.001 + 0.002X	0.78[2]

[1]Significant at $P < 0.05$.
[2]Significant at $P < 0.01$.

DISCUSSION

Dry-matter intake was affected by the crude-protein content of the pasture. Crude protein and DM contents of the forage were negatively correlated (r = −0.78). As DM content increased, CP content decreased to limit intake. The role of CP as a critical factor controlling DMI has been reported (Bredon and Horrell, 1962; Butterworth, 1961, 1965). Furthermore, the low CP values (8.0–11.4%) reported here fall within those known to limit intake of tropical grasses (Milford and Minson, 1968). The negative relationships between forage DM content and the digestibility of DM and CP suggested that when the DM content was high, DM and CP digestibility declined and rumen retention-time increased (Blaxter et al., 1961) thus limiting the amount of feed consumed to maintain a constant volume of rumen contents (Stanley-Price, 1977). Digestibility coefficients of DM (41.6—53.5%) reported here were below 66% which has been shown to limit intake of tropical forages by grazing animals (Mugerwa et al., 1973).

Fibre increased with herbage maturity and was inversely related to protein. As ADF increased, CP decreased and this must have limited the digestibility and intake of DM, protein and energy. Mugerwa et al. (1974) similarly reported that when lignin, which is a component of ADF, was highest, forage digestibility and DMI were lowest.

Dry matter and GE yield were negatively related to effective rainfall distribution, but CP yield was positively related. Whilst CP may be adequate for normal animal-performance during the wet periods, DM and GE levels would be limiting. Glover and Dougall (1961) reported similar findings. The limiting effects of GE and DM yield on the utilisation of CP have, however, not been demonstrated here, because the highest weight gains were obtained during periods of high rainfall. It would appear, therefore, that when CP levels were high, DM and GE did not drop to concentrations limiting protein utilization.

Dry matter intake was similar for most periods of the trial. This may be due partly to selectivity for herbage of high digestibility during the dry periods, since DMI and digestibility were highly positively related. It was also possible to underestimate DMI during the dry periods if the portions of the plant actually consumed by the animals were lower in lignin than the representative grass upon which the lignin analysis was made. This difference is, however, unlikely since the collection periods employed here were longer than four days (Kane et al., 1952) and the lignin content of the forage consumed was consistently greater than 5% throughout the study period (Streeter, 1969). At lower lignin concentrations, the errors involved in isolation of lignin are of such magnitude that small differences in the digestibility of different forages cannot be accurately detected. This would affect the nutrient intake estimates. Throughout the study, daily consumption of digestible protein was above maintanance requirements (National Research Council, 1971). Elliot (1967) reported similar findings.

The performance of the animals during the relatively wet conditions showed that pasture provided enough energy (DE) to support the weight gains obtained. Under drier conditions, the DEI was below the National Research Council (1971) requirement figures and was unlikely to have effected the observed weight gains. It would appear, therefore, that the lignin ratio technique was more efficient in estimating energy intake during wet than during dry conditions. In this study, liveweight changes were erratic and consistent with those reported for Red Poll heifers (Kidner, 1966). There was a general trend towards lower liveweight gains as herbage matured and decreased in nutritive value. Such a trend had been shown before (Elliot and Topps, 1963). Performance was more positively related to DDMI, DEI and DCPI than to DMI, GEI and CPI, implying that the nutritive value of the herbage was the more important to the animal than the consumption of bulk.

Intake estimates offer practical guidelines to supplementary feeding of cattle on pasture. When conditions were relatively wet (effective rainfall, 4.63 mm) in period 4, the heifers consumed 40.3 g DDM, 5.4 g DCP and 174 kcal DE per kg$W^{0.75}$ daily and gained satisfactorily at 480 g per day. When conditions were relatively dry (effective rainfall, 0.31 mm) in period 10, the heifers ingested 26.1 g DDM, 1.6 g DCP and 110 kcal DE per kg$W^{0.75}$ daily and gained at 200 g per day. Under such conditions, supplementary feeding was deemed necessary to sustain an average daily gain of 550 g, as recommended by the National Research Council (1971).

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