ANALYSIS OF BLOOD CHEMISTRY IN GRAZING CATTLE AND HEIFERS SUPPLEMENTED WITH ENERGY AND MINERALS

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SUMMARY

Comparisons were made on the level of blood parameters in grazing cattle and heifers supplemented with energy and minerals to reduce the nutritional cause of anaemia. The purpose was to determine if supplementary feeding reduces anaemia observed in cattle in tropical humid zones and influences plasma minerals. Three diets composed of (A) hay and molasses, (B) hay, molasses, energy concentrates and (C) hay, molasses, energy concentrates with mineral mix were fed to three groups of five Frisian heifers each. Plasma glucose, calcium, sodium and potassium, haemoglobin concentration, hematocrit, red and white blood cell counts were measured at two -week intervals for 14 weeks in the three groups of heifers and were determined in 78 apparently healthy grazing cattle. Heifers supplemented with energy concentrates and minerals showed increased feed intake, daily weight gains, haemoglobin, plasma glucose, calcium and sodium concentrations, red blood cell counts and packed cell volume. In grazing cattle receiving no supplementation values for white and red blood cell counts, haemoglobin concentration, hematocrit, plasma glucose, calcium, sodium, potassium and total serum proteins concentrations were statistically similar to those of heifers receiving no energy and concentrate supplementation. It is concluded that mineral and energy supplementation increases the level of most blood parameters. The most salient increases were in body weight, serum proteins, glucose, calcium, haemoglobin concentration and packed cell volume.

INTRODUCTION

Changes in the level of some blood parameters due to type and adequacy of nutrition in ruminants have been reported (Rowlands, 1980; Biswas *et al.*, 1986). The changes have been used as metabolic profile tests in cattle (Rowlands, 1980) and goats (Bagliaca *et al.*, 1988). Although nutrition in ruminants is so important the greatest constraints to production and reproduction in cattle in Sub-saharan Africa are diseases and inadequate feeds, being additionally of poor nutritive value, particularly in the dry season (Mujuni *et al.*, 1990). Inadequate minerals and energy result in poor performance, while excess energy predisposes animals to laminitis and other production diseases (Mgasa and Mbassa, 1988; Mgasa *et al.*, 1988).

Although the nutritive value of ingredients used in feed formulation and the

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minimum nutrient requirements of dairy cattle are well established (McDonald *et al.*, 1988) scarcities of these in Africa cause large variations and low production and reproduction rates (Pleasants and McCaul, 1993). Evaluation of glucose, calcium, phosphorus, urea, albumin, proteins and blood cells have been reported to provide some indication of adequacy of nutrition (Oltner and Berglund, 1983; Mbassa and Poulsen, 1991a, b, c). The magnitude of inadequate nutrition as a cause of stunted growth and low production in tropical cattle compared to other causes like parasitic diseases and as reflected in its relationship with the level of blood parameters have not been studied in Africa. This study was partly addressed to evaluate the response of blood parameters to concentrates and mineral supplementation in heifers. In addition to this, the majority of animals in Africa are under grazing system and have been observed to have low grade to severe anaemia (Mbassa and Poulsen, 1992). Among the causes of this are haemolytic protozoa (Dolan, 1989; Mbassa *et al.*, 1994) and helminths and have been reported to be of relatively high importance in the dry and wet season, respectively. Since nutrients are always inadequate, many animals may be anaemic due to nutritional deficiencies and most likely a combination with diseases. Dry season feeding of ruminants is one of the major problem facing developing tropical countries. The magnitude of these causes of anaemia have not been adequately investigated. Availability of this information is a prerequisite to improvement of animal health. The second part of this investigation was aimed to determine if a difference in blood cell number exists between grazing cattle and those supplemented with concentrates and minerals and to determine if supplementary feeding changes the levels of these blood parameters.

MATERIALS AND METHODS

Fifteen 17 to 20 months old Frisian heifers weighing 161 to 182 kg were randomly assigned to three dietary treatments (A, B and C). The compositions of these were, A; hay and molasses, B; hay, molasses, maize bran (61 %), cotton seed cake (38 %) and salt (1 %), C; hay, molasses, maize bran (68 %), cotton seed cake (30 %), salt (1 %) and 1 % mineral mix. Molasses constituted 3% of hay to improve intake. In diets B and C, a roughage to concentrate ratio of 70:30 was maintained. Maize bran constituted the main source of energy. Maize bran, cotton seed cake, mineral premix and salt were obtained from commercial suppliers.

Animals were fed twice daily at 8.00 and 16.00 h, with free access to clean water. They were weighed weekly, dewormed at the start and mid period of experiment with albendazole and weekly sprayed against ticks with organophosphates.

Samples of hay, maize bran and defated cotton seed cakes, and complete diets A, B and C were analyzed for dry matter (DM), crude protein (CP), crude fibre (CF), ether extract (EE), ash, calcium (Ca) and phosphorus (P) content. CP was determined by the Kjeldahl method. EE was determined by extraction with ethyl ether. CF was determined by boiling a known weight of feed in weak sulphuric acid, washing in water, filtering, boiling in weak alkaline solution to dissolve structural carbohydrates, washing, filtering and washing in ether to remove lipids and waxes. The residue was dried and ashed, the weight difference in dry residue and ash being the crude fibre. Ash content was obtained by burning known weight of dry

sample in the oven at 550° C, the residue being the inorganic constituent of the feed.

To measure the calcium and phosphorus content, feeds were ashed at 550° C for 3 hours, cooled and digested with hydrochloric acid and filtered. Phosphorus was determined with a spectrophotometer, while calcium was measured using an atomic absorption spectrophotometer (Pelkin Elmer, 5000).

Blood samples were collected from heifers at intervals of two weeks from the jugular vein in vacuum tubes containing 143 units sodium heparin (USP), sodium fluoride (NaF), 0.12 ml of 0.34 M potassium ethylene diaminotetracetate (K_3EDTA) and plain clot activated vacuum tubes (Becton Dickinson, England) for 14 weeks. Samples in NaF were used for the determination of plasma glucose with spectrophotometer, those in sodium heparin for plasma calcium, sodium and potassium using ion module of a spectrophotometer. Blood samples in K_3EDTA were used for the determination of red and white blood cell counts, haemoglobin concentration and hematocrit. Blood samples from clot activated vacuum tubes were used to obtain serum for determination of total serum proteins spectrophotometrically by the Biuret method. Haemoglobin concentration was determined by the cyanmethaemoglobin method using a spectrophotometer. Packed cell volume (PCV, Hematocrit) was determined with a microhaematocrit centrifuge. Red and white blood cells were counted using a haemocytometer.

Similar blood samples were collected in K_3EDTA from the jugular vein from 78 apparently clinically healthy cattle on pastures in nearby villages. These did not receive any supplementary feeding.

The response of heifers on the three diets and grazing cattle were analyzed by the general linear models procedure of the Statistical Analysis System (SAS Institute, North Carolina) for differences in mean weight gains, feed intake and blood parameters. The initial body weights were corrected by analysis of covariance (Snedecor and Cochran, 1989). The data presented are means plus or minus standard deviations.

RESULTS

The composition of the diets as formulated and analyzed is indicated in Table 1. The manufacturers composition of mineral mix in diet C for Ca, P, Mg, Fe, Cu, Mn, Co, Zn, S, Se, NaCl were 18.51, 11.0, 3.0, 0.5, 0.16, 0.4, 0.02, 0.5, 0.4, 0.0015, 27.0 gkg^{-1} respectively and the Ca/P ratio wa 1.68.

The daily feed intake of heifers on diets B and C after 6 weeks were similar and significantly higher ($p < 0.05$) than those on diet A (Table 2). The highest daily body weight gains were in heifers on diet C (0.59 $kgday^{-1}$) followed by those on diet B (0.40 $kgday^{-1}$). Those on diet A had lowest gains (-0.17 $kg.day^{-1}$). Changes in body weight, feed intake and total serum proteins between diet groups within weeks were significant ($p < 0.05$) from week 6 onwards (Table 2). There were declines in serum protein concentration for heifers on diet A, while those of diets B and C were relatively constant.

The means $\pm$ standard deviations of values of plasma glucose, calcium, sodium and potassium are indicated in table 3. Plasma glucose concentration decreased in heifers on diet A but were constant in those on diet B and C. Heifers on diet C had the highest plasma calcium concentration while those on diet B showed an increasing trend.

Table 1: Composition of maize bran (MB), defated cotton seed cake (DCSC), hay and after mixing of ingredients to form diets A, B, C. NFE= non fibre extract.

Ingredient	DM	CP	CF	EE	NFE	ASH	Ca	P	Energy $Mjkg^{-1}$
MB	93.0	10.2	7.8	8.79	63.5	2.73	0.92	0.52	-
DCSC	95.8	34.2	23.8	0.47	31.6	5.71	1.01	0.69	-
Hay	94.8	4.5	36.6	2.09	43.0	8.61	0.42	0.13	-
A	94.87	4.52	36.58	2.09	43.07	8.61	0.42	0.13	10.68
B	94.43	16.21	20.71	5.28	46.54	5.69	0.64	0.39	15.18
C	93.96	17.67	16.77	6.47	47.43	5.62	1.30	0.64	15.29

Plasma potassium concentration in heifers on diets A, B and C were not significantly different. Sodium concentrations were significantly lower in heifers on diet A than on diets B and C.

From week 12 onwards heifers on diet B showed higher red blood cell counts, packed cell volume and haemoglobin concentration, followed by those on diet C (Table 4). Heifers on diet C had higher white cell counts in weeks 12 and 14 followed by those on diet B.

The red blood cell (RBC) and white blood cell (WBC) counts, haemoglobin concentration and packed cell volume, total serum proteins, glucose, calcium, sodium and potassium concentrations for grazing cattle were significantly lower than those of heifers on energy and mineral supplementation. The values were, however, similar to those of heifers receiving no supplements. RBC values were considerably lower than those of heifers on concentrate and mineral supplementation (Table 4).

DISCUSSION

Crude protein, ether extract, ash, calcium and phosphorus contents of diets B and C were higher than those on diet A but within recommended limits (McDONALD *et al.* 1988). Diet A had relatively higher crude fibre content, low crude protein, ether extract, calcium and phosphorus compared to diet B and C. Diets B and C appeared to be well balanced.

In the first week of the experiment, all animals gained weight, probably due to the compensatory growth (Payne, 1990). In the subsequent weeks animals on diet A lost weight while those on B and C gained (Table 2). The highest body weights in week 14 were in heifers on diet B. This was, however, due to a higher initial bodyweight of 182.2 kg compared to 161.2 kg of those in diet C. The mean daily body weight gain of 0.59 $kgday^{-1}$ for heifers on diet C is consistent with 0.455 to 0.50 $kgday^{-1}$ of Church (1984). The daily weight gain for heifers on diet B was 0.40 $kgday^{-1}$ and that of heifers on diet A was -0.17 $kgday^{-1}$.

Table 2: Mean ± standard deviation bodyweight (kg), feed intake ($kgday^{-1}$) and serum protein (gl^{-1}) in Frisian heifers fed on diets A, B and C (n=5 each group) and 78 grazing cattle (GC).

Week	Diet	Bodyweight	Feed intake	Serum proteins
0	A	177.0±49.95	5.78	64.9±1.08
	B	182.2±17.90	5.22	65.7±1.54
	C	161.2±37.05	5.12	66.3±1.97
	GC	-	-	65.8±3.54
2	A	183.2±45.90^{a}	5.72	64.5±1.82^{b}
	B	183.4±16.41^{a}	5.66	66.3±0.78
	C	163.6±32.76^{b}	5.72	66.0±1.02^{ab}
4	A	176.0±46.34^{b}	5.86	61.8±3.08^{b}
	B	190.4±21.95^{a}	5.70	66.4±0.91^{a}
	C	181.0±37.16^{b}	5.46	67.0±0.88^{ab}
6	A	175.2±46.18^{b}	6.12^{a}	56.0±3.89^{b}
	B	96.8±21.02^{a}	4.98^{b}	65.7±1.39^{a}
	C	191.6±37.55^{a}	5.64^{b}	66.2±0.33^{a}
8	A	169.2±46.54^{b}	4.12^{a}	50.6±6.07^{b}
	B	202.0±21.90^{a}	6.40^{b}	66.2±0.61^{a}
	C	198.6±38.43^{a}	6.66^{b}	66.1±0.62^{a}
10	A	163.2±40.90^{b}	4.04^{a}	46.0±1.70^{b}
	B	207.8±22.52^{a}	6.50^{b}	66.2±0.38^{a}
	C	201.4±36.75^{a}	6.28^{b}	65.9±1.51^{a}
12	A	163.2±40.90^{b}	4.34^{a}	46.0±1.70^{c}
	B	207.8±22.52^{a}	6.28^{b}	66.2±0.38^{b}
	C	201.4±36.75^{a}	6.40^{b}	65.6±1.51^{a}
14	A	160.0±44.86 11^{b}	4.34^{a}	44.0±2.59^{b}
	B	221.6±15.71^{a}	6.48^{b}	67.8±1.55^{a}
	C	219.6±36.29^{a}	6.54^{b}	68.1±1.97^{a}
Mean	A	-0.17^{b}	5.04	54.2±8.91^{b}
	B	0.40^{a}	6.03	66.3±1.16^{a}
	C	0.59^{a}	5.98	66.4±1.36^{a}

Means in columns within diet groups significantly differring are indicated with different superscripts ($p < 0.05$).

Table 3: Mean ± standard deviation of plasma glucose, calcium, sodium and potassium levels (mmol/l) of Frisian heifers fed on diets A, B and C (n= 5 each) and 78 grazing cattle (GC).

Week	Diet	Glucose	Calcium	Sodium	Potassium
0	A	6.14±0.42	6.22±0.86	146.22±0.86	5.30±0.46
	B	6.36±0.11	6.50±0.71	146.50±0.71	5.64±0.73
	C	6.38±0.12	7.26±0.83	147.26±0.83	5.26±0.13
	GC	5.88±0.58	6.18±0.45	141.6±7.20	5.31±0.33
2	A	4.84±0.18	6.38±0.35^{b}	146.38±0.35^{b}	5.29±0.56
	B	5.53±1.02	6.20±0.80^{b}	146.20±0.80^{b}	5.16±0.25
	C	5.77±0.708	8.00±1.35^{b}	148.00±1.35^{b}	4.58±0.75
4	A	4.21±0.13^{b}	6.12±0.58^{b}	146.12±0.58^{b}	5.31±0.24
	B	5.38±0.859^{a}	5.90±1.60^{a}	145.90±1.60^{a}	5.19±0.17
	C	5.01±0.868^{ab}	10.36±1.47^{ab}	150.36±1.47^{a}	4.91±0.25
6	A	4.06±0.22^{b}	5.76±0.77^{b}	145.76±0.77^{b}	4.95±0.26
	B	5.45±1.17^{a}	6.44±1.35^{a}	146.44±1.35^{a}	5.14±0.58
	C	5.18±0.397^{a}	10.38±1.23^{a}	150.38±1.23^{a}	4.92±0.20
8	A	3.54±0.482^{b}	5.38±0.52^{b}	145.38±0.52^{b}	5.27±0.53
	B	5.09±0.728^{a}	6.60±1.16^{a}	146.60±1.16^{a}	4.91±0.16
	C	5.30±1.113^{a}	9.82±1.18^{a}	149.82±1.18^{a}	4.90±0.57
10	A	3.32±0.310^{b}	5.24±0.61^{b}	145.24±0.61^{b}	5.11±0.29
	B	5.24±0.934^{a}	6.84±1.89^{a}	146.84±1.89^{a}	4.84±0.16
	C	5.47±0.360^{a}	9.56±2.08^{a}	149.56±2.08^{a}	4.85±0.35
12	A	3.32±0.310^{c}	5.02±0.81^{c}	145.02±0.81^{c}	4.92±0.15
	B	5.24±0.934^{b}	6.80±1.32^{b}	146.80±1.32^{b}	4.78±0.65
	C	5.47±0.360^{a}	11.40±1.36^{a}	151.40±1.36^{a}	4.66±0.26
14	A	3.21±0.257^{b}	5.18±0.84^{b}	145.18±0.84^{b}	5.56±0.25
	B	5.96±0.669^{a}	7.04±1.88^{a}	147.04±1.88^{a}	5.09±0.65
	C	6.10±0.447^{a}	13.06±2.25^{a}	153.06±2.25^{a}	4.52±0.32
Mean	A	4.09±1.006^{b}	5.66±0.80^{b}	145.66±0.80^{b}	5.23±0.40
	B	5.63±0.850^{a}	6.54±1.32^{a}	146.54±1.32^{a}	5.08±0.50
	C	5.33±0.788^{a}	9.98±2.26^{a}	149.98±2.26^{a}	4.83±0.43

Means with different superscript tags within columns within diet groups differ significantly ($P < 0.05$).

Table 4: Mean ± standard deviation of RBC counts ($x10^{12}$/l), Hb level (mmol/l), PCV (l/l) and WBC counts ($x10^{9}$/l) of heifers on diets A, B, (n= 5 each) and 78 grazing cattle (GC).

Week	Diet	RBC	Hb	PCV	WBC
0	A	4.88±0.62	7.66±0.56	0.30±0.12	11.2±2.98
	B	6.78±1.22	7.04±0.96	0.30±0.12	9.74±1.28
	C	5.06±0.67	6.78±1.05	0.28±0.04	12.6±5.02
	GC	4.68±2.62	5.29±1.54	0.26±0.04	10.64±4.16
2	A	4.94±0.79	6.10±0.50	0.26±0.03	6.66±4.01
	B	6.26±1.24	8.54±0.64	0.27±0.04	4.82±2.80
	C	4.96±1.12	5.60±0.94	0.26±0.01	5.6±0.94
4	A	4.52±0.93	5.86±0.90	0.24±0.04	10.4±1.41
	B	4.36±0.34	5.86±0.42	0.24±0.01	12.0±2.58
	C	4.12±0.41	5.92±0.68	0.27±0.03	12.3±2.46
6	A	4.26±0.34	6.72±0.25	0.25±0.01	12.4±1.14
	B	3.96±0.73	6.66±0.49	0.26±0.01	10.8±1.82
	C	4.20±1.27	7.04±1.46	0.27±0.03	13.8±3.92
8	A	5.62±1.22	5.72±0.51	0.26±0.03	10.2±2.43
	B	5.06±1.27	5.52±0.43	0.27±0.03	10.8±1.61
	C	5.40±0.82	6.18±0.93	0.30±0.04	9.2±2.59
10	A	5.28±0.83	6.30±1.14	0.26±0.03	11.5±4.32
	B	4.94±1.42	7.24±1.14	0.31±0.04	16.6±5.55
	C	4.76±0.58	7.26±0.70	0.28±0.02	14.4±2.07
12	A	5.28±0.83^{c}	6.30±1.14^{c}	0.26±0.09^{c}	11.5±4.32^{c}
	B	4.94±1.42^{b}	7.24±1.14^{b}	0.31±0.04^{b}	16.6±6.66^{b}
	C	4.76±0.58^{a}	7.26±0.70^{a}	0.28±0.02^{a}	14.4±2.07^{a}
14	A	3.52±1.17^{b}	5.08±0.70^{b}	0.21±0.01^{b}	7.62±2.70^{b}
	B	5.76±0.80^{a}	6.38±0.64^{a}	0.29±0.03^{a}	11.7±2.07^{a}
	C	5.52±0.59^{a}	7.42±0.53^{a}	0.31±0.02^{a}	13.0±2.28^{a}
Mean	A	4.79±0.21	6.21±0.25	0.25±0.08^{b}	10.1±1.02^{b}
	B	6.01±0.21	6.56±0.25	0.26±0.05	11.3±1.02
	C	4.85±0.21	6.68±0.25	0.28±0.08	11.9±1.02

Means with different superscript tags in columns within diet groups differ significantly ($P < 0.05$).

This is poor growth rate in the latter group attributed to poor nutrient content that reduced feed intake, hence body weights as has been observed before (Schiere *et al.*, 1989). All the heifers were housed in the same building, under similar environment and management including feeding times. This eliminates this source of variation.

The lower feed intake in heifers on diet A could be attributed to its poor palatability and low energy density, which is characteristic in a diet of high fibre content. Digestibility and nutrient content of hay decline rapidly as grasses mature, dry and become fibrous (Crowder and Chheda, 1982). Initially this increases voluntary feed intake but in the long run even the feed intake is reduced. A major factor influencing animal preference and voluntary feed intake is the rate at which a forage can be eaten. Ruminants fed on poor quality roughage stop eating before consuming sufficient nutrients to meet energy for growth (Weston, 1982). This is why there was a negative weight gain in heifers fed on diet A. The low daily weight gain in these may also have resulted from poor nutrient content with a high fibre content. The low voluntary feed intake in these heifers may have been due to low mineral and protein content. Schiere *et al.* (1989) showed that minerals, energy and nitrogen levels are low in poor quality feeds. This reduces the voluntary feed intake. The benefits of concentrate and mineral supplementation are apparent in the diet containing hay, molasses and concentrates (diet B and C), where daily weight gains were 0.40 and 0.59 kgday^{-1} respectively.

The means of red and white blood cell counts, hematocrit, haemoglobin electrolyte concentration and bodyweight were significantly higher in cattle supplemented with energy and minerals (heifers on diet B and C) than those without supplementation (heifers on diet A, and on grazing). Heifers on diet A showed reduced plasma ions, glucose, serum proteins, haemoglobin concentration and red blood cell counts.

Plasma glucose and protein concentrations in heifers on diet B and C were within standard values. In heifers on diet A values were lower than standard levels. This is reflected also in the low growth rate and daily weight gains compared to other groups. It is known that in ruminants propionate and acetate affect energy level and control feed intake, thus the small amount of glucose absorbed from the digestive tract have little effect on blood glucose levels in relation to feeding (McDonald *et al.*, 1988). Results of this study, however, show increased plasma glucose concentration on feeding energy and minerals over 14 weeks. It appears that sustained energy supplementation has this trend. Bas *et al.* (1981) and Oltner and Berglund (1983) also report increase in plasma glucose in well fed animals.

McDonald *et al.* (1988) observed that serum protein level is only affected by nitrogen supplied in the diet, not increases in crude protein. This is probably also in short durations. In the long run protein levels in the diet lead to stabilized albumin and globulin levels thus, total serum proteins. This was found in this study. Okorie and Anugwa (1986) showed that nutritional status of animals can be monitored by analyses of plasma urea and ammonia. However, because of their gaseous nature they are very difficult to measure, thus subject to wide variations. Serum protein levels for heifers on diet B and C were within standard values of 68.0 gl^{-1}. Differences other than nutrition may also result from breed, age and health of

animals (Biswas *et al.* 1986, Mbassa *et al.*, 1989). Serum protein levels were lowest in heifers on diet A (44.0 gl^{-1}) (initially 64.9 gl^{-1}) as a result of low levels in diet A and low intake, meaning that animals on grazing can pick up more proteins than those confined on hay alone. In this study animals on grazing had 65.8 gl^{-1} protein level. Sawadogo *et al.* (1991) found significantly higher serum protein in animals on concentrate supplementation than in those on hay alone. This study has shown unequivocally that total serum proteins concentration increase in animals receiving concentrate and mineral supplementation.

Potassium concentrations were closely similar in heifers on diet A, B and C were within normal limits (3.9 - 5.8 $mmoll^{-1}$), meaning that levels of this mineral are attained in ruminants under natural condition. Physiologically this is an intracellular ion concentrated in cell by active mechanisms.

Heifers on diet C showed highest plasma calcium level, those on B showed an increase, those on diet A decreased. Plasma Ca^{2+} levels in heifers on diet C were comparable to other cattle (McDonald *et al.*, 1988; Payne, 1990). This indicates that Ca^{2+} levels stabilize in animals with adequate nutrients in diets.

Plasma Na^{+} concentrations were constant in heifers on diets A and B, whereas those on C increased but within reference range. Heifers on diet A had lowest Na^{+} level. Deficiency of Na^{+} has been reported to occur, causing unthriftness, loss of appetite, dullness, lowered milk yield and intense carving for salt (McDonald *et al.* 1988).

Little fluctuations in RBC, haemoglobin concentration (Hb), PCV, WBC levels occurred in the first weeks. From week 12, levels in heifers on diet A were low, while those on diet B and C increased. Red blood cell counts were lower than $6.5x10^{12}l^{-1}$ of white fulani cattle (Okorie and Anugwa, 1986), $6.3 x10^{12}l^{-1}$ of Gambian cattle (Walshe and Gilles, 1962) and $7.10^{12}l^{-1}$ of standard Holstein Frisian cattle.

PCV in the present heifers were within the lower limit of reference values for healthy animals slightly lower than for white fulani (Okorie and Anugwa, 1986; Walshe and Gilles, 1962). WBC counts and Hb for heifers on diets A, B, and C were within normal values (Oduye and Okusaiya, 1971), higher in heifers on diets B and C than those on diet A and grazing cattle.

From this study it can be deduced that adequacy and balance of nutrients affect the number of red and white blood cells, haemoglobin concentration and packed cell volume. Adequate nutrition raises levels of these parameters as was observed by Biswas *et al.* (1986) and removes nutritional deficiency anaemia. The effect observed in this study on heifers supplemented or not supplemented is, however, small but this is probably due to the short duration of the experiment and the small sample size. With prolonged nutrient deficiency as for diet A the animals may become anaemic. As the deficiency is removed by supplementation, anaemia disappears and animals improve in health. The present findings provide some evidence of nutritional influence on bodyweight, glucose, protein, Ca, Na, red and white blood cell counts, packed cell volume and haemoglobin level, thus allowing the following conclusions.

This study was to evaluate the response of blood parameters to concentrates and mineral supplementation in heifers. Results indicate that mineral and concentrate supplementation changes the level of blood constituents providing blocks for synthesis of functional and structural proteins, thereby

eliminating nutritional deficiency anaemia. The results show that mineral, energy and protein supplementation removes stunted growth, which is common in grazing calves. The second part was to determine if a difference in blood cell number exists between grazing cattle and those supplemented with concentrates and minerals and to determine if supplementary feeding changes the levels of these blood parameters. Results indicate differences between grazing cattle and those supplemented. In the absence of mineral supplementation, concentrate supplements provide relatively better performance than those on poor quality roughage alone. It is evident from this study, that heifers given hay and molasses alone (diet A) and those on grazing alone result in poor growth and anaemia than those supplemented, although the anaemia in grazing cattle may have been due to gastrointestinal and intracellular blood parasites.

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