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Blood metabolites and their relationship with production variables in dual-purpose cows in Venezuela

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Abstract

A survey was carried out on 79 lactating *Bos taurus/indicus* cross-bred cows on three dual-purpose cattle farms to measure the blood concentration of metabolites and to evaluate possible relationships with nutritional status and productive variables. A rotational grazing system on Star grass and other tropical pastures (10–12% CP in leaves) was used and 2–3 kg/cow/day of concentrate were fed on two farms. Restricted calf suckling was used in two herds. Average milk yield sold per farm was 6 kg/day/cow and body condition scores (BCS) were between 3.0 and 3.8 on a scale of one-to-five. On two farms, the average interval from calving to conception (ICC) was more than 145 days. Mean blood concentrations of albumin, globulin, urea, beta-hydroxybutyrate and phosphorus were generally within reference values, but a significant group of cows had low levels of albumin and urea and high levels of globulin. Packed cell volume (PCV) was below normal values, with anemia in 63% of cows during the second trimester of lactation, which was negatively correlated to milk yield. The high incidence of anemia could be related to factors such as hematophagic parasites, not evaluated in this study. ICC values were negatively related to albumin level and could be associated with protein deficiency in the diet or with disease, as globulin values were high in many cows. Based on these diagnoses, an experiment was carried out on one of the farms to evaluate the influence of supplementation with 0.5 kg/cow/day of fish meal. Total milk yield was not influenced by the fish meal and reproductive efficiency was high in the two supplemental treatments. It was shown that supplementation with undegraded protein is not required in these cows. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Dual-purpose cattle; Milk yield; Reproductive efficiency; Blood metabolites; Fish meal

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1. Introduction

The dairy industry in Venezuela is based on dual-purpose systems of milk and beef, where crosses of Zebu and European breeds are sustained on grazed tropical grasses and with generally low levels of supplementation. Average milk yields are low, varying from three to nine kg/cow/day (Vaccaro and López, 1994). Nevertheless, in many situations, the quality of feeds is insufficient to support these milk yields, and reproductive efficiency is often poor.

This paper discusses a baseline survey of lactational and reproductive performance and blood metabolite concentrations, and an intervention designed to measure the response to enhanced protein supply in early lactation.

2. Materials and methods

2.1. Location

For the survey phase of this study in 1993–1994, three farms (A, B and C) located near the northern coast of Venezuela were selected. A summary of climatic and soil conditions as well as some general aspects of the farms are presented in Table 1. The climatic conditions and the production systems used were typical of the main dual-purpose cattle areas of the country. The intervention phase of the experiment was carried out on Farm A.

2.2. Animals and management

Crosses between *Bos taurus* and *B. indicus* were used in all farms, with more than 5/8 of European breeding on farms B and C and between 1/2 and 3/4 Holstein on Farm A. Natural service was used, with crossbred bulls staying with the cows continuously on

Table 1
Size, climate and soil conditions on farms A, B and C

	Farm		
	A	B	C
Location	Maracay	Yaracal	Yaracal
Surface area (ha)	22	25	100
No. animal units	100	60	100
Climate	seasonal	humid	humid
No. dry months	5	2	2
Mean daily temperature (°C)	24.7	26.5	26.5
Annual precipitation (mm)	931	1176	1176
Annual evaporation (mm)	1126	2219	2219
Relative humidity (%)	60–70	80–90	80–90
Soil class	molisol	ultisol	inceptisol
Soil fertility	high	low	moderate
Drainage	good	good	good

Table 2
Ingredients of supplementation on Farm A

Ingredients	Treatments (%DM)	
	Fo	Fm
Maize meal by-products	45.5	37.9
Soybean hulls	35.0	29.1
Crude palm oil	14.0	11.7
Urea	2.5	2.1
Mineral mixture	3.0	2.5
Fish meal	—	16.7

farms B and C, and during a mating season from August to February on Farm A. Artificial rearing of calves was used on Farm C, whereas restricted suckling was used until three to four months of age on Farm A, and during the whole lactation on Farm B. Cows were machine-milked twice daily on Farm A and by hand twice daily on farms B and C. For the survey phase, the cows grazed on pastures of *Digitaria swazilandensis* (swazy grass) and *Brachiaria mutica* (para grass) on Farm A and *Cynodon nlemfuensis* (star grass) on farms B and C. Rotational grazing was used on all farms, and 200, 100, and 0 kg/ha urea fertilizer were applied during the study on farms A, B and C, respectively. In addition, sprinkle irrigation was used on Farm A during the dry season.

Cows on Farm A received 2.0 kg/cow/day before calving and 3.0 kg/cow/day after calving of a supplement consisting of 53% maize meal, 41% soybean hulls, 2% urea, 3% mineral mixture and 1% common salt. Cows on Farm B were supplemented daily with 1.3 and 2.3 kg before, and after, calving with a concentrate containing 48% maize meal, 28.5% soybean hulls, 19% cotton seed meal, 2% mineral mixture and 2% common salt. Neither mineral nor concentrate supplementation was used on Farm C.

For the intervention phase, forty cows were selected from Farm A. These were divided into two groups on the basis of parity and date of calving and allocated to the following treatments:

1. Fo, 2.5 kg/cow/day of normal concentrate (control); and
2. Fm, 0.5 kg/cow/day of fish meal plus Fo (Table 2).

These feeds were offered at milking during the first 120 days of lactation. Subsequently, all animals received 2.5 kg/cow/day of Fo supplement. Animals grazed all day on pastures of *C. plectostachyus* and *D. swazilandensis* at a stocking rate of 3.5 animals/ha. Pastures were sprinkle-irrigated during the dry season from December to April.

2.3. Measurements and analysis

2.3.1. Feeds

Standing forage was estimated monthly by sampling six quadrants of $0.5\times0.5\ m^2$ at ground level, in the paddock where the animals were grazing during the survey phase.

During the intervention phase, the same measurements were made before, and after, grazing the paddock. Samples were weighed, mixed, and 1 kg subsample stored frozen before separating into leaves and stems. All samples were dried at 65°C for 48 h. Survey samples were ground through a 1-mm screen for chemical analysis and samples from the intervention phase were divided in two, one portion ground through a 2.5-mm and the other through a 1-mm screen. Coarse (2.5 mm) samples were used to estimate dry matter (DM) disappearance 'in situ' (DMD 48 h) by incubating 2×5 g sample bags in each of two rumen fistulated cows for 48 h following the technique described by Orskov et al. (1980). Finely ground (1 mm) samples were used to determine DM at 105°C, ash, crude protein, ether extract (AOAC, 1984), neutral detergent fiber (NDF) (Goering and Van Soest, 1970), calcium (Fick et al., 1973) and phosphorus (Harris and Popat, 1954). Samples of concentrates were dried at 65°C for 48 h, ground through a 1-mm sieve and chemical fractions analyzed as for the forages.

2.3.2. Animals

For the survey phase, 30 pregnant cows on farms A and C and 19 on Farm B were selected. After calving average daily milk yield was estimated every month from daily records on farms A and B and biweekly records on Farm C. Yields on farms A and B do not include the milk consumed by calves which were allowed to suckle for 30 min after the morning milking. Weekly milk samples were taken and preserved with a sodium azide tablet for progesterone analysis using a radioimmunoassay method (Plaizier, 1993). Monthly samples were taken for milk fat estimation by the Babcock method (AOAC, 1984). However, during the intervention phase, sold milk was measured daily and the milk consumed by the calves was estimated twice a week by weighing the calves before, and after, suckling. Fat percentage was estimated in the milk obtained during milking by the normal sampling process. Subsequently, calves were allowed to suckle their dams and a second sample obtained from the residual milk during suckling. Milk fat content was 8.6% in residual milk during calf suckling and 2.2% in the sold milk with a calculated value of 3.8% in total milk. No differences were observed between treatments. One month before calving (bc), 7–20 days after calving (ac_1) and 60–90 days after calving (ac_2) the cows were weighed with a scale of 0.5 kg precision, body condition was scored (Edmonson et al., 1989), and blood sampled from the tail vein. During the intervention phase, cows were weighed just after calving. Monthly rectal palpation of cows was carried out starting one month after calving to 200 days of lactation or until pregnancy was confirmed.

2.3.3. Blood samples

Tail-vein samples were collected into heparinized vacutainers, and PCV was measured immediately by the microhematocrit technique. Plasma was obtained by centrifugation and stored frozen at −20°C to be analyzed for total protein, albumin, urea, betahydroxybutyrate (β-HOB) and inorganic phosphorous, following the procedures described by the FAO/IAEA protocol (1989). Globulin was estimated by subtracting albumin from total protein.

2.3.4. Statistical analysis

For the survey phase, the mean and standard deviation values for all measurements per farm were calculated. A simple linear correlation analysis was carried out between BCS, milk yield, interval from calving to first estrus (ICFE), ICC and blood metabolites, which were analyzed 60–90 days after calving.

For the intervention period, the effects of treatment on live weight (LW), BCS, blood metabolite content and their variation between periods were analyzed using a split-plot design, where the treatments were the whole plots and the periods the subplots (Cochran and Cox, 1983). Total, and sold, milk yield, milk consumed by the calf, milk fat, duration of lactation, ICFE and ICC were analyzed using a Student *t* test. Pregnancy rate at 200 days of calving and number of cows repeating estrus at least once before pregnancy were evaluated by χ-squared analysis using the software SAS (SAS, 1985).

3. Results

3.1. Chemical composition and weight of standing forage

The stoloniferous grasses allowed the animals to select primarily leaves and, consequently, it was decided to separate the analysis of leaves and stems. The weight of standing forage ((kg DM)/(100 kg LW)) during the survey was high: 803±191 for Farm A, 914±469 for Farm B and 1090±312 for Farm C, with a stocking rate of 4, 2.4 and 1.0 cows/ha, respectively. Leaves constituted on average between 30 and 52% of the herbage, had a high content of NDF (70–77%), and an average crude protein (CP) content between 10 and 12%, with small variation between farms (Table 3). Stems contained

Table 3
Chemical composition and rumen DM disappearance (DMD 48 h) of forage

	% DM						Leaf : stem ratio (w/w [a])
	Ash	CP	NDF	Ca	P	DMD 48 h	
Survey							
Farm A							
leaves	11.9	11.9	74.2	0.32	0.22	65.8	0.43 : 1
stems	7.0	5.0	81.2	0.20	0.28	42.1	
Farm B							
leaves	9.7	11.7	79.6	0.50	0.20	63.2	1.10 : 1
stems	8.8	3.8	87.9	0.21	0.33	40.3	
Farm C							
leaves	12.0	10.0	77.2	0.52	0.31	59.9	0.63 : 1
stems	7.8	2.8	87.9	0.13	0.25	43.3	
Intervention							
Farm A							
leaves	10.3	8.8	69.4	0.51	0.33	62.5	0.55 : 1
stems	8.8	4.6	82.1	0.22	0.23	38.5	

[a] Expressed as 100% dry matter.

Table 4
Productive and reproductive characteristics of cows during the survey phase one month before calving (bc), 7–20 days after calving (ac_1), and 60–90 days after calving (ac_2)

Variables	Farm		
	A	B	C
Live weight (LW, kg)			
bc	485±66 (sd)	449±43	475±65
ac_1	452±72	386±42	429±61
ac_2	447±64	382±41	417±59
Body condition score			
bc	3.4±0.5	3.8±0.3	3.5±0.5
ac_1	3.0±0.4	3.3±0.5	3.1±0.5
ac_2	3.0±0.3	3.0±0.5	3.0±0.3
Milk sold			
kg/120 days	995±221	832±301	955±344
kg/lactation	1596±485	1736±416	1729±585
Duration (days)	208	282	296
Intervals (days)			
CFE [a]	94±46	103±60	80±46
CC [b]	145±64	168±47	114±74
Pregnant cows (%)	51.9	52.6	93.3

[a] Calving to first estrus.
[b] Calving to conception.

about 81–88% NDF, and CP content was markedly lower (3–5%) than that in leaves. The calcium and phosphorus contents, 0.30 and 0.20%, respectively, were within the range usually obtained for tropical forages (Minson, 1990). During the intervention phase, the availability of herbage was 765±89 (kg DM)/(100 LW). The chemical composition of leaves and stems is shown in Table 3.

Concentrates given during the survey period had about 20% CP, 45% NDF, 1.10% Ca and 0.70% P. During the intervention phase, both the supplements had 13% crude palm oil, but Fm had a higher content of CP (24.6 vs. 19.4%), Ca (1.81 vs. 0.79%) and P (1.44 vs. 0.63%) due to the addition of fish meal.

3.2. Productive characteristics of the herds

Average LW and BCS of all the cows during the survey and intervention phases as well as milk yield are shown in Table 4. The changes in these parameters on farms A, B, and C during the survey phase were similar and the data were combined to provide means. During the survey, cow weights averaged 442±58 kg. The BCS varied between 3.0 and 3.5, decreasing from before calving to 7–21 days after calving and from 7–21 days to three months after calving, with a similar trend occurring in body weight. Average milk yield sold was 1680±526 kg/lactation, and the milk fat content was 3.8±0.5%.

Table 5
Productive and reproductive characteristics of cows during the intervention phase one month before calving (bc), 7–20 days after calving (ac_1) and 60–90 days after calving (ac_2)

Variables	Treatments		SE
	Fo	Fm	
Live weight (LW, kg)			
bc	488	478	53.2
ac1	474	468	57.1
ac2	493	474	55.6
Body condition score			
bc	2.9	2.8	0.5
ac1	2.9	2.6	
ac2	2.6	2.7	0.7
Milk sold			
kg/120 days	1484	1517	185.6
kg/lactation	2383	2151	507.6
Duration (days)	259	229	29.5
Intervals (days)			
CFE [a]	95	85	45.9
CC [b]	117	100	49.5
Pregnant cows (%)	93.8	90.2	

[a] Calving to first estrus.
[b] Calving to conception.

During the intervention period, LW and BCS of cows decreased slightly between calving and 7–21 days after calving but increased again at two-to-three months of lactation, with no significant differences observed between the two treatments. BCS tended to fall from 2.8–2.9 before calving to 2.6–2.7 in the last sampling, although the values were not significantly different. Milk yield was similar between treatments with mean values of 1484 kg in Fo and 1517 kg in Fm. Lactation tended to be shorter in Fm than in Fo (229 and 259 days, respectively) and lactation milk yield was lower in Fm, with daily milk averages of 9.2 kg (Fo) and 9.4 kg (Fm), but none of the differences reached statistical significance.

3.3. Reproductive status of the herds

The reproductive status of the herds is shown in Table 4. Better reproductive performance was observed in Farm C, where all the animals except two became pregnant during the study and the lowest ICFE and ICC were obtained. Farm B had a low rate of conception with an average ICC of 168 days. The ICC value on Farm A is also shown in Table 4, but it was affected by the controlled mating season which started in August, four months after the beginning of the study.

For the intervention phase, which was carried out on Farm A, pregnancy rate was high in both the treatments and no statistical differences were observed in any of the variables measured ($p > 0.05$) (Table 5). But there was a considerable improvement in fertility and milk yield on all cows compared with results obtained during the survey phase.

3.4. Blood metabolite concentration

On the three surveyed farms, mean values of blood metabolites were within the normal reference ranges (Table 6). Information from the three herds was grouped and the percentages of cows with values outside the reference range for these metabolites calculated. The critical thresholds were taken from Whitaker and Kelly (1993), except for the PCV which was derived from the ranges for hemoglobin given by F. Wittwer (personal communication). A significant proportion of cows had low values of PCV,

Table 6
Blood metabolite concentrations one month before calving (bc), 7–20 days after calving (ac_1) and 60–90 days after calving (ac_2), including reference ranges [13]

Metabolite	Survey	Intervention			Critical ranges
		Fo	Fm	SD [a]	
Albumin (g/l)					
bc	34.5±3.1	34.2	34.4	3.0	<30
ac_1	33.5±4.3	33.1	32.0	2.8	
ac_2	33.6±4.4	32.6	31.6	3.1	
Globulin (g/l)					
bc	42.8±9.4	41.7	41.1	6.6	<50
ac_1	42.9±8.0	47.4	46.3	5.7	
ac_2	45.1±8.3	51.0	50.5	7.1	
Urea (mmol/l)					
bc	5.2±1.4	5.4	6.1	2.2	<3.6
ac_1	5.3±1.3	7.0	8.4	1.9 [a]	
ac_2	5.4±1.6	7.1	8.0	1.7 [a]	
B-OH-Butyrate (mmol/l)					
bc	0.42±0.2	0.44	0.48	0.2	>0.6
ac_1	0.43±0.2	0.62	0.57	0.2	>1.0
ac_2	0.44±0.2	0.67	0.56	0.2	>1.0
Phosphorus (mmol/l)					
bc	1.97±0.4	1.81	1.85	0.2	<1.4
ac_1	1.98±0.4	1.74	2.10	0.4 [a]	
ac_2	1.99±0.3	1.76	2.01	0.3 [a]	
Packed cell volume (%)					
bc	28±3	28	30	3.5	<27
ac_1	28±3	28	29	4.1	
ac_2	27±3	26	27	2.9	

[a] $p < 0.05$.

albumin and urea and high levels of globulin. The proportion of high globulin values increased as lactation proceeded.

At the sampling period 60–90 days after calving, albumin values in 26% of the animals were below 30 g/l and 16.2% showed urea values <3.6 mmol/l. Low levels of these metabolites are indicative of protein deficiencies in the diet, particularly at the peak of milk production when the highest demand for nutrients occurs. The concentration of globulin was in excess of 50 g/l in 10% of the animals before, and after, calving and increased to 25.7% of animals after two-to-three months of lactation. These high values could indicate disease not identified in this study. The PCV showed that the proportion of animals with anemia (PCV<27%) increased from 28% before calving to 62.5% after two-to-three months of lactation. The number of animals with values of phosphorus below 1.4 mmol/l were insignificant.

Very few cows had β-HOB values above the reference range before calving, suggesting no energy problems at that stage and only 6.3% showed values >1.0 mmol/l at 20–30 days after calving. During the intervention phase, between 40 and 60% of the animals showed PCV values below 27% at the two post-calving periods and 30–40% of the cows presented albumin values below 30 g/l at ac_1 and ac_2 for both the treatments. Urea values were >3.6 mmol/l in all the animals during the two sampling periods, but were slightly higher in cows which received fish meal ($p<0.05$). Globulin figures were high at both post-calving samplings. However, values over 50 g/l were shown by 65% of the Fo cows on both occasions, while the number of such cases in the Fm group increased from 30% at two-to-three weeks after calving to 58% at three months after calving.

β-HOB values were not >1.0 mmol/l in any of the animals at either of the two sampling times. Phosphorus values were below 1.4 mmol/l in about 20% of the cows two-to-three weeks after calving but this proportion decreased to 6% at three months after calving. The correlation analyses carried out between productive variables and blood metabolite concentrations reached significance only in two comparisons, both cases at two-to-three months after calving. A negative relationship was found between ICC and albumin ($r=-0.565$, $p<0.01$) and between milk yield and PCV ($r=-0.274$, $p<0.05$).

4. Discussion

4.1. Pastures

Animals had access to sufficient forage which enabled considerable selection for leaf material. Based on the evidence of Minson (1990), we would not anticipate intake to be restricted by feed availability. However, even assuming that the leaves were the only constituent of the diet, the CP and, possibly, mineral concentrations appear to be insufficient to fulfil the needs of these cows (Table 3). The requirements of CP, Ca and P, according to NRC (1989), are 11.6, 0.42 and 0.28% of the diet and their content in leaves were in many cases below these values. During the intervention phase, the daily degraded and undegraded protein requirements (NRC, 1989) estimated from production values were of 922 and 598 g/day. It was not possible to determine daily intakes of these nutrients, but an estimation was done assuming a leaf intake of 8.7 and 9.2 kg/cow/day with treatments Fm and Fo, and protein undegradability of 0.64 for fish meal and 0.20 for leaves and concentrate without fish meal (Combellas et al., 1993). The estimated ingestion of these nutrients was 990 and 1040 g of degraded protein and 248 and 390 g of undegraded protein with treatments Fo and Fm. The estimated consumption of degradable protein was probably slightly above the animals' needs as indicated above, and this is supported by the urea results (Table 6); however, while the undegradable protein in both diets was in theory insufficient to fulfil the cows' requirements, failure to respond to fish meal supplementation suggests that, in fact, this was not the case. The standards of NRC (1989) were established for high yielding cows and may not necessarily apply to the low yielding animals used in dual-purpose systems.

4.2. Milk yield, BCS and LW of cows

Milk yields measured do not reflect the total milk production on farms A and B. Milk yields obtained were within the range of values observed in dual-purpose cows in tropical America (Vaccaro and López, 1994). The mean values obtained on these farms were 6.5 kg/cow/day excluding the milk suckled by the calves. Differences between farms were not significant, probably because calf suckling on farms A and B was confounded with supplementation, which was absent on Farm C where calves were raised artificially. It was surprising that milk yield during the experimental period was similar between treatments with values of 1484 kg in Fo and 1517 kg Fm, especially since undegraded dietary protein supply, though calculated to be still deficient, was 142 g/day or 24% greater in Fm than Fo cattle. But as mentioned before, it is possible that the standards do not apply to the low yielding cows used in these trials.

LW decreased from just before calving to just after calving and to two-to-three months of lactation. The magnitude of change varied between farms, and was smaller on Farm A. BCS followed the same trend as LW. These results may be related to the level of concentrate offered, which was higher on Farm A.

4.3. Reproductive status of herds

Only on Farm C did reproductive efficiency come close to one calf per year, i.e. 114 ICC. On the other farms, the much lower efficiency (50% of cows were still not pregnant after 200 days of lactation) was due to a combination of slightly delayed onset of postpartum ovarian activity, 80, 94 and 103 days after calving, respectively, but a much larger interval between first estrus and conception, 34 and 65 days on farms B and C, respectively. The negative influence of high milk yield (Vaccaro et al., 1994) may have been partly responsible, since total yields (including milk consumed by the calf) would have been higher on farms A and B. The possibility that sustained suckling affected performance is also important and seems worthy of exploration. There is conflicting evidence for effect of suckling on reproduction, both negative (Velazco et al., 1983; Little et al., 1991) and positive or neutral (Veitía and Simon, 1972; Ugarte and Preston, 1975; Leon and Vaccaro, 1984; Sanh et al., 1995).

The trend for better performance on Farm A, both in Fo and Fm cows, is difficult to explain because suckling continued as in the year before. There was a trend for a higher conception rate in Fm cows at first estrus and for fewer days on average to conceive, but Fo cows reached a slightly higher pregnancy rate and no statistical differences were obtained for these variables. These results indicate, as with milk yield, that undegraded protein was not deficient in the control diet (Fo). Other reasons not evaluated in this study could be associated with the better general performance of all cows during the intervention year in relation to the year before. The inclusion of palm oil and a higher level of energy supplementation during the second year, or variations in climate conditions not evaluated, could be related to the results obtained.

4.4. Blood metabolites

Blood metabolite values suggest that differences in reproductive performance could not be explained in nutritional terms. Higher levels of β-HOB on Farm B appear to correspond to a temporary shortage of herbage availability. Blood metabolite averages on all farms were within the reference ranges given for these animals (FAO/IAEA, 1989; Payne, 1978; Swenson, 1984) but a variable proportion of cows were outside these ranges, indicating some possible nutritional constraints (Table 6).

The low PCV in a significant percentage of cows agrees with the findings of Baldizán (1982) who observed low PCV values in the rainy season but not during the dry season (29.3±3.6 vs. 35.3±4.1%). Although we were unable to find any relationship between these values and parasite eggs in feces, low PCV suggests the need for research on the effect of hematophagic parasites, especially since animals with high nutrient demands are likely to be more susceptible to infection.

The trend for elevated globulin concentration suggests chronic inflammatory response (Whitaker and Kelly, 1993) which, together with trends for reduced albumin concentration, further suggests the need to look for a chronic disease, such as helminth parasites (Van Hutert and Sykes, 1996) and determine its importance as a potential constraint.

The small number of β-HOB values above the reference ranges at any one point implies that dietary energy shortages were not great, a conclusion supported by small BCS changes. Low levels of phosphorus in the blood were observed in very few cows. The phosphorus content in leaves on all farms was theoretically adequate to fulfill the estimated requirement of 0.28% in DM (NRC, 1989), and did so, judging by the blood results on Farm C. There was no evidence of a need for phosphorus supplementation as practised on farms A and B.

For the intervention phase, β-HOB profiles indicate that the energy supplied in the diet met the animal requirements and this was supported by the small changes in body condition and LW after calving. However, if the improved performance of cows during the intervention year was a consequence of a higher level of energy supplementation with the use of palm oil, as suggested before, the energy deficiencies during the survey were not predicted in this metabolite. Blood phosphorus of treatment Fm cows was slightly higher than those in Fo, and fewer animals were in the critical range, but the difference was probably associated with the high content of phosphorus in fish meal. Mean blood urea was slightly higher in cows supplemented with fish meal, although this was of statistical, not biological, significance.

The same trends of PCV, globulin, and albumin were obtained in both treatments (29% showed low PCV, 32% low albumin and 50% high globulin) which suggests that improving protein supply did not change these values, but also that the infection they represent was not sufficiently serious to inhibit the general improvement in the intervention trial. They still need to be investigated, however, as possible contributors to suboptimal performance.

5. Conclusions

The results obtained in the survey have shown large ICC values in two farms and critical levels of albumin, urea and globulin in a significant number of cows, but statistically significant correlation was only observed between albumin and ICC. The supplementation with fish meal in the intervention trial did not improve milk yield or reproductive efficiency, yet average production performance of cows on this farm was better than the year before. There is no evidence to explain these results; however, a higher level of energy supplementation by the inclusion of palm oil in the diet or variations in climate conditions between years could be involved. The elevated globulin concentration together with low albumin and PCV levels suggests the need to look for chronic disease. Because higher performance during the intervention trial was not associated with changes in metabolites, it is suggested that the level of disease does not inhibit an improvement in milk yield and reproductive status of cows.

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References

AOAC., 1984. Official Methods of Analysis. 14th edn. Association of Official Agricultural Chemists: Washington.

Baldizán, G., 1982. Hematología y seroproteínas en bovinos de diferente mestizaje sometidos a variación en suplementación alimenticia. Trabajo de Ascenso, Facultad de Ciencias Veterinarias, Universidad Central de Venezuela, pp. 117.

Cochran, W., Cox, G., 1983. Diseños Experimentales. Trillas, México, pp. 661.

Combellas, J., Priore, F., Peralta, J., Zavarce, O., 1993. Influence of the addition of fish meal to diets of roughage or roughage and concentrate on the consumption and live weight gain of grazing cattle. Ani. Feed Sci. Techn. 42, 319–331.

Edmonson, A., Lean, I., Weaver, L., Farver, T., Webster, G., 1989. A body condition scoring chart for Holstein dairy cows. J. Dairy Sci. 72, 68–78.

FAO/IAEA., 1989. Nutritional metabolite kit protocols. Animal Production and Health Joint FAO/IAEA Programme. Agency's Laboratories, Austria and Faculty of Veterinary Medicine, University of Utrecht, Netherlands, pp. 20.

Fick, K.R., Ammerman, C.B., McGowan, C.H., Loggings, P.E., Cornell, J.A., 1973. Influence of supplemental energy and biuret nitrogen on the utilization of low quality roughage by sheep. J. Ani. Sci. 36, 137–147.

Goering, H.K., Soest, P.J. Van, 1970. Forage Fiber Analysis. Agricultural Research Service, USDA Agricultural Handbook, No. 21.

Harris, W., Popat, P., 1954. Determination of the phosphorus content of lipids. J. Am. Oil Chem. Soc. 32, 124–127.

Leon, I., Vaccaro, R., 1984. The effect of suckling on the growth of calves, and the milk yield and fertility of their dams. Informe Anual 1983, Instituto de Producción Animal, Universidad Central de Venezuela, Maracay, pp. 70–71.

Little, D.A., Anderson, F.M., Durkin, J.W., 1991. Influence of partial suckling of crossbred dairy cows on milk offtake and calf growth in Ethiopian Highlands. Trop. Ani. Health Prod. 23, 108–114.

Minson, D.J., 1990. Forage in Ruminant Nutrition. Academic Press, San Diego.

NRC, 1989. The Nutrient Requirements of Dairy Cattle. National Research Council. National Academy of Science, Washington DC.

Orskov, R., Hovell, F., Mould, F., 1980. Uso de la técnica de la bolsa de nylon para la evaluación de los alimentos. Producción Animal Tropical 5, 213–234.

Payne, J.M., 1978. The Compton metabolic profile test. In: The Use of Blood Metabolites in Animal Production, BSAP Occasional Publication 1: 3–12.

Plaizier, J., 1993. Validation of the FAO/IAEA RIA kit for measurements of progesterone in skim milk and blood plasma. In: Improving the Productivity of Indigenous African Livestock. IAEA TECDOC-708, IAEA, Vienna, pp. 151–156.

Sanh, M.V., Preston, T.R., Fajersson, P., 1995. Effects of restricted suckling versus artificial rearing on performance and fertility of *Bos taurus* and *Bos indicus* cows and calves in Tanzania. Livestock Research for Rural Development 6 (3) (47kb).

SAS., 1985. SAS User Guide: Statistics. SAS Institute, Inc. Cary, NC.

Swenson, M.J., 1984. Physiological properties and cellular and chemical constituents of blood. In: Swenson, M.J. (Ed.), Dukes' Physiology of Domestic Animals, tenth ed. Cornell University Press, New York, pp. 15–40.

Ugarte, J., Preston, T.R., 1975. Restricted suckling 6. Effects on milk production, reproductive performance and incidence of clinical mastitis throughout the lactation. Cuban J. Agri. Sci. 9, 15–26.

Vaccaro, L., López, D., 1994. Taller de Trabajo Latinoamericano sobre el Mejoramiento Genético de Bovinos de Doble Propósito: Conclusiones y Recomendaciones. Archivos Latinoamericanos de Producción Animal, Volumen 2 Suplemento 1, 15.

Vaccaro, L., Vaccaro, R., Verde, O., Mejías, H., Pérez, A., Ríos, L., Romero, E., 1994. An improvement program for tropical dual purpose cattle. Proceedings of the 5th. World Congress on Genetics Applied to Livestock Production. Ottawa, Canada 20, 313–318.

Van Hutert, M., Sykes, A., 1996. Implications of nutrition for the ability of ruminants to withstand gastrointestinal hematode infections. J. Parasitology 26, 1151–1167.

Veitía, J.L., Simon, L., 1972. Effect of two restricted suckling systems of calf rearing on milk production and calf growth. Cuban J. Agri. Sci. 6, 189–193.

Velazco, J., Calderón, J., Guevara, S., Capriles, M., Martínez, N., Paredes, L., López, S., 1983. Effect of restricted suckling on the growth of calves, milk yield, ovarian activity and progesterone levels in Holstein–Friesian and Brown Swiss cows. Informe Anual 1981, Instituto de Producción Animal, Universidad Central de Venezuela, Maracay, pp. 43–44.

Whitaker, D.A., Kelly, J.M., 1993. Use and interpretation of metabolic profiles in dairy cows (mimeo).