Low Cost Feeding Strategies for Dual Purpose Cattle in Venezuela

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This simulation study was to evaluate low cost feeding strategies in response to higher cost of commercial concentrates to maintain current milk sales from dual purpose cattle herds in the humid lowlands of western Venezuela. Data were from farm surveys in 1987 and 1988. Baseline net margins from milk and beef per cow per year were $132 and $99 for two farm cases with average dally milk of 10 and 7 kg/cow and grazing mature forage supplemented with commercial concentrate. Alternative diets were 1) improving forage quality by more intensive grazing; 2) replacing commercial concentrate with a mixture of cassava tuber *(Manihot esculenta),* urea, and molasses and 3) supplementing grazing with a mixture of molasses and urea. Alternatively priced feeding strategies were compared by partial budgeting. Using less mature forage was .always more profitable than mature grass. Feeding molasses and urea with mature forage increased profits at least $64/cow on the high milk yield farm and $44/cow on the low milk yield farm compared with feeding commercial concentrate. The most costly cassava mixture with mature forage increased annual profit over the baseline diet at least $11/cow on the high milk yield farm and by $22/cow on the low yield farm. Efficient use of existing feed resources may enhance economical livestock production in the humid lowlands of Venezuela.
(Key words: dual purpose cattle, alternative diets, Venezuela)

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INTRODUCTION

Venezuelan producers of dual purpose (milk and beef) cattle faced substantial increases in the cost of commercial concentrate feeds due to discontinuation of a 30% government subsidy in 1988 (27). Sown pasture is the principal forage resource, which is frequently undergrazed, resulting in mature plants with substantial dead matter. Commercial concentrate feeds are used widely to supplement diets based on these mature forages. Holmann (8) found that highest annual net margin per cow (annual receipts from milk and beef minus the sum of feed, labor, health, and reproduction costs per cow) was associated with lowest cost of production on farms in the humid lowlands of western Venezuela. Thus, more costly commercial concentrates portend reduced farm profits, which would be an incentive to alter feeding programs in this region.

Alternative Diets

Compared with mature plants, more intensively grazed, young tropical grasses generally 1) are more digestible and contain more CP and 2) contain less cell wall constituents that are less lignified, which promotes increased voluntary intake of DM (7, 9, 12, 25, 26). Depending on environmental conditions during growth and the species, young grasses supply more digestible nutrients per unit of DM than do mature ones. Thus, forage quality may be improved through investments in added labor and fencing to increase pasture rotations to obtain younger, less mature plant material (5, 25).

Cassava roots and sugarcane molasses are valuable energy sources for ruminants (1, 4, 6, 13, 14, 20). However, nitrogen (e.g., urea) needs to be supplemented to assure a nitrogen-carbohydrate substrate containing a 16% CP equivalent to support protein synthesis by rumen microbes. Furthermore, cassava *(Manihot esculenta)* is widely cultivated in the tropics, yielding a harvest under a wide range of soil conditions.

To avert risk, alternative diets should at least maintain animal productivity. Consequenfiy, diets must provide the same quantity of nutrients (e.g., CP, NDF, TDN) as original diets. Management requirements also should not exceed the capabilities of producers. Therefore, our objectives were to evaluate the direct effect on herd profitability of the cost of alternative diets that were at least nutritionally equivalent to those provided by supplementing mature pasture with commercial concentrate on farms in the humid lowlands of western Venezuela (8). Feasible dietary alternatives were 1) less mature forage from more intensive grazing, 2) a mixture of fresh cassava roots, molasses, and urea, and 3) a molasses and urea mixture.

MATERIALS AND METHODS

Farm survey data collected in 1987 to 1988 provided a subset of dual purpose cattle farms using Holstein germplasm in the humid lowlands of the Venezuelan states of Mérida, Táchira, and Zulia (8). Of the 48 farms surveyed in this agro-ecozone, milking cows were fed commercial concentrate feeds on 79% of them. These 38 dual purpose farms constituted the sample for this simulation study.

Description of Farms

Milking cows were fed an average of 3 kg of commercial concentrate per day, which was 30% of total costs for feed, labor, health, and reproduction. Forage was supplied by combinations of several grasses (percentage of total area): *Panicum maximum* (Guinea grass, 26%), *Echinochloa polystachya* (African wonder grass, 19%), *Brachiaria rnutica* (Para or Angola grass, 12%), *Cynodon plectostachyus* (Africa star grass, 12%), *Brachiaria decurnbens* (Signal grass, 11%), *Brachiaria humidicola* (creeping signal grass, 7%), and various others (13%).

Average annual rainfall was 2725 mm (range 2500 to 2800 mm) with a 9-mo rainy season. Average temperature and altitude were 28°C and 225 m. Commercial fertilizer, mostly urea, was used at an average rate of 166 kg/ha (range 0 to 700) of pasture. Average stocking rate was 1.6 animal units/ha (range .5 to 4.3). An animal unit (AU) was defined (8): bull = 1.5 AU, cow = 1.0 AU, mature heifer = .9 AU, immature heifer = .7 AU, calf = .3 AU. Salt and minerals were generally fed for ad libitum consumption.

Seventy-five percent (range 47 to 95%) of farm income was from the sale of milk, averaging 8 kg per cow/d. Herds in this sample consisted of mixtures of *Bos indicus* (Zebu) and Holstein with an average herd size of 230 milking and dry cows (range 10 to 760 cows). Breed groups were defined as in the national milk recording system as >50% and <50% Holstein genes. Males were sold at an average weight of 266 kg (range 40 to 500 kg). At the time of the survey about 60% of farm employecs had spent less than 1 yr in their current jobs. Annual net margin per cow (lactating and dry cows) averaged $169 (range $41 to $470).

Twenty-six producers in this region were personally surveyed about the feasibility of feeding cassava roots. They were asked why they thought feeding cassava was a good or a bad idea. Producers may have had prior knowledge about the use of cassava as animal feed, because it is already grown in this area for human consumption.

Case Farms

The 38 farms comprised two groups of equal size based on average milk per cow/yr (<3000, >3000 kg) to evaluate the effects on profit of alternative diets. Daily milk yields averaged 10 kg in high yielding herds and 7 kg in low yielding herds. No information was available to account for stage of lactation of cows in these herds. The simple correlation was .6 (P<.01) between average commercial concentrate fed and average milk per cow. High yielding herds averaged 4 kg and the low yielding herds average 2 kg daily commercial concentrate per lactaring cow. Two-thirds of farms producing at least 3000 kg milk per cow/yr used >50% Holstein germplasm, and two-thirds of farms in low milk yielding farms used <50% Holstein germplasm.

One farm case from each group was selected for study based on nearness to group average milk yield, feeding management, and herd germplasm composition. Henceforth, farm 1 refers to the case farm from the high milk yielding group and farm 2 refers to the case farm from the low yielding group. Farm 1 averaged >50% Holstein germplasm, 10 kg milk per cow/d, and 4 kg commercial concentrate per cow/d. Farm 2 averaged <50% Holstein germplasm, 7 kg milk per cow/d and 2 kg commercial concentrate per cow/d. These and other characteristics of the groups and farm cases are in Table 1.

Composition of Diets

Nutritional values for tropical grasses from the humid lowlands of Venezuela (3) were used to calculate dietary composition. Values were for the same grass species and were assumed representative of the mature forages fed on the case farms (Table 2). The TDN content of the forage was calculated from the modified equation of Van Soest et al. (24): TDN = digestible DM - total ash + .60 ether extract + silica + . 1.9. The coefficient for the ether extract contribution to TDN was .60 (instead of 1.25) to account for differences in lipid sources in concentrates and forages. Total ash was assumed to be 9% based on values for grasses under similar conditions (7, 10). Values for NDF, CP, digestible DM, and ether extract were from Combellas et al. (3).

Values for TDN, NDF, and CP were altered to represent the same forage under a more intensive grazing system. Composition of this less mature forage was assumed from analyses of grasses under similar conditions at 40 d compared with 60 d of age (7, 23). The CP, NDF, and TDN values were altered conservatively, assuming proportional changes among them (Table 2).

Nutrient composition of commercial concentrate was determined by methods described elsewhere (19, 21, 24) for samples collected in Venezuela in May 1988 (M. Morales, 1988, unpublished data) (Table 2). Composition and feeding properties of cassava were the average of published results (4, 13, 14, and our unpublished data for NDF content). Nutritive values for urea and molasses were from NRC (16). Soluble protein values for forage, commercial concentrate, and cassava were adjusted based on principles developed by Wohlt et al. (28).

Diets

Baseline diets were mature forage and commercial concentrate for milking cows on farms 1 and 2. Concentrates fed were based on averages from the survey. Forage intake was predicted using Dairy Digest, a computerized diet formulation program (18).

Alternative diets were formulated with Dairy Digest, using combinations of less mature forage, commercial concentrate, cassava, molasses, and urea to supply at least the same dally quantities of TDN, NDF, and CP as the baseline diets, and to determine how much commercial concentrate could be replaced (Table 3). Intake of DM was predicted based on dietary NDF composition as described by Mertens (11). Intake of NE1 was calculated to estimate net energy balance in milking cows (24).

Cassava roots were assumed to be fed fresh after being broken by mallet or machete. A 5:1 molasses:urea mixture (as fed basis) was assumed applied to the cassava to enhance uniform consumption of urea. This step was considered important because urea is highly soluble. To avoid ammonia toxicity, soluble protein content of the diets was restricted to a maximum of 45%.

Animal nutrient requirements for protein and energy were as recommended in (15, 16). Estimated maintenance requirements were increased by 10% to account for grazing activity and heat stress. Animal characteristics to predict nutrient requirements of milking cows were medium frame and body weights of 500 kg for farm 1 and 450 kg for farm 2. Milk was assumed to contain 4% milk fat.

Fee;ling Costs

Prices for commercial concentrate, molasses, urea, and labor were averages from the surveys. Annual feed cost per cow (lactating cows plus dry cows) was estimated based on intake as a percentage of body weight. Pasture DM consumed was assigned a cost equal to the market value of hay, which helped ensure that forage cost was not underestimated (e.g., due to losses from trampling and defection). Annual cost of pasture DM per cow was multiplied by total animal units and added to total expenditures for fertilizer to obtain total forage cost. Improved quality forage was valued by adding 1 man-yr of labor per farm ($956 on farm 1; $737 on farm 2) to decrease plant age by rotating animals between pastures more frequently.

Costs of producing one metric ton of cassava were $30 and $40 for average yields of 8

TABLE 1. Characteristics of 19 farms averaging at least 3000 kg milk per cow/yr and 19 farms averaging less than 3000 kg milk per cow/yr and selected farm cases representing each group.

	≥3000 kg milk per cow/yr					<3000 kg milk per cow/yr				
Characteristic	$\overline{X}$	SD	Min	Max	Farm 1	$\overline{X}$	SD	Min	Max	Farm 2
Climate										
Temperature, °C	29	.8	27	30	30	28	.8	27	30	29
Rainy season, mo	9	1.1	8	12	8	9	.8	8	11	9
Farm and herd										
Herd size (total cows)	170	140	10	483	145	289	217	65	760	140
Total pasture, ha	224	156	6	500	200	376	246	69	850	325
Paddock size, ha	5	2.7	1	11	3	7	3.5	3	18	9
Fertilizer, kg/ha	224	187	0	700	150	108.2	131.4	0	500	150
Stocking rate, AU/ha	1.5	.7	.5	3.2	1.4	1.7	.9	.6	4.3	.9
Animal units per worker	29	11	10	51	22	38	14	19	67	21
% Workers <1 yr[2]	54	31	0	100	62	63	27	0	100	79
Milk per cow/d, kg										
Rainy season	10	1.9	8	14	10	7	1.2	3	9	7
Dry season	10	2.4	8	16	10	7	1.2	4	9	7
Feeding										
Pasture interval, d										
Rainy season	30	5.7	20	40	30	27	8.9	6	40	35
Dry season	32	6.5	20	45	20	33	12.4	6	60	40
Concentrate per cow/d, kg										
Rainy season	4	1.4	1	6	4	2	1.3	0	5	2
Dry season	4	1.4	1	6	4	2	1.1	1	5	2
Economic										
Land value, $/ha	1130	477	500	2667	1000	1020	264	500	1333	1333
% Income from milk	79	9.8	54	95	78	71	12.5	47	86	74
Total cost as concentrate, %	36	12.2	15	51	37	25	9.8	6	42	28
Net margin/cow, $	204	108	52	470	132	127	53	41	241	99

[1]AU = Animal unit. Bull = 1.5 AU, cow = 1 AU, mature heifer = .9 AU,

[2]Percentage of farm employees having worked less than 1 yr.

TABLE 2. Composition of feeds used in alternative diets.

Feed	% DM	TDN	NDF	CP	SP[1]
		% of DM			
Forage					
Mature	23	49.9	70.1	7.1	25
Less mature[2]	23	54.9	67.1	8.1	25
Commercial concentrate	89.8	67.8	20.1	16.3	25
Cassava roots[3]	35	83	7.1	2.5	30
Molasses	75	72	. . .	4.3	100
Urea	89			281	100
5:1 Mix[4]	77.3	58.2	. . .	57.4	100

[1] Soluble protein.

[2] proportional changes in NDF, CP and TDN similar to those for tropical grasses 40 d vs. 60 d of age (7).

[3] Average from several references [(4, 13, 14) unpublished data].

[4] Molasses:urea mixture, 5:1 (as fed basis).

and 12 metric tons (t)/ha (J. H. Cock, Centro Internacional de Agricultural Tropical, Cali, Colombia, personal communication), which included farm delivery. Labor to feed cassava cost $2.62/man-d for Farm 1 and $2.02/man-d for Farm 2. Two man-days of labor cost were added per metric ton of cassava assuming that two laborers could process and feed 1t of it in two feedings. Table 4 shows prices for the various supplements and labor under different economic scenarios.

Partial Budget

A partial budgeting template was developed using an electronic spreadsheet that included feed and labor prices, quantifies fed, and total receipts from milk and beef for the two farm cases. Milk price was $.163/kg. Beef prices were $150/195-kg male and $240/cull cow on farm 1 and $200/300-kg male and $177/cull cow on farm 2.

Changes in profit were from different costs of feed and labor. Alternative feed price scenarios were 1) subsidized price of commercial concentrate ($78.33/t on farm 1, $100/t on farm 2), 2) 50% higher price of commercial concentrate ($117.50/t on farm 1, $150/t on farm 2) from removing the 30% government subsidy and assuming a 20% increase in the cost of imported feed ingredients, 3) a cassava price of

TABLE 3. Alternative diets for the farm cases.

	Diet					
Feed	B[2]	L[3]	C[4]	CL[5]	M[6]	ML[7]
Mature	X		X		X	
Less mature		X		X		X
Commercial concentrate	X	X				
Cassava root			X	X		
5:1 Mix[1]			X	X		
Molasses					X	X
Urea					X	X

[1] Molasses:urea mixture, 5:1 (as fed basis).

[2] B = Predicted baseline diet of mature forage and commercial concentrate from the surveys of Holmann (8)

[3] L= Less mature forage and commercial concentrate.

[4] C = Mature forage, cassava, and 5:1 molasses:urea mixture.

[5] CL = Less mature forage, cassava, and 5:1 molasses:urea mixture.

[6] M = Mature forage, molasses, and urea.

[7] ML = Less mature forage, molasses, and urea.

TABLE 4. Prices of supplements and labor under four economic scenarios for case farms 1 and 2, for all females, and for milking cows only.

	Concentrate, subsidized		Concentrate, unsubsidized	
	$40/t[1]	$30/t	$40/t	$30/t
	($/t)			
Concentrate				
Farm 1	78.33	78.33	117.50	117.50
Farm 2	100.00	100.00	150.00	150.00
Milking cows2	78.33	78.33	117.50	117.50
Cassava3				
Farm 1	45.24	35.24	45.24	35.24
Farm 2	44.06	34.06	44.06	34.06
Milking cows2	44.06	34.06	44.06	34.06
Molasses				
Farm 1	45.00	45.00	45.00	45.00
Farm 2	45.00	45.00	45.00	45.00
Milking cows	45.00	45.00	45.00	45.00
Urea				
Farm 1	22.00	22.00	22.00	22.00
Farm 2	22.00	22.00	22.00	22.00
Milking cows	22.00	22.00	22.00	22.00
	($/man-d)			
Labor				
Farm 1	2.62	2.62	2.62	2.62
Farm 2	2.02	2.02	2.02	2.02
Milking cows2	2.02	2.02	2.02	2.02

[1]Cost of cassava.

[2] prices for both farms set equal to those for farm I for concentrate, farm 2 for cassava, and farm 2 for labor.

[3] Cost of production plus labor.

$40/t (yielding 8 t/ha), and 4) a cassava price of $30/t (yielding 12 t/ha) to account for production cost and farm delivery.

Economic impacts from alternative diets were examined for all females in the case herds normally receiving concentrates. Case farms differed in prices for labor and commercial concentrate and in animals receiving concentrates. Therefore, equal prices for labor ($2/man-d) and concentrate ($78/t) were used to evaluate the economic impacts of alternative diets when fed only to the milking females in these herds with differing average yield.

RESULTS AND DISCUSSION

Farmers opined that there is substantial potential from feeding cassava to dual purpose cattle. Fifty percent of respondents indicated that feeding fresh cassava was a good idea (Table 5). More emphatically, more than three-fourths of them identified attributes favoring adoption, which included ease of cultivation, palatability, low cost, and increased milk yield. About one-third of respondents were uncertain

TABLE 5. Results from a survey of 26 dual purpose producers in western Venezuela about the use of cassava roots as feed for dual purpose cattle.

Question	Frequency	(%)
Good idea to feed cassava	13	50
Inexpensive	22	85
Palatable	22	85
Easy to cultivate	21	81
Animals do produce	21	81
Maintains stable production	1	4
Bad idea to feed cassava	5	19
Costly		
Not palatable		
Difficult to cultivate		
Difficult to store		
Animals do not produce	3	12
Not customary to use	2	8
Shortens lactation	2	8
No opinion	8	31

if they would use cassava as cattle feed. About one-fifth of them rejected it because of expected low milk yield and lack of custom.

Baseline Diets

Predicted daily DM intakes were 10.4 and 8.3 kg for lactating cows on farms with high (farm 1) and low (farm 2) milk yields using baseline diets comprising mature forage and commercial concentrate (Table 6). Estimated daily DM intakes to meet nutrient requirements were 12.8 and 10.9 kg, which indicated approximate DM deficits of 19 and 24% on these farms. Ironically, cows in the low yielding herd received less adequate diets than cows in the high yielding herd.

If it is assumed that estimates of diet nutritive values are accurate, then NDF content probably constrained forage DM intake resulting in body tissue catabolism to obtain the corresponding average yields of 10 and 7 kg milk per cow/d. Calculated negative energy balances were 4.44 and 4.94 Mcal NE_1/d, which corresponded to average daily body weight losses of about .9 kg per cow on farm 1 and 1.0 kg per cow on farm 2 (16, 24). Neidhardt et al. (17) found body weight losses up to 100 kg in Brahman cows yielding more than 1340 kg milk in 217 d in Venezuela. For our simulation, ignoring stage of lactation, this loss in body weight would occur in less than 112 d in the high yielding herd and in less than 100 d in the low yielding herd.

Differences in calculated energy balance and in dally CP intake (27% less energy and 31% less CP than required on farm 1, and 36% less energy and 39% less CP on farm 2) showed that the diet for the low yielding farm was less adequate than the one for the high yielding farm. If reproductive rate is correlated with body energy reserve, then the low yielding farm case may not have a reproductive advantage over the high yielding one.

Alternative Diets

Due to the low energy content of the commercial concentrate (67.8% TDN, Table 2), it was not possible to duplicate exactly the nutritional attributes of baseline diets when less mature forage was fed with concentrate. The resultant TDN supplied by this alternative was 3 to 4% higher than for the baseline diet to provide baseline CP. Although an increase in milk yield might be predicted, it was ignored in this study.

Intake of forage DM was predicted to increase 4 to 9% when less mature grass was grazed (Table 6). However, less DM was consumed to meet the baseline nutrient intake restriction. Greater total DM intake would be likely under actual feeding situations, which portends higher yield and income from milk. Compared with mature grass, less mature forage permitted feeding less supplement to achieve the same milk yield in all diets.

Commercial concentrate was completely replaced nutritionally by mixtures of cassava-urea-molasses or molasses-urea, regardless of forage maturity (Table 6). Little cassava was needed to supply baseline nutrients with less mature forage on farm 2.

Soluble protein supplied per cow on farm 1 was .63 kg/d when the cassava-urea-molasses mixture was fed and .65 kg/d when molasses and urea were fed with mature forage. Maximum allowable soluble protein for cows on farm 1 was .7 kg/d, indicating that caution is needed to avoid ammonia toxicity when feeding these diets. Assuring thorough mixing and two (or more) meals per day would help disperse soluble protein intake. Table 6 summarizes diet formulations and predicted intakes of DM and TDN.

Farm Profitebility

Baseline Diets. Annual net margins per cow were $132 for farm 1 and $99 for farm 2 for the baseline diets. A 50% higher commercial concentrate price reduced profits from $132 to $49 (63%) for the high yielding farm 1 and from $99 to $63 (36%) on the low yielding farm 2 (Table 7, Figures 1 and 2).

When only milking cows were fed alternative diets, annual net margins per cow were $150 for farm 1 and $115 for farm 2 for the baseline diet because concentrate and labor prices were standardized (Table 4). Farm 1 depended more on concentrates and was 31% more adversely affected *(55%* less profit) than was farm 2 by more costly concentrates (24% less profit; Table 8).

Increased Forage Quality. Annual net margins per cow were $152 for farm 1 and $119 for farm 2 when less mature forage was supplemented with subsidized, commercial concentrate. When concentrates cost 50% more, farm

TABLE 6. Diet formulations and predicted DM intake per cow per day for the case farms.

		Predicted DM intake as:									Predicted nutrient intake				
		Forage													
Diet	Farm[1]	Mature	Less[2]	Conc.[3]	Cassava	Molasses + urea[4]	Molasses	Urea	Total	BW[5]	TDN	CP	SP[6]	NDF	Energy balance[7]
		(kg/d)								(%)	(kg/d)				(Mcal/d)
Baseline[8]															
B	1	6.8		3.59					10.39	2.08	5.83	1.07	.27	5.5	–4.44
	2	6.54		1.8					8.34	1.85	4.48	.76	.19	4.95	–4.94
Alternatives															
L[9]	1		7.32	2.93					10.25	2.05	6.00	1.07	.27	5.5	–4.09
	2		7.03	1.17					8.20	1.82	4.65	.76	.19	4.95	–4.64
C[10]	1	7.66			1.83	.84			10.33	2.07	5.83	1.07	.63	5.5	–4.41
	2	6.97			.91	.42			8.3	1.85	4.48	.76	.37	4.95	–4.91
CL[11]	1		8.07		1.22	.67			9.96	1.99	5.83	1.07	.56	5.5	–4.65
	2		7.34		.35	.27			7.96	1.77	4.48	.76	.31	4.95	–5.17
M[12]	1	7.85					2.66	.14	10.65	2.13	5.83	1.07	.65	5.5	–4.3
	2	7.06					1.33	.07	8.46	1.88	4.48	.76	.38	4.95	–4.8
M[13]	1		8.2				1.85	.12	10.16	2.03	5.83	1.07	.57	5.5	–4.54
	2		7.38				.6	.05	8.02	1.78	4.48	.76	.31	4.95	–5.12

[1]Farm 1: 500 kg cow yielding 10 kg milk/d. Farm 2: 450 kg cow yielding 7 kg milk/d.

[2]Less mature.

[3]Commercial concentrate.

[4]Molasses:urea mixture 5:1 as fed basis.

[5]DM intake as percentage of body weight.

[6]Soluble protein.

[7]Calculated energy balance: NE_l (21).

[8]B = Predicted baseline diet of mature forage and commercial concentrate from the surveys of Holmann (8).

[9]L = Less mature forage and commercial concentrate.

[10]C = Mature forage, cassava, and 5:1 molasses:urea mixture.

[11]CL = Less mature forage, cassava, and 5.1 molasses:urea mixture.

[12]M = Mature forge, molasses, and urea.

[13]ML = Less mature forage, molasses, and urea.

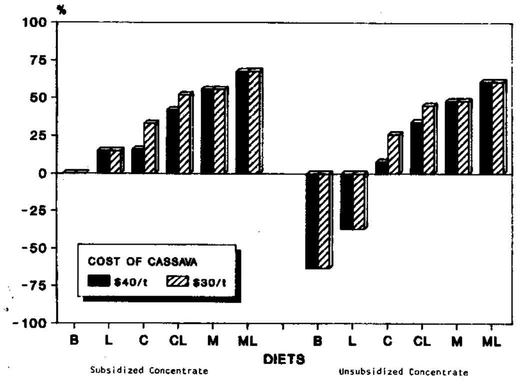

Figure 1. Percentage change in annual net margin per cow by diet for all females in the dual purpose herd averaging 10 kg milk per cow per d (farm 1). Economic scenarios include two prices for cassava and subsidized or unsubsidized commercial concentrate. Diets are mature for- ,age and commercial concentrate (baseline, B); !ess mature forage and commercial concentrate (L); mature forage, cassava, and 5:1 molasses:urea mixture (C); less mature forage, cassava, and 5:1 molasses:urea mixture (CL); mature forage, molasses, and urea (M), and less mature forage, molasses and urea (MI.).

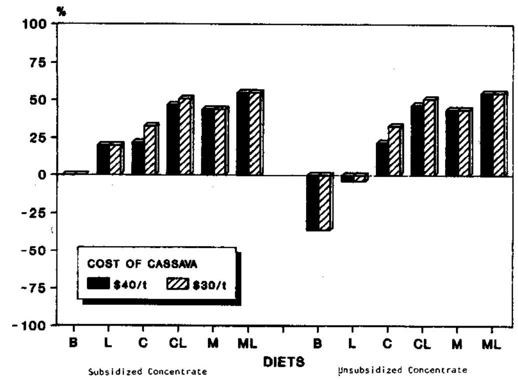

Figure 2. Percentage change in annual net margin per cow by diet for all females in the dual purpose herd averaging 7 kg milk per cow/d. Economic scenarios include two prices for cassava and subsidized or unsubsidized commercial concentrate. Diets are mature forage and commercial concentrate (baseline, B); less mature forage and commercial concentrate (L); mature forage, cassava, and 5: 1 molasses:urea mixture (C); less mature forage, cassava, and 5:1 molasses:urea mixture (CL); mature forage, molasses, and urea (M); and less mature forage, molasses, and urea (ML).

profits were reduced 37% ($49) on farm 1 and 4% ($4) on farm 2 compared with the baseline diets (Table 7, Figures I and 2).

When only milking cows received improved forage, commercial concentrate 50% more costly decreased profits 30% more on farm 1 than on farm 2 ($61 vs. $13 less profit, Table 8). Apparently, a modest increase in forage quality (Table 2) is effective either to increase profits or to buffer economic losses from more costly purchased concentrates.

Feeding Cassava. The mixture of fresh cassava, molasses, and urea replaced the commercial concentrate supplement. Farm profitability by feeding cassava increased 16% ($22 per cow/yr) on farm 1 and 22% ($22 per cow/yr) on farm 2 when concentrate price was subsidized and cassava cost $40/t (Table 7). When concentrates were 50% more costly, feeding cassava increased farm profits by 8% ($11 per cow/yr) on farm 1 and by 22% ($22 per cow/ yr) on farm 2 over the baseline diets using mature forage. If cassava could be produced for $30/t, profits on farm I would increase by 26% and on farm 2 by 33% (Table 7, Figures 1 and 2).

Profits were 4% higher ($10 per cow/yr) on farm 1 than on farm 2 ($4 per cow/yr) when cassava cost $40R and was fed only to milking cows. When cassava cost less profits were 7% greater on farm 1 than on farm 2. For both farms, economic losses were less by feeding the cassava mixture than by feeding more costly commercial concentrates (Table 8).

A diet comprising the cassava mixture and less mature forage was more profitable than diets based on mature forage, regardless of ingredient costs, which emphasized the value of improving forage quality. Annual net margins per cow reached $201 on farm 1 and $149 on farm 2 when cassava cost $30/t (Table 7, Figures 1 and 2).

Profitability generally increased on both farms from replacing commercial concentrate with high cost cassava to supplement less mature forage for milking cows. Farm 1 realized $31 and farm 2 realized $16 more profit per cow/yr when concentrate was subsidized; deviations in annual net margins were —8 and $4 when it was not (Table 8).

Feeding Molasses and Urea. Replacing subsidized commercial concentrate with molasses and urea increased farm profitability by up to

56% ($74 per cow/yr) over the baseline diet on farm 1 and up to 44% ($44 per cow/yr) on farm 2 (Table 7, Figures 1 and 2).

When farm cases were compared based only on milking cows and subsidized concentrate prices, $42 per cow/yr more profit was predicted on farm 1 and $16 per cow/yr more profit resulted on farm 2. When concentrate was more expensive, net returns from replacing concentrate with molasses and urea for milking cows were similar ($2 vs. $4 more profit, Table 8).

Supplementing less mature forage with molasses and urea was the most profitable diet for both farms. Profits on farm 1 increased by 68% ($90 per cow/yr) over the baseline diet when the price of commercial concentrate feed was subsidized and increased by 61% ($80 per cow/yr) when concentrates were 50% more expensive. Profits on farm 2 increased *55%* ($54) for either economic situation (Table 7, Figures 1 and 2). When only milking cows were supplemented, farm 1 obtained $53 per cow/yr and farm 2 obtained $23 per cow/yr more profit compared with profit from the baseline diet (Table 8).

CONCLUSIONS

Nutrition

This study showed that diets of mature forage and commercial concentrate are nutrition-

TABLE 7. Deviation in annual net margin per cow on farms representing high (farm 1) and low (farm 2) daily milk yield for the six diets with commercial concentrate prices either subsidized or unsubsidized and two alternative costs for cassava ($40 or $30/t).

	Subsidized		Unsubsidized	
Farm and diet	$40/t	$30/t	$40/t	$30/t
	($)			
Farm 1				
Diet				
B[1]	0[7]	0	–83	–83
L[2]	20	20	–49	–49
C[3]	21	44	11	34
CL[4]	55	69	45	59
M[5]	74	74	64	64
ML[6]	90	90	80	80
Farm 2				
Diet				
B	0[7]	0	–36	–36
L	20	20	–4	–4
C	22	33	22	33
CL	47	50	47	50
M	44	44	44	44
ML	54	54	54	54

[1] B = Predicted baseline diet of mature forage and commercial concentrate from the surveys of Holmann (8).

[2] L = Less mature forage and commercial concentrate.

[3] C = Mature forage, cassava and 5:1 molasses:urea mixture.

[4] CL = Less mature forage, cassava and 5:1 molasses: urea mixture.

[5] M = Mature forage, molasses and urea.

[6] ML = Less mature forage, molasses and urea.

[7] Annual net margins per cow were $132 for farm 1 and $99 for farm 2.

TABLE 8. Deviation in annual net margin per cow on farms representing high (farm 1) and low (farm 2) daily milk yield for the six diets when fed only to the milking cows with commercial concentrate prices either subsidized or unsubsidized and two alternative costs for cassava ($40 or $30/t).

	Subsidized		Unsubsidized	
Farm and diet	$40/t	$30/t	$40/t	$30/t
	($)			
Farm 1				
Diet				
B[1]	0[7]	0	–83	–83
L[2]	14	14	–61	–61
c[3]	10	24	–29	–15
CL[4]	31	41	–8	1
M[5]	42	42	2	2
ML[6]	53	53	13	13
Farm 2				
Diet				
B	0[7]	0	–28	–28
L	10	10	–13	–13
C	4	10	–9	–3
CL	16	18	4	6
M	16	16	4	4
ML	23	23	11	11

[1] B = Predicted baseline diet of mature forage and commercial concentrate from the surveys of Holmann (8).

[2] L = Less mature forage and commercial concentrate.

[3] C = Mature forage, cassava and 5:1 molasses:urea mixture.

[4] CL = Less mature forage, cassava and 5:1 molasses: urea mixture.

[5] M = Mature forage, molasses and urea.

[6] ML = Less mature forage, molasses and urea.

[7] Annual net margins per cow were $150 for farm 1 and $115 for farm 2.

ally inadequate to support daily milk yields of 7 to 10 kg in dual purpose cattle in the humid lowlands of Venezuela. Dally intake of DM, predicted to be 1.85 to 2.08% of body weight for current feeding situations, was identified as a major constraint on animal performance by restricting appetite. Alternative diets supplied at least equivalent nutrients as the baseline situations and likely would permit greater expression of appetite. Intake of less mature forage increased by 4 to 9% to replace partly current amounts of commercial concentrate feeding. Twice daily feeding of well-mixed energy supplements containing urea is recommended to restrict the risk of ammonia toxicity and to maximize utilization of the nitrogen.

Economicos

Even without an increase in the cost of commercial concentrate, producers of dual purpose cattle in western Venezuela appeared to have economic incentives to provide alternative diets. Improved forage quality was effective in increasing profits or buffering losses from higher cost of purchased feeds. Feeding cassava, molasses, and urea appear to be economical alternatives under the scenarios considered, regardless of forage quality. Even if the energy density of commercial concentrate was 85% TDN, the dietary alternatives, especially less mature forage from more intensive grazing, would be effective in increasing profits or reducing losses for the concentrate prices considered.

Although a cost was not assigned for management, alternative diets require relatively more skill than the baseline diets. These skills include 1) management of animals and pastures to increase nutrient intake from forage, 2) management of concentrated sources of soluble protein such as urea to avoid ammonia toxicity while supplying adequate N to rumen microbes, 3) meeting and managing increased labor demands to utilize cassava and to obtain less mature forage, and 4) obtaining continuous supplies of feeds that may not be consistently available (e.g., molasses).

Future Research

A needed sequel to this study would be to validate results under farm conditions. Also, although considerable research has been done to evaluate cassava as ammal feed, much of this effort has been directed to nonmminants. More research is needed to determine tractable sources of energy and protein for ruminant production using local feeds, such as protein from tree legumes to complement tropical grasses and dietary energy supplements.

Efficient utilization of local feed resources can lead to a more sustainable system (2) of livestock production. These local resources are potentially economically feasible for many dual purpose producers. Maybe more importantly, these locally produced feeds may be less influenced by changing governmental policies than are imported inputs.

Epilogue

Research results and experimental design sometimes need modification after field observation. After completing this study, cattle and farm habitats in this study were observed and nutritional issues in the tropics were reviewed in a Cornell videotape presentation (22). After viewing these tropical realities, nutritionists on our team considered that gut capacity of cows was restricted relative to frame size and body weight. This implied that the upper limit of daily NDF intake may be less than our assumption of 1.1% of body weight.

If maximum daily intake of NDF instead was 1.0% of body weight, then daily DM intake and resulting energy balance would be about 8% less than assumed for these diets (Table 6). Consequenfiy, there is need 1) to determine actual limit of NDF intake in this (and other) tropical environment(s) and 2) to estimate the residual effect of nutritional management in early life on ultimate gut capacity in adult animals. For example, if judicious nutritional formulations for growing animals would increase frame size and gut capacity as adults, then more forage intake would be predicted with less substitution of supplement for tropical forage.

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