Supplemental concentrates with four levels of crude protein for grazing Dairy Cows[1]

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ABSTRACT

Four treatments (T_1 through T_4), based on pelleted concentrates varying in as fed crude protein (CP) contents (10.8, 12.2, 13.4, and 15.3%, respectively), but theoretically isocaloric (1.67-1.70 Mcal net energy/kg), were compared for efficacy as pasture supplements. Eighteen multiparous cows began the experiment individually not later than 8 weeks postpartum. Five were assigned to T_1 and T_3 and four to T_2 and T_4. Daily concentrate allowances were according to milk production, but 4.5 kg was set as the arbitrary minimum. Nocturnal rotational grazing was in 12 0.5-ha paddocks of little fertilized, heterogeneous, gramineous swards, which fluctuated in quality from adequate to marginal during 11½ months of experimentation. Cows assigned to the four treatments in order produced 21.3 ± 3.0, 22.5 ± 4.4, 20.3 ± 2.5, and 20.4 ± 4.5 kg of milk daily during the 5 days before commencing the experiment, and 14.4 ± 1.2, 16.8 ± 3.9, 15.2 ± 2.4 and 14.2 ± 2.4 kg during the 32 weeks of experimentation. Although treatments did not differ significantly ($P>.05$) over-all, T_1 dropped in daily production by 2.7 kg during the initial 4-week interval and persistency decreased in high-producing cows; T_2 also caused a large early decline in production, but superior persistency thereafter. Mean milk fat percentages were 2.78 ± .49, 2.68 ± .44, 2.88 ± .33, and 3.17 ± .37 for T_1 through T_4. Early depression of milk fat was probably due to high concentrate and inadequate fiber intakes. Concentrate intake ranged from 5.82 kg in T_4 to 7.10 kg in T_2 over 32 weeks; milk/concentrate ratio ranged from 2.33 in T_3 to 2.45 in T_4. Only in T_1 was appreciable liveweight (20 kg) temporarily lost early in the experiment. Concentrates containing 13 to 14% CP can be tentatively recommended as supplements to pastures of adequate quality, when fed to meet energy requirements of cows producing up to at least 20 kg of milk daily.

RESUMEN

Cuatro niveles de suplementación de proteína bruta para vacas pastando

Se compararon cuatro tratamientos (T_1 al T_4), basados en concentrados aperdigonados con contenidos de proteína bruta (CP), de 10.8, 12.2, 13.4 y 15.3%, respectivamente tal como suplidos, pero teóricamente isocalóricos (1.67-1.70 Mcal, energía neta/kg), como suplementos al forraje pastorado. Las asignaciones de concentrados se basaron en la producción de leche, pero fijando un mínimo arbitrario de 4.5 kg diarios. La pacedura rotacional nocturna se efectuó en 12 predios de 0.5 ha de gramíneas heterogéneas,

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que recibieron poco abono y fluctuaron en calidad de adecuada a marginal en 11½ meses de experimentación.

Las vacas asignadas a los cuatro tratamientos produjeron, en el mismo orden, 21.3 ± 3.0, 22.5 ± 4.4, 20.3 ± 2.5 y 20.4 ± 4.5 kg diarios de leche durante los 5 días anteriores al inicio del experimento, y 14.4 ± 1.2, 16.8 ± 3.9, 15.2 ± 2.4 y 14.2 ± 2.4 kg. durante las 32 semanas experimentales. Aunque los promedios generales de producción no difirieron significativamente ($P>0.05$), las vacas de T_1 disminuyeron su producción de 2.7 kg diarios durante el primer intervalo de 4 semanas y hubo una menor persistencia en las de alta producción; en T_2 también disminuyó la producción inicial, pero posteriormente la persistencia resultó ser superior. Los porcentajes de grasa láctea arrojaron una media de 2.78 ± .49, 2.68 ± .44, 2.88 ± .33 y 3.17 ± .37 en el T_1 al T_4. Su temprana disminución se debió, probablemente, al excesivo consumo de concentrado y al bajo consumo de fibra. El consumo de concentrado varió de 5.82 kg en T_4 a 7.10 kg en T_2 durante 32 semanas; la razón de leche producida a concentrado consumido varió de 2.33 en T_3 a 2.45 en T_4. Sólo en la etapa inicial de T_1 hubo una apreciable pérdida temporera de peso vivo (20 kg). Se puede recomendar tentativamente el uso de concentrados con 13 a 14% de CP para suplementar animales que pastan forrajes de calidad adecuada si se les suministran las cantidades adecuadas para cubrir los requisitos de energía de vacas que producen diariamente hasta 20 kg de leche.

INTRODUCTION

The availability of concentrates of relatively low cost compared with high prices received for milk sold has resulted in heavy use of this convenient feed resource in nearly all the dairy herds of Puerto Rico (8). Efforts to induce dairy farmers to make greater use of high-quality pastures and reduce their dependency on imported concentrates have met with little success, in spite of experimental evidence demonstrating the feasibility of this alternative (17). Since this situation is likely to continue in the foreseeable future, research directed toward more efficient and less expensive formulation of concentrate feeds, adapted to local conditions, is well justified in economic terms.

Protein supplements are the most expensive macro-ingredients used in commercial concentrates. Controlled experiments to better define the protein levels genuinely needed to supplement grazing cows might save feed costs by adjusting protein contents downward. Previous short-term experiments at the Lajas Substation have suggested the feasibility of such adjustments (4, 13). The present study was planned to test over a longer period concentrates of simple formulas and essentially constant theoretical net energy contents, but with 4 different levels of CP: one undoubtedly adequate (17.5%, on the as fed basis), one expected to be suboptimal (10%) and two evenly spaced intermediates (12.5 and 15%). The objective was to determine the level above which additional CP in the concentrate produces no further improvement in animal performance.

MATERIALS AND METHODS

The experiment included 18 multiparous cows, 16 Holstein and 2 Brown Swiss, beginning not later than 8 weeks postpartum. The genital tracts of cows were examined by rectal palpation and those pronounced normal were incorporated into both the present study and another compatible experiment in which estrus synchronization was tested (3). A surgically modified heat detector bull was kept with the cows at pasture and while resting under shade during most of the first 9 months of observation, as required by the reproductive experiment.

Treatments compared in the feeding experiment consisted of supplementation with four different pelleted concentrate mixtures prepared in the mill facilities of the Lajas substation (table 1). These were formulated to be essentially isocaloric, on the basis of tabular values of NRC (12), and to increase in CP content by increments of approximately 2.5%, from 10% to 17.5%, in T_1 through T_4. Daily concentrate allowances were calculated at 4-week intervals according to the formula: (daily milk production −5) ÷ 2. However, a minimum allowance was arbitrarily set at 4.5 kg Thus the above formula became inoperative at daily productions below 14 kg. This minimum supplementation was deemed necessary to maintain reasonable production in all cows, since adequate grazing conditions could not be guaranteed at all times.

The experiment was a complete randomized design with 5, 4, 5 and 4 cows assigned to T_1 through T_4. The first 15 cows began the experiment from late November 1986 to mid February 1987; thereafter, the last 3 cows became available more slowly until the group was completed in early April 1987. All but one of the 18 cows were 5 to 8 weeks postpartum upon beginning the experiment. The lone exception (assigned to T_3) was at an earlier stage of lactation. Each cow received her experimental concentrate feed for 32 weeks. Eleven received hormonal treatment for synchronization of estrus one or more times during the said period, including 4, 2, 3 and 2 cows in T_1 through T_4 (3).

TABLE 1.—*Percentage formulas, crude protein and net energy contents*[1] *of the four concentrates*

	Treatment			
Ingredient or component (%)	T_1	T_2	T_3	T_4
Ground maize	65.5	60.5	55.4	50.3
Wheat middlings	23.0	21.2	19.5	17.7
Soybean meal	0	6.8	13.6	20.5
Cane molasses	10.0	10.0	10.0	10.0
Salt	1.0	1.0	1.0	1.0
Dicalcium phosphate	0.5	0.5	0.5	0.5
Theoretical net energy (Mcal/kg)	1.70	1.69	1.68	1.67
Theoretical crude protein (%)	10.0	12.4	14.8	17.5
Analyzed crude protein (%)	10.8	12.2	13.4	15.3

[1]Expressed as fed basis.

Concentrates were fed individually while the cows were confined to stanchions in a shade barn, from about 10:30 am to 1 pm daily. Concentrate refusals were recovered and small amounts (less than 0.5 kg) were added to the next day's offering, whereas occasional larger quantities were subtracted from that offered to determine intake. During the remaining hours between the two daily milkings the animals rested in shaded areas nearby with only water available. Following milking at 2:30-3:00 pm they returned to pasture for approximately 13-14 hours until first milking of the following day.

A 6-ha pasture area, divided into 12 contiguous rectangular 0.5-ha paddocks was grazed by 18 or 19 animals (3 or 3.167/ha stocking rate) for a 24-day cycle. The lower numbers applied during the initial and final months of the experiment. When fewer than 17 or 18 experimental cows were participating, the balance of the animals needed to complete the group (excluding the lone male) were either the same cows before or after their 32 experimental weeks, or other lactating members of the herd.

Only paddock 1 (nearest the barn) supported a relatively pure stand of stargrass (*Cynodon nlemfluensis*), the others had mixed gramineous swards, with generally decreasing proportions of stargrass and increasing amounts of pajongrass (*Andropongon annulatus*), until the latter predominated in paddocks 9 through 12. Paragrass (*Brachiaria mutica*) was present in a low-lying strip of variable width that crossed the long axis of the pasture area. This strip received irrigation unintentionally because of leakage from nearby ditches, and tended to remain green during drought. Spot infestation with the gramineous weeds "cortadera" (*Paspalum millegrana*) and "matojo" (*Sporobolus indicus*) was common, but broadleaf weeds were a problem only in paddock 8, where hand cutting was used sporadically to combat these weeds. The whole area was machine clipped once early in the experiment. These pastures had received only a light fertilization for several months before commencing this study and not until September 1987 was another 135 kg of 15-5-10 fertilizer applied to each paddock, by which time most of the cows had completed their 32 experimental weeks. Thus, conditions of little fertilization generally prevailed.

The experiment began with well rested pastures and abundant soil moisture, as 161 mm of rain fell in November 1986. Moderate precipitation of 33 mm in December, 62 mm in January and 60 mm during the first half of February was sufficient to maintain a good herbage supply. A dry spell lasted from mid February until mid May, during which time rainfall totaled only 50 mm. By mid April an accumulative effect of the grazing pressure was evident in reduced height of the sward. Three times in late March and early April flood irrigation of the pastures was attempted, but with the ditches in an imperfect state of repair, water was distributed unequally. Abundant rains fell during the latter half of May (116 mm), but the corresponding increase in herbage availability lagged for some time. June was also favorable in rainfall (158 mm), but precipitation was suboptimal in July, August and early September (46 mm total) and herbage productivity declined once more. Finally, during the last 2 months of experimentation rain was plentiful (306 mm) and the sward recuperated. Clearly, grazing conditions fluctuated greatly over the course of the experiment.

Beginning in January, when the 12th cow began the experiment, until September, pasture herbage was sampled 45 times. This process sought to provide quantitative estimates of vegetative material available. At each sampling, 24 hours or less before grazing, herbage in 5 widely dispersed and randomly selected 1 m^2 plots per paddock was hand cut, weighed, and incorporated into a compositie sample to be oven dried at 60° C for dry matter (DM) determination. Six samples, one from each of the even numbered paddocks, taken in January and February, were analyzed for CP (14), ash (2), and fibrous fractions (7). Six samples of each of the four concentrates, accumulated over several weeks, were analyzed for CP content.

An aliquot of the milk from two consecutive milkings of each cow was obtained once per 4-week interval for determination of fat content by the Babock procedure (2). Every 4 weeks each cow was weighed once after morning milking. The data were submitted to a single factor analysis of variance (15).

RESULTS AND DISCUSSION

Analyzed CP contents of T_1 and T_2 concentrates agreed reasonably well with the theoretical values of 10% and 12.5% as fed, whereas those of T_3 and T_4 showed increasing discrepancies relative to the intended 15% and 17.5%, respectively (table 1). Means and standard deviations of this variable on a DM basis were 12.1 ± 0.7, 13.6 ± 0.3, 15.0 ± 1.2, and 17.1 ± 1.3% for T_1 through T_4 in that order. The use of different lots of ingredients and mixing these feeds on many different dates over nearly 12 months of experimentation were unavoidable disadvantages, which increased this variability. The assumption used as to CP content of soybean meal (48% as fed) may have been too high during much of the experiment, and this would have progressively reduced the real CP contents of concentrates in T_2, T_3 and T_4 (but not in T_1), according to the proportion of this ingredient in the formulas (table 1). Conversely, it was difficult to incorporate the full 10% of molasses in these mixtures, and inclusion of a lower level on some occasions increased analyzed CP values relative to the theoretical. Mean contents of chemical fractions observed in the pasture herbage DM were CP, 8.6 ± 2.3; ash, 11.3 ± 1.2; neutral detergent fiber, 75.0 ± 2.6; acid detergent fiber, 36.1 ± 4.6; hemicellulose, 39.0 ± 3.4; lignin, 6.6 ± 0.9%.

Mean milk production of all 18 cows during the 5 days immediately before commencing their participation in the experiment was 21.1 kg daily (table 2). The groups destined to T_3 and T_4 had similar means that were inferior to those of T_1 and T_2 cows by approximately 1 and 2.2 kg, respectively. Within-group variability was less for T_1 and T_3 than for T_2 and T_4. Regression coefficients relating daily milk production during the experiment to the same variable during the 5-day preliminary period differed markedly among treatments, from 0.32 kg for T_1 to 0.92 kg for T_3. T_2 also gave a high coefficient (0.88 kg), whereas that of T_4 was surprisingly low (0.51 kg). These regressions indicate that cows of higher initial milk yield maintained their advantage better in T_2 and T_3 than in T_1 and T_4. Since the variability among individual treatment regressions was significant ($P<.05$), use of a common regression was rendered null and the possibility of submitting the milk production data to the corresponding covariance analysis was precluded (15).

Milk production during 32 weeks of experimentation was highest in T_2 and lowest in T_4, similar to preliminary period standings; T_3 improved its relative position, whereas T_1 declined in mean standing and also in within-group variability (table 2). This tendency was also evident in T_4. Treatments did not constitute a significant source of variance in milk yield ($P>.05$). The ratio of experimental period production/preliminary period production, used as an index of lactational persistency, gave the mean result 0.75 for both T_2 and T_3, compared with lower values of 0.68 and 0.70 for T_1 and T_4, respectively (table 2).

The low-protein concentrate fed in T_1 was expected to adversely affect lactation, but there is no evident explanation for the negative effect of T_4. The poor results obtained with the cows in T_4 can probably be

TABLE 2.—*Mean daily milk production during the preliminary and experimental periods, index of lactational persistency and milk fat content*

Treatment	Milk production			Experimental period milk fat
	Preliminary	Experimental	Persistency[1]	
	kg	*kg*		%
T_1	21.32 ± 2.99[2]	14.43 ± 1.20	0.68	2.78 ± 0.49
T_2	22.53 ± 4.42	16.81 ± 3.91	0.75	2.68 ± 0.44
T_3	20.33 ± 2.48	15.17 ± 2.36	0.75	2.88 ± 0.33
T_4	20.37 ± 4.54	14.25 ± 2.44	0.70	3.17 ± 0.37
Total	21.10 ± 3.38	15.12 ± 2.53	0.72	2.87 ± 0.41

[1]Ratio of experimental period to preliminary period milk production.
[2]Standard deviation.

ascribed to random effects of assignment of cows to treatments. With only 4 animals in T_4 random differences could easily have been important. A comparison of milk production in T_1 vs T_2, T_3 and T_4 combined gives respective means of 14.43 and 15.41 kg daily. This 0.98-kg difference represents a reduction in milk production of 6.4% ascribable to restricted protein intake in T_1, although the statistical validity of this effect was not established by the present limited data. If results with T_4 are excluded as possibly atypical, the comparison of T_1 vs T_2 and T_3 shows mean daily productions of 14.43 and 15.99 kg, representing a difference of 1.56 kg or 9.8%. By either estimate no more than 10% of expected production was lost because of protein restriction.

Milk production data during successive 4-week intervals of experimentation (table 3) show that the adverse effect of T_1 was limited mostly to the first 4 weeks. Mean production by T_1 cows of 18.60 kg during this interval was 2.72 kg below that of the 5-day preliminary period. Thereafter milk yield in T_1 declined to 10.05 kg daily during the final 4 weeks, a total reduction of 8.55 kg in 7 successive steps or 1.22 kg per 4-week interval. Cows of T_2, T_3 and T_4 produced respectively 2.19, 0.36 and 1.24 kg less during the first 4 weeks than during the

TABLE 3.—*Daily milk production and concentrate intake during successive 4-week intervals, milk fat content and liveweight determined once per interval*

Weeks of experiment	Treatment				Treatment			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
	Milk production (kg)				*Liveweight (kg)*			
0[1]	21.3	22.5	20.3	20.4	560	523	545	544
4	18.6	20.3	20.0	19.1	549	519	541	553
8	17.4	18.4	18.5	17.5	549	532	538	549
12	16.6	18.4	16.8	16.0	540	526	547	551
16	15.2	17.2	15.8	14.2	549	523	552	544
20	14.1	16.3	14.4	13.5	550	516	553	554
24	12.1	16.0	13.6	12.7	564	548	552	562
28	11.3	14.8	11.7	11.4	565	553	566	572
32	10.0	13.0	10.6	9.6	568	563	574	579
	Concentrate intake (kg)				*Milk fat (%)*			
4	8.05	8.57	8.34	7.65	2.68	2.08	2.46	2.66
8	7.58	8.43	8.10	7.24	2.03	2.06	2.50	2.94
12	6.86	8.02	7.22	6.68	2.67	2.30	2.40	2.95
16	6.30	7.51	6.68	5.76	2.59	2.52	2.70	3.15
20	5.84	6.84	6.01	5.30	2.99	2.78	3.06	3.38
24	4.96	6.15	5.80	4.70	3.12	3.04	3.29	3.55
28	4.54	5.74	5.17	4.70	3.42	3.10	3.50	3.70
32	4.50	5.52	4.68	4.52	3.42	2.98	3.93	3.67

[1]Preliminary period of 5 days.

preliminary period. Thus, T_2 also had an appreciable negative effect upon first exposure of the animals. However, during the remaining 28 weeks the cows in this treatment compensated for the previous decline with greater persistency, losing 1.05 kg per 4-week interval, compared with 1.34 and 1.36 kg in T_3 and T_4, respectively.

Before the experiment these animals had been receiving the regular herd concentrate with at least 16% CP in the DM. Two factors may have contributed to adverse effects of the lower protein concentrates of T_1 during the first 4-week interval: first, protein restriction had a greater impact at higher levels of production; second, gradual adjustment to the lower protein rations was needed. Ruminant animals can save scarce dietary nitrogen, once adjusted to low intakes, especially if digestible energy is not limiting, by several physiological adjustments, including recycling urea back to the rumen for microbial protein synthesis (16). Earlier introduction of the lower protein concentrates might have permitted such adjustments before peak production, but this is a matter of speculation. Observations beginning in earliest lactation or even before parturition, would shed light on this question.

In a Cuban study, Holstein cows in early lactation grazing coastcross bermudagrass (*Cynodon dactylon*) at a stocking rate of 3.5/ha and supplemented with 6 kg of concentrates daily, produced significantly more milk (16.9 vs 16.3 kg daily) when the supplement contained 18% rather than 16% CP (5). However, the former was also higher in metabolizable energy (13.3 vs 11.6 MJ/kg DM). Thus the specific effect of protein level could not be ascertained. At any rate, the relative difference in production between treatments was only 4%.

Table 4 presents theoretical calculations of CP required and CP consumed by cows in the four treatments under the mean conditions of this experiment. A liveweight (LW) of 550 kg was used in accounting for maintenance needs, and protein required per unit of milk produced was

TABLE 4.—*Theoretical estimates of daily dry matter intake from pasture herbage required to satisfy that part of the crude protein requirement not supplied by concentrates*

Treatment	Crude protein requirement[1]			Crude protein intake		Herbage DM intake[2]	
	Maintenance	Milk production	Total	From concentrate	From pasture	Total	Relative to liveweight
	g	*g*	*g*	*g*	*g*	*kg*	%
T_1	461	1082	1543	657	886	10.30	1.87
T_2	461	1244	1705	866	839	9.76	1.77
T_3	461	1153	1614	871	743	8.64	1.57
T_4	461	1126	1587	890	697	8.10	1.47

[1]According to NRC (12).

[2]Assuming 8.6% crude protein in the dry matter.

assumed to vary with milk fat percentage (12). The mean of 8.6% CP found in the pasture herbage agrees with past experience (1, 4). This figure, which applies to the total DM on offer, was used with no attempt to take selective grazing into account. The capacity to consume forage would logically have increased with time as intake of concentrates declined; however, averaging over-all, cows in T_1 would have had to ingest 10.3 kg of herbage DM daily, equivalent to 1.87% of LW, to obtain the necessary 886 g of CP not supplied by the concentrate. This estimate is reasonable for a ration also including 6.08 kg of concentrate (table 5), equivalent to 5.43 kg of DM (approximately 1% of LW daily) (6). Estimated pasture herbage intakes required to complete the CP requirements of cows in T_2, T_3 and T_4 are progressively lower (table 4). Thus, all of these rations should have supplied adequate CP over-all. A deficiency is postulated for T_1 and less so for T_2 only during the early weeks of experimentation.

Based on 43 of 45 pasture samplings (data from 2 partially lost), mean availability of green herbage per 0.5 ha paddock was 2.46 metric tons and herbage DM content 35.2%. The latter figure indicates the presence of much dead vegetative matter in lower strata of the sward. Based on 36 or 38 animal-days per paddock per grazing over the experiment, herbage DM available was estimated as 22 ± 11 kg per animal-day. This high variability (C.V. 50%) is not surprising. Individual samplings based on only 5 sub-samples per 0.5-ha paddock of heterogeneous herbage are not very reliable, but the pooled data permit following the general trend with time and provide a mean estimate of herbage DM available equivalent to 4 kg per 100 kg of LW daily. Accordingly, the animals could consume DM at the rate of 2% of LW by ingesting half of the herbage on offer. This would permit selective grazing. Variations over seasons and among different paddocks were undoubtedly important, but these could not be quantified from the limited data available. However, the trends observed toward less height of the sward and lower DM availability with time indicate that the grazing pressure used was not sustainable under these conditions of little fertilization and periodically inadequate soil moisture.

TABLE 5.—*Mean daily intake of concentrates, ratio of milk produced to concentrate consumed and mean liveweight*

Treatment	Concentrate intake	Milk/concentrate	Liveweight
	kg		*kg*
T_1	6.08	2.37	554
T_2	7.10	2.37	535
T_3	6.50	2.33	553
T_4	5.82	2.45	558
Total	6.38	2.38	550

Mean milk fat content over 32 weeks was below the legal minimum of 3% in all except T_4 (table 2). Depressed milk fat was observed early in the experiment in most of the cows, but this condition improved with advancing lactation as milk production declined (table 3). An inverse relationship between milk yield and milk fat percentage is normal (11). Also, with time forage intake should have increased in absolute terms and the ratio of forage to concentrate consumed certainly became wider. Protein intake may have been an additional factor. Investigators in North Carolina (9) compared concentrates containing 13 vs 23% CP in conjunction with widely different concentrate: forage ratios, using alfalfa-grass mixed hay, and found a significant effect of the high-protein concentrate in mitigating milk fat depression when the diet was low in fiber, especially in primiparous cows, whereas little effect was seen with the high-fiber diet. A subsequent similar study (10) confirmed the effect of a high-protein concentrate, fed with a low proportion of hay, on milk fat content, but also showed that a high level of body condition in early lactation tends to counteract this effect. In the present study, with a more limited range of CP percentages in the concentrates, treatments did not significantly affect milk fat; the same general trend was noted, however, toward increased milk fat with higher concentrate CP, especially during the early stages (table 3). Possibly, the quantity of protein supplied by concentrates affected consumption and/or digestibility of the pasture herbage.

The vast majority of all concentrate offerings were consumed; thus mean intakes per treatment varied directly with milk production (tables 2 and 5). The ratio of milk produced to concentrate consumed (partial feed efficiency) varied little among treatments, highest in T_4 and lowest in T_3 (table 5). Variability in feed conversion efficiency was mostly a function of the method of allotting concentrates rather than an effect of the treatments. At any rate, the over-all ratio of 2.38 represents better efficiency in the use of concentrates than usually prevails on local commercial dairy farms (8).

Mean LW over the experiment was nearly alike in T_1, T_3 and T_4, whereas T_2 cows were about 20 kg lighter (table 5). Only in T_1, was any appreciable LW loss recorded during the early stages (20 kg), but this had been recovered by the 24th experimental week (table 3). Cows of T_2, T_3 and T_4 showed over-all LW increments of 40, 29 and 35 kg, respectively, vs only 8 kg for T_1. This difference might be another reflection of protein supply.

Cows of T_2 and T_3 were free of clinical mastitis during the experiment; two cows of T_1 were affected briefly and one cow of T_4 was affected on two separate occasions. Two abortions occurred, one each in T_1 and T_3, but the cows in question were rebred and all 18 animals had a subsequent calving in the herd, following mean intervals of 464, 438, 430, and 438 days in T_1 through T_4. The mean number of inseminations required to achieve subsequent calving was 3.6, 3.0, 2.8 and 3.25, respectively. Three T_4 cows conceived at first service and had calving intervals of less than 365 days, but the 4th member of this group was a very slow breeder (718-day calving interval and 10 inseminations required) and markedly affected the treatment means. These data provide a slight indication that protein restriction in T_1 could have adversely affected reproductive efficiency (possibly as a result of the transient loss of body condition), but these limited data do not permit a meaningful assessment of this relationship.

The present results need confirmation, but if upheld by further experimentation they could have important practical implications. Under conditions of liberal (not extreme) concentrate supplementation for cows averaging 21 kg of milk per day initially and grazing generally adequate but sometimes marginal swards, the 10.8 and 12.2% CP (as fed) concentrates of T_1 and T_2 showed signs of adversely affecting lactational performances only during the early weeks when production was highest, relative to the results obtained with 13.4 and 15.3% CP concentrates of T_3 and T_4. In a previous study of similar procedure but shorter duration, liberally fed 13% CP concentrates (either bulky or of conventional type) appeared adequate as supplements for grazing cows of similar productive capacity but of later initial stage of lactation, relative to the present case, although concentrates of different CP percentages were not included for comparison (13).

Since most dairy farmers in Puerto Rico feed concentrates containing at least 16% and often 18% CP, even for cows grazing pastures better than those of the present experiment, it can be tentatively concluded that over-feeding of protein is a common practice. A saving in feed costs could be realized by using concentrates with lower CP contents, when grazing conditions are reasonably favorable and sufficient concentrate is fed to meet energy requirements. It should be stressed that this conclusion applies specifically to grazing situations and should not be extrapolated to rations based on harvested forages without verification by controlled experimentation.

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