Value of Supplementary Feeding with Pelleted Maize or Grass Hay for Lactating Cows Grazing Fertilized Grass Pastures in Puerto Rico[1]

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ABSTRACT

Forty-eight lactating Holstein cows were randomly distributed on four treatments at the Gurabo Substation: T_8, grazing; T_9, grazing + 2.3 kg per day of dehydrated, whole-plant maize (*Zea mays*) pellets; T_{10}, grazing + 2.3 kg per day of Stargrass (*Cynodon nlemfuensis*) hay; and T_{11}, drylot feeding of Stargrass hay + 4.5 kg per day of pelleted maize, to evaluate preserved forages in terms of variations in pasture quality. Grazing was at the rate of five cows per ha. Cows in all groups received concentrates at the rate of one unit of concentrate to two units of milk. The cows started on the treatments at 45 days postpartum.

Analysis by covariance showed significant treatment effects in milk yield with pretrial production as the covariate. The adjusted means for daily milk yield over an 8-week period were 23.2, 23.8, 23.1 and 23.1 kg for T_8, T_9, T_{10} and T_{11}, respectively. Treatment effects were not significant for either fat percent or body weight gain.

Cows fed hay, pellets and concentrates (T_{11}) equaled those on grazing plus concentrates (T_8) in milk yield, but cows on grazing supplemented with concentrates and pelleted forages (T_9) were significantly higher in milk yield. Cows on grazing supplemented with hay and concentrates (T_{10}) were significantly lower in milk yield. The study showed that good quality pelleted forages may be used effectively in combination with pasture of hay. However, tropical grasses, cut at 45 to 55 days of age and artificially dried, have limitations in nutritive value and palatability for use in conjunction with good quality pastures.

INTRODUCTION

Previous experiments in Puerto Rico have shown that Holstein cows will average 2,700 to 3,400 kg of milk per lactation when grazing heavily fertilized grass pastures at the rate of 2.5 cows per ha (1, 3, 4, 12). When supplemented with molasses, urea-molasses, corn or concentrates, milk yields may be increased to 3,600–5,450 kg (3, 4, 12). High yields may be obtained (5,500 kg) when cows are grazed at the rate of five cows per ha with high concentrate feeding, 1:2 (12). It was also found that the intake

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of total digestible nutrients (TDN) from pasture averaged about 1.8 times maintenance needs (range 1.4 to 2.3) due to changes in pasture quality. Limitations in pasture quality were attributed to dry matter (DM) and crude protein (CP) (4). This may be the case for tropical grass pastures. Thomas et al. (10) found that, with maize silage moisture per se did not necessarily limit DM intake, but other factors correlated to percent DM had an effect. Independent of the causes for variation in pasture intake, a high level of concentrate feeding would be required to insure energy needs of 2.8 to 3.0 times the maintenance requirements recommended for high milk yields (6).

The present study is a continuation of a series of experiments begun in 1969 at the Gurabo Substation on feeding systems for lactating cows utilizing tropical grass pastures. The objective was to explore the feasibility of using preserved forages to compensate for variations in pasture quality. Dehydrated pellets made from whole-plant maize (*Zea mays*) or Coastal Bermudagrass (*Cynodon dactylon*) are being imported by dairymen in Puerto Rico. Production of forage sorghums for dehydration appears practical, particularly under irrigation on the south coast of the island (9). Commercial hay production is rapidly expanding in Puerto Rico, but there are no guidelines on how hay or pelleted forages may be used to supplement pasture or to replace concentrate feeding for lactating cows.

MATERIALS AND METHODS

This study was conducted at the Gurabo Substation. The type of pastures, climatic conditions and herd management procedures were described in an earlier report (4).

There were four feeding regimes designated as follows: T_8, grazing; T_9, grazing + 2.3 kg per day of dehydrated whole-plant maize pellets; T_{10}, grazing + 2.3 kg per day of Stargrass (*Cynodon nlemfuensis*) hay; T_{11}, Stargrass hay *ad libitum* + 4.5 kg per day of the maize pellets.

All cows were fed 1 kg of concentrate mix (20% crude protein, 72.5% TDN) per 2 kg of milk. Cows on T_8, T_9 and T_{10} were grazed on the same pastures at the rate of five cows per ha. Salt and a mineral supplement were available to all groups. Cows in second or later lactation were assigned to a treatment at 45 days postpartum. Two weeks were allowed for adjustment to the experimental regimes. The test period was from the eighth to sixteenth weeks of lactation.

Milk yields were recorded twice daily, while fat percentages and body weights were recorded the last day of each week. Concentrates were fed individually to all cows just prior to the a.m. and p.m. milkings. Level of concentrate feeding was adjusted according to milk yield at 10-day intervals.

The Stargrass hay was harvested at 45- to 55-day intervals from fields fertilized with a 15-5-10 analysis after each harvest (calculated rate of 5 tons per ha per year). A few hours after harvest, the grass was dried in a forced hot air dryer to 15–18% moisture. The hay was baled and stored until time of feeding. Cows on T_{10} were individually fed the 2.3 kg of hay following the a.m. milking.

Cows on T_{11}, were confined to a dry lot adjacent to the milking parlor and allowed to consume Stargrass hay ad libitum. The hay was group-fed and offered at 10 to 15% above consumption. Refused hay was removed once daily.

Pellets for T_9 and T_{11} were 1.0 cm in diameter and 2.5 cm in length, made from dehydrated whole plant maize. The pellets were a commercial feed produced by Glenelg Dehydrators. Cows on T_9 received their pellets individually following the a.m. milking before returning to pasture. T_{11} cows were individually fed 2.3 kg of pellets after both a.m. and p.m. milkings prior to returning to the dry lot for hay feeding.

Samples of the hay, hay orts, pellets, and concentrates offered were obtained weekly from composites of daily grab samples. Pastures were sampled just before grazing by clippings from numerous locations made to a height expected after 7 days of grazing. All samples were analyzed for CP content with a Technicon microanalyzer by the method modified by Riera and Rivera-Núñez (7). Neutral-detergent fiber (NDF), acid-detergent fiber (ADF), permanganate lignin (L), silica and estimated digestibility were determined by the methods of Goering and Van Soest (2).

The basic model used to estimate treatment effects on milk yield, body weight gain and fat percent was:

$$Y_{ijkl} = \mu + T_i + C_{ij} + W_k + TW_{ik} + e_{ijkl}$$

where:

Y_{ijkl} =the l^{th} observation measured on the j^{th} cow of the i^{th} treatment in the k^{th} week of lactation;

μ =effect common to all records;

T_i =effect due to i^{th} treatment, $i = 1$ to 4;

C_{ij} =effect due to j^{th} cow nested in the i^{th} treatment, $j = 1$ to 12;

W_k =effect due to the k^{th} week of lactation, $k = 8$ to 17;

TW_{ik} =interaction effect between the i^{th} treatment and k^{th} week of lactation; and

e_{ijkl} =random effect associated with the l^{th} observation measured on the j^{th} cow of the i^{th} treatment in the k^{th} week of lactation with mean zero and variance σ^2.

All components of variance, except e, were assumed fixed. Scheffe's method (8) was used for multiple comparison of class means when the F-test was significant in order to minimize Type I errors (11).

RESULTS AND DISCUSSION

Cows on T_9 and T_{11} relished the maize pellets, but acceptance of hay by T_{11} cows varied. The quantity of hay consumed by T_{10} cows varied inversely with the quality of the pasture; i.e., more hay was consumed when the cows went on to fresh pasture than at the end of the 7-day cycle.

Treatment effects were not significant for milk yield (table 1) because variation due to cows nested within treatments was large (table 2). However, treatment effects were significant for milk yield in an analysis of covariance where the same model was used as for variance with the cow component eliminated and substituting pretrial average daily milk yield (30–39th day of lactation) as the covariate (table 3). Treatment effects were significant for the X's, indicating that assignments of cows to treatment groups according to previous production was not balanced as planned; therefore, the adjusted means for treatments were slightly distorted because they attempted to compare treatments with the same average initial milk yield.

Variation due to weeks or stage of lactation and interaction between treatments and stage were significant (table 2). Interaction significance is explained by T_9 cows, which were most persistent in milk yield (table 1). It may be that T_9 cows had a more consistent quality of total feed supply; therefore, changes in pasture quality influenced production less than for T_8 and the palatability of the hay restricted consumption by T_{10} cows. From these observations, variation in daily milk yield (standard deviation) should have been less for T_9 cows, but the opposite may be the case (table 1).

From covariance analyses, with estimated digestibility of pasture, NDF, ADF, L/ADF ratio, and CP as covariates, the regression coefficients for milk yield were significant only for T_9 (table 4). When similar analyses were performed for hay quality, only CP showed significant regression for T_{10} and T_{11}. Estimated digestibility and NDF also had significant regression on milk yield of T_{11} cows (table 4). For the measures of quality in both hay and pasture, the differences between adjusted means, as determined by covariance analyses, were all significant. The differences between slopes were also significant for digestibility, CP, NDF and L/ADF ratio. The slopes of the regressions of milk production on pasture digestibility NDF, ADF, and CP were −.58, .53, 1.04, and −.36, respectively, for T_9. These slopes were all significantly different from zero and all opposite from the other treatments and opposite from expectations for this treatment.

TABLE 1.—*Means and standard deviations for daily milk yield (kg) by weeks and treatment*

Treatment Codes	No. Cows	Weeks								Treatment Mean[1]
		1	2	3	4	5	6	7	8	
T_8	11	25.0[2]	25.1	24.3	23.2	22.3	22.2	21.7	20.9	23.2
		(4.5)[3]	(5.0)	(4.9)	(4.3)	(3.8)	(4.2)	(4.2)	(4.0)	(4.6)
T_9	11	25.2	25.2	24.5	24.6	23.5	23.3	22.2	22.3	23.8
		(4.4)	(4.7)	(4.4)	(4.5)	(4.5)	(5.1)	(4.9)	(4.6)	(4.8)
T_{10}	11	25.4	24.5	23.8	23.0	22.5	22.6	21.7	21.3	23.1
		(3.5)	(3.3)	(3.8)	(2.9)	(3.6)	(3.0)	(2.8)	(3.0)	(3.5)
T_{11}	12	25.7	25.5	24.6	23.8	23.0	22.0	22.3	21.5	23.6
		(4.6)	(4.3)	(4.0)	(4.2)	(4.2)	(4.1)	(3.9)	(3.9)	(4.4)
Mean[4]		25.1_{u}	24.9_{uv}	24.1_{vw}	23.5_{wx}	22.7_{xy}	22.3_{y}	21.7_{yz}	21.3_{z}	
		(6.2)	(7.1)	(9.4)	(9.7)	(12.2)	(12.8)	(14.1)	(14.8)	

[1] Treatment means do not differ significantly.

[2] Scheffe's estimates for significant differences among subclass means, 3.0 kg.

[3] Standard deviation.

[4] Values in the same row with differing subscripts are significantly different $P < .05$.

CP intake may have limited milk yield of T_{11} cows because the regression of milk yield on the hay CP was significant (table 4). Mean hay and pellet CP were 8.47 and 8.54 percent, respectively. Although concentrate feeding at the rate of 1:2 should have provided nearly all of the CP requirements recommended by the National Research Council (5), the cows on grazing (T_8, T_9 and T_{10}) no doubt had higher intakes of CP. Mean CP for pasture was 14.7 percent. Maintenance requirements of the T_{11} group were probably lower than for the other groups because the dry lot regime for this group required little walking, whereas the other groups walked 3.2 km or more per day to and from pasture.

TABLE 2.—*Mean squares, F-values and tests of significance for milk yield*

Source	Degrees of freedom	Mean squares	F-values
Mean	1		
Treatment (T)	3	379.7	.09
Cow	41	4204.6	329.59[1]
Stage of lactation (S)	7	2964.3	232.36
T × S	21	49.8	3.90
Residual	2363	12.8	

[1] Significant at the 1% level.

TABLE 3.—*Covariance adjusted treatment means for milk yield*[1]

Treatment code	Milk[2] yield ($\bar{Y}_i$)	Constant[3] (b)	Milk[4] yield ($\bar{X}_{i.}$)	Milk[5] yield ($\bar{X}_{..}$)	Adjusted[6] milk yield (T_i)
	Kg		*Kg*	*Kg*	*Kg*
T_8	23.14	(.7225)	25.85	26.29	23.45y
T_9	23.84	(.7225)	25.97	29.29	24.06x
T_{10}	23.12	(.7225)	26.42	26.29	23.03z
T_{11}	23.60	(.7225)	26.87	26.29	23.19yz

[1] Adjusted treatment means for $T_i = \bar{Y}_i - b(\bar{X}_{i.} - \bar{X}_{..})$, i = 1 to 4.

[2] Average daily yield for 8-week treatment period.

[3] Residual $\Sigma X^2/\Sigma XY$.

[4] Average daily milk yield for 30 to 39th day of lactation.

[5] Average daily yield for all cows 30 to 39th day of lactation.

[6] Adjusted means with differing subscripts are significantly different $P < .05$.

The T_{10} cows averaged significantly above the other groups in fat percentage (table 5). Differences among treatments were unexpected as all groups had ample opportunity for high intakes of forages. Treatment, cow, and stage of lactation effects were not significant for body weight gain.

CONCLUSIONS

The addition of pelleted whole plant maize significantly increased milk yield over grazing with concentrates as the only supplement, but the

TABLE 4.—*F-values and tests of significance of milk yield regression on various chemical components of feeds*

Treatment codes	EAD[1]		NDF		ADF		L/ADF		CP	
	Pasture	Hay	Pasture	Hay	Pasture	Hay	Pasture	Hay	Pasture	Hay
T_8	.00		.39		2.05		.00		.02	
T_9	25.98**[2]		15.54**		27.38**		10.91**		6.68**	
T_{10}	.25	.50	2.20	.01	.10	.31	.02	.24	.17	4.62*[3]
T_{11}		4.68**		5.06*		.04		1.12		96.70**
Slopes[4]	9.61**	1.69	3.67*	3.71	.02	.02	4.33*	.19	2.50	77.27**
Means[5]	5.05**	7.59**	5.59**	6.92**	4.83*	4.83*	5.42**	5.83*	5.39**	36.18**

[1] EAD, estimated apparent digestibility; NDF, neutral-detergent fiber; ADF, acid-detergent fiber; L, permanganate lignin; CP, crude protein.

[2] Significant at the 1% level.

[3] Significant at the 5% level.

[4] Difference between slopes as determined by covariances analysis.

[5] Differences between adjusted means as determined by covariance analysis.

response to supplementary feeding with hay was less than expected. The reason for the differences in the utilization of the additional forages appears related to fill and dry matter intake. The regressions of milk yield on estimated pasture digestibility were not significant for grazing supplemented with concentrates and hay. Contrary to expectation, the regression for grazing supplemented with concentrates and pellets was significantly negative. Further studies are needed in relation to DM intake and digestibility in order to resolve the causal relationship.

Dry lot feeding with hay, pellets and concentrates gave milk yields similar to that obtained on grazing with concentrates; grazing supplemented with concentrates and maize forage pellets gave higher milk yield; grazing supplemented with concentrates and hay gave significantly lower milk yield. While CP may have been deficient and digestible energy intake less, cows fed hay, pellets and concentrates in dry lot performed as well as cows on pasture with concentrates, probably due to reduced maintenance requirements. Additional investigations will be needed to determine whether the increased herbage yield and consequent milk production per ha will compensate for the cost of hay making and its feeding compared to that of selectively grazed pasture.

TABLE 5.—*Means for milk fat percent by weeks and treatment*

Treatment code	Weeks								Treatment mean[1]
	1	2	3	4	5	6	7	8	
T_8	2.64	2.61	2.56	2.94	2.81	3.05	2.92	2.79	2.79z
T_9	2.89	2.73	2.89	2.50	2.89	2.87	2.79	2.87	2.80z
T_{10}	2.91	2.69	3.97	2.75	3.12	3.23	3.21	3.20	3.15y
T_{11}	2.71	2.39	2.57	2.89	2.69	2.92	2.41	1.97	2.57z
Mean	2.77	2.60	2.98	2.78	2.88	3.03	2.84	2.75	

[1] Mean values with one common letter do not differ significantly at the 5% level.

This study showed that high quality pelleted forages can be used successfully in combination with pastures or hay. It is evident that when pastures are good, supplementary hay must be of excellent quality. Grass hay can compete with grazing when it is of high quality. Further research will be conducted to determine whether commercial production of high quality hay (and pelleted forages) is economically feasible in Puerto Rico.

RESUMEN

Se utilizaron 48 vacas Holstein de la Subestación de Gurabo en cuatro regímenes de alimentación: T_8, apacentamiento; T_9, apacentamiento más 2.3 kg por día de perdigones deshidratados de la planta del maíz; T_{10}, apacentamiento más 2.3 kg por día de heno del pasto Estrella (*Cynodon nlemfuensis*); y T_{11}, heno del Estrella más 4.5 kg por día de

perdigones de maíz. Se evaluaron los forrajes preservados en término de la variación en la calidad de los pastos. El apacentamiento se realizó a razón de cinco vacas por ha. Además, todas las vacas recibieron alimento concentrado a razón de una unidad de concentrado por cada dos unidades de leche producida. Las vacas comenzaron en el experimento a los 45 días después del parto.

Los análisis de covarianza demostraron efectos significativos por tratamiento en producción de leche con la producción por tratamiento como la covariante. Los promedios ajustados para la producción media de leche en un período de 8 semanas fueron de 23.2, 23.8, 23.1 y 23.1 kg para los tratamientos T_8, T_9, T_{10} y T_{11} respectivamente.

Las vacas que recibieron heno, perdigones y alimento concentrado (T_{11}) igualaron a las que, además de pastar, recibieron alimento concentrado (T_8) en producción de leche. Las producciones de leche de las vacas en apacentamiento suplementado con alimentos concentrados y forrajes en perdigones (T_9), y las que recibieron pasto, heno y alimentos concentrados (T_{10}) fueron significativamente altas y bajas, respectivamente. El estudio demostró que los forrajes en perdigones de buena calidad se pueden usar efectivamente en combinación con pastos o henos. Sin embargo, los pastos tropicales de 45 a 55 días de edad y henificados artificialmente tienen limitaciones en valor nutritivo y sapidez para usarse con los pastos de buena calidad.

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