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Two levels of liquid *Streptomyces* solubles in pelleted concentrate feeds for dairy cows[1]

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ABSTRACT

Pelleted commercial concentrate feeds containing 0,3 and 6% of liquid *Streptomyces* solubles (LSS) and 18% crude protein (CP) were fed as pasture supplements to Holstein and Brown Swiss cows in a 3x3 Latin square experiment, replicated 4 times, and with 3-week comparison periods. To simulate conditions of time limited to that spent in the milking parlor for consuming concentrates, as practiced on many local farms, the animals had individual free access to their respective concentrates for exactly 7.5 minutes twice daily. Twelve experimental cows grazed rotationally at 4/ha in six 0.5-ha paddocks of abundant gramineous herbage that analyzed 7.06% CP. Means observed with supplements containing 0,3 and 6% LSS: daily production of milk, 15.4, 15.5 and 15.9 kg; 4% fat-corrected-milk (FCM), 13.8, 13.4 and 13.7 kg; percentage milk fat, 3.33, 3.07 and 3.10; and solids-not-fat, 8.33, 8.29 and 8.36; daily concentrate intake, 7.67, 7.30 and 7.03 kg; rate of eating concentrate, 0.511, 0.487 and 0.469 kg/min; ratio of FCM/concentrate dry matter, 1.85, 1.87 and 2.01 kg/kg; daily change in liveweight, 0.191, -0.006 and 0.161 kg. Consumption of the control concentrate exceeded ($P<0.05$) that of the two LSS-containing concentrates combined. Other treatment effects were not significant. Addition of the present levels of LSS to the concentrates was compatible with maintaining both pellet quality and animal performance normal. Therefore, LSS seems suitable for use in this manner. Another important conclusion is that sufficient concentrate was consumed in 15 minutes daily to adequately supplement grazed herbage at these levels of milk production.

RESUMEN

Evaluación de dos cantidades de fracciones solubles de estreptomicetos anãdidas a alimentos concentrados aperdigonados para vacas lecheras.

Se ensayaron tres alimentos concentrados comerciales que incluían 0, 3 y 6% de fracciones solubles de estreptomicetos (LSS) y 18% de proteína bruta (CP), como suplementos del pasto en vacas Holstein y Suza Parda,

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en un experimento de diseño cuadrado latino 3x3, repetidos 4 veces y con períodos comparativos de 3 semanas. A los efectos de simular las condiciones existentes en muchas vaquerías locales, donde el tiempo de que disponen las vacas para consumir el concentrado se limita a su estancia en la sala de ordeño, se les permitió libre acceso, individualmente, a sus respectivos concentrados por exactamente 7½ minutos dos veces al día. Las 12 vacas experimentales pastaron rotacionalmente a razón de 4/ha. en 6 predios de 0.5 ha., donde había abundancia de forraje de gramíneas, cuyo análisis arrojó un 7.06% de CP. Los resultados medios observados con los suplementos incorporando 0, 3 y 6% de LSS fueron: producción diaria de leche, 15.4, 15.5 y 15.9 kg. y de leche corregida a 4% de grasa (FCM), 13, 8, 13.4 y 13.7 kg.; porcentaje de grasa láctea, 3.33, 3.07 y 3.10 y de sólidos lácteos no grasos, 8.33, 8.29 y 8.36; consumo diario de alimento concentrado, 7.67, 7.30 y 7.03 kg.; rapidez de ingestión del alimento concentrado, 0.511, 0.487 y 0.469 kg./minuto; proporción de FCM/materia seca del alimento concentrado, 1.85, 1.87 y 2.01 kg/kg; cambio diario de peso vivo, 0.191, -0.006 y 0.161 kg. El consumo del alimento concentrado testigo excedió ($P<0.5$) al de los dos piensos con LSS combinados. Ningún otro efecto de los tratamientos fue significativo. La adición a los niveles presentes de LSS al alimento concentrado dio resultados satisfactorios referentes a la calidad del perdigón y el comportamiento productivo de los animales, lo cual apoya el posible uso de LSS de este modo. Otra conclusión importante fue que los animales consumieron suficiente alimento concentrado en 15 minutos diarios para suplementar el pasto y cubrir sus requisitos nutritivos a estos niveles de producción de leche.

INTRODUCTION

High cost of feeds, especially imported concentrates, is a major economic constraint to dairy farming in Puerto Rico. Although the relationship between price received for milk sold and that paid for concentrates has been relatively favorable in recent years, future price fluctuations are unpredictable. Hence, a dependency on imports renders the insular dairy industry vulnerable. Research is needed to identify and evaluate local raw materials as potential ingredients in concentrate feeds for dairy cattle. In addition to possible benefits to feed companies, livestock producers and consumers, enhanced utilization of local industrial by-products could bring additional revenues to the firms generating the by-products.

One such by-product, liquid *Streptomyces* solubles (LSS), has traditionally been shipped from Puerto Rico to the United States for use at low concentrations in poultry feeds. It has served primarily as a source of fermentation factors and as a liquid carrier for other additives, such as mold inhibitors[3]. Previous research indicated that LSS supplied either alone (5) or in combination with cane molasses (6,7), can be used as a liquid energy supplement for dairy cattle (9). One local blender and distributor has been marketing an LSS-molasses combination[4] for nearly a decade in the Arecibo milkshed.

[3]Personal communication with Perl V. Farrington, Abbott Laboratories, Inc., North Chicago, IL. 1986.

[4]Solub Mol™ of Torrado Solub Mol Inc., Hatillo, P. R.

Research into the suitability of mixtures containing LSS and dry concentrates was deemed necessary to find alternative means for its incorporation into dairy rations, particularly as fractional substitution for imported ingredients. The present experiment with LSS was undertaken in collaboration with its pharmaceutical producer and a local manufacturer of concentrate feeds[5]. These firms have interest in its potential as a locally available and relatively inexpensive raw material. The principal objective was to compare pelleted concentrates containing 0, 3 and 6% of LSS as supplements to lactating cows managed under a system of rotational grazing. A second objective was to determine whether these concentrates would be consumed in sufficient quantities by cows allowed 15 minutes daily for consumption (similar to the situation existing on many local dairy farms) to satisfy animal energy and protein requirements.

MATERIALS AND METHODS

Fifteen cows of the Lajas Substation dairy herd participated in all or part of this experiment. It began in April 1984 and continued for 17 weeks in 4 treatment periods. Nine Holstein and 3 Brown Swiss cows were initially grouped into trios in accordance with stage of lactation and production level and kept for 5 weeks in period 1. One member of each trio was randomly assigned to each of the three experimental treatments. Thereafter, cows of the least well balanced trio (1 Holstein and 2 Brown Swiss) were replaced by a better balanced trio of recently calved animals of the same breed. The latter participated in periods 2, 3 and 4, each of 4 weeks duration. The remaining nine cows, most of which were 2 to 3 months post-freshening at the start, participated in all four periods. Data from the final 3 weeks of each period were used for comparison of treatments, following an interval for adjustment of 2 weeks (period 1) or 1 week (periods 2, 3 and 4).

The three treatments, designated A, B and C, were based on concentrate feeds containing 0, 3 and 6% of LSS, respectively (table 1). All were produced in the form of 4.8 mm-diameter pellets by the collaborating feed company and had the following guaranteed composition: crude protein, 18% minimum; crude fat, 3% minimum; crude fiber, 6% maximum. The feeding procedure used was intended to simulate conditions existing on many local dairy farms, where cows receive as much concentrate as they are able to ingest while in the milking parlor twice daily. Accordingly, the experimental animals received their respective concentrates individually in stanchions following each of the two daily milkings. An excess of concentrate was provided and the cows were allowed to eat for

[5]Molinos Nacionales, Guánica, P. R.

TABLE 1.—*Percentage formulas of the concentrate feeds supplied to lactating dairy cows at the Lajas Substation, 1984.*

Ingredients	Treatment		
	A	B	C
Solid			
Ground corn	39.50	36.80	35.60
Wheat middlings	21.58	24.76	19.48
Cottonseed meal	15.00	15.00	15.00
Soybean meal	12.66	11.26	12.66
Ground limestone	1.83	2.00	1.83
Salt	.66	.66	.66
Dicalcium phosphate	.58	.33	.58
Liquid			
Cane molasses	8.00	6.00	8.00
LSS	—	3.00	6.00
Micro solid			
Magnesium oxide	.05	.05	.05
Trace mineral mixture	.05	.05	.05
Sodium selenite	.005	.005	.005
Vitamin premix	.025	.025	.025
Micro liquid			
Pripionic acid	.025	.025	.025

exactly 7.5 minutes before being rapidly released from the stanchions. Feed left in the manger was then reweighed and intake recorded.

Grazed herbage constituted the remainder of the rations. The 12 experimental cows of any given period were rotated among six uniform paddocks, 0.5-ha, stocking rate four animals/ha. There were 4 days of grazing and 20 days of rest per paddock in each cycle. Of four paddocks used throughout the experiment, three supported stands of relatively pure stargrass (*Cynodon nlemfuensis*) plus some *Andropogon annulatus*, whereas the fourth was primarily a mixture of *Andropogon annulatus* and *Paspalum millegrana*. The fifth and sixth paddocks used initially (not contiguous to the other paddocks) supported a very heterogeneous herbage. Midway through the experiment these were replaced by two contiguous enclosures having a plant composition similar to that of the fourth paddock. Irrigation was used only during the first 2 weeks of the experiment. Natural precipitation was adequate thereafter for vegetative growth. Monthly rainfall from April to August was 45,103,71,148 and 84 mm, respectively. No fertilizer was applied to these pastures during the course of the experiment.

Herbage in each paddock grazed during the comparison periods was sampled the day preceding its exposure to the animals. Samples were hand cut approximately 10 cm above ground from five 1-m^2 plots distributed throughout the enclosure. The green forage from each plot was weighed, and a composite of the 5 samples was dried to constant weight at 80° C to determine dry matter (DM) percentage. The latter was used along with the green forage yield to estimate herbage availability on a dry basis. An accumulative sample of each concentrate feed was taken per period. Crude protein (8) and ash (1) analyses were performed on composited herbage samplings from each period and on the four per period samples of each concentrate. Detergent fiber fractions (3,11) were determined in composite samples representing the entire experiment.

Aliquot milk samples were taken from two consecutive milkings of each cow during the comparison periods. Fat (1) and solids-not-fat (SNF) (12) contents were determined. The liveweight (LW) of each animal was recorded at the beginning and end of each experimental period. All weighings occurred after the morning milking, before the cows were offered concentrates and water. The cows normally had the opportunity to drink *ad libitum* for about 2 hours twice daily during the time that they were in the area of the stable and milking parlor.

The experimental design was a 3x3 replicated latin square with an extra period, except that the last trio of cows completed only three periods. These were not simultaneous with periods 1 through 3 for the three trios that participated in all four periods. Data from these 12 cows were analyzed by standard procedures (2); orthogonal comparisons were treatments A vs. B + C and treatments B vs. C.

During a 27-day post-experimental period, further observations were made on animal acceptance and intake of the experimental concentrates by twenty lactating cows. The 10 higher producers and the other 10 lower producers were permitted 15 and 10 minutes for eating, respectively, once per day, by the procedure described previously. Concentrates A, B and C were used exclusively until supply was exhausted, i.e., for 10, 11 and 6 days, respectively.

RESULTS AND DISCUSSION

The following ranges in CP content of per period feed samples were found: in concentrate A, 17.6 to 18.5%; B, 17.6 to 18.7%; C, 17.9 to 19.6%; in pasture herbage, 6.39 to 7.73%. Amplitude of variation among the three concentrates in mean CP content over the full experiment was 0.68%, increasing from A to C (table 2.) Other consistent trends in composition with increasing inclusion of LSS in the formula were increasing ash and decreasing acid detergent fiber (ADF), whereas neutral detergent fiber (NDF) was lower with 3% LSS, but higher with 6% LSS in the formula, than for the control (table 2). These differences were too small to produce important effects on animal performance. Logically, the fiber content of pasture herbage was much higher than that of concentrates. Hemicellulose (HC), estimated as the difference between NDF

TABLE 2.—*Percentage chemical composition of concentrate feeds and pasture herbage supplied to lactating dairy cows at the Lajas Substation*

Component	Concentrate of treatment			
	A	B	C	Herbage
Crude protein[1]	18.02	18.28	18.70	7.06
Ash[1]	6.94	7.22	7.84	8.35
Neutral detergent fiber[2]	28.8	26.5	32.4	76.8
Acid detergent fiber[2]	8.8	8.4	7.9	41.6
Hemicellulose[2]	20.0	18.1	24.5	35.2

[1]Based on means of 4 composite samples, one from each period.
[2]Based on a single combined sample for the full experiment.

and ADF (3), constituted the principal fibrous fraction of the concentrates, whereas lignocellulose was the most prominent in the herbage, as expected (10).

On the basis of data from 12 cows in the 3 x 3 latin square, milk production was highest for treatment C in periods 1 and 3, whereas C ranked last in period 2; treatment A was highest in period 2, but lowest in period 1; B ranked second in the first two periods and last in the third (table 3). Mean differences among treatments over the full experiment were less than 0.5 kg of milk daily. The general mean of 4% fat-corrected-milk (FCM) production was approximately 2 kg daily below that of uncorrected milk (table 3). Highest treatment mean (13.76 kg) corresponded to the control, with C ranking second and B third; however, these were small differences not exceeding 0.35 kg.

Milk fat percentage increased as the experiment progressed, resulting in a general mean of 3.17% (table 4). Treatment A, with the highest means in two of the three periods and overall (3.33%), exceeded B and C by 0.26 and 0.23%, respectively. Milk SNF percentage showed a general mean of 8.32 and was the least variable of the parameters in table 4. Overall differences among treatment means were less than 0.10%. Milk total solids had essentially the same variability as milk fat (table 4). None of the milk components were affected by factors included in the statistical analysis.

Concentrate consumption was affected by squares, animals within squares and periods. Consumption was highest in period 1, decreased slightly in period 2, and decreased further in period 3 (table 5). Overall, there was a uniform trend toward decreased intake of concentrate with each increment of LSS. Mean eating rates of concentrates in periods 1, 2 and 3 declined successively (0.515, 0.506 and 0.467) with a general mean of 0.489 kg/min. At this mean rate, 2.04 minutes is required for the ingestion of 1 kg. No attempt was made to evaluate changes in eating

TABLE 3.—*Mean daily production of milk and 4% fat-corrected-milk (FCM) of 12 cows fed three different supplemental concentrates*

Period	Treatment A	Treatment B	Treatment C	Total
	kg	*kg*	*kg*	*kg*
1				
Milk	14.38	16.24	16.65	15.89
FCM	11.95	13.46	14.42	13.28
2				
Milk	17.20	16.11	15.56	16.29
FCM	15.20	14.02	13.35	14.13
3				
Milk	14.66	13.77	15.43	14.62
FCM	14.30	12.74	13.26	13.43
Total				
Milk	15.41	15.51	15.88	15.60
FCM	13.76	13.41	13.68	13.61

rate during different parts of the 7.5-minute sessions. Kertz et al. (4) reported a similar mean rate of ingestion of pelleted concentrate during the first 4 minutes of access by cows in midlactation. Further observation during the post-experimental period confirmed the trend toward slightly lower intake of concentrates containing LSS (relative consumptions of

TABLE 4.—*Mean percentage content of milk fat, solids-not-fat (SNF) and total solids (TS) of 12 cows fed three different supplemental concentrates*

Period	Treatment A	Treatment B	Treatment C	Total
1				
Fat	2.91	2.91	3.14	2.99
SNF	8.32	8.20	8.42	8.31
TS	11.23	11.11	11.56	11.30
2				
Fat	3.24	3.14	3.09	3.16
SNF	8.39	8.35	8.27	8.33
TS	11.63	11.49	11.36	11.49
3				
Fat	3.85	3.16	3.08	3.36
NSF	8.29	8.31	8.39	8.33
TS	12.14	11.47	11.47	11.69
Total				
FAT	3.33	3.07	3.10	3.17
SNF	8.33	8.29	8.36	8.32
TS	11.66	11.36	11.46	11.49

TABLE 5.—*Mean daily intake of concentrate, partial feed efficiency*[1] *and daily gain or loss in liveweight of 12 cows fed three different supplemental concentrates*

	Treatment			
Period	A	B	C	Total
1				
Concentrate intake (kg)	7.82	7.86	7.48	7.72
Partial feed efficiency (kg/hg)	1.60	1.70	2.00	1.77
Change in liveweight (kg)	-.35	-.16	-.01	-.17
2				
Concentrate intake (kg)	7.89	8.19	6.68	7.59
Partial feed efficiency (kg/kg)	1.97	1.80	2.10	1.96
Change in liveweight (kg)	.18	.42	.48	.36
3				
Concentrate intake (kg)	7.31	5.85	6.94	6.70
Partial feed efficiency (kg/kg)	1.98	2.12	1.94	2.01
Change in liveweight (kg)	.74	-.29	.42	.29
Total				
Concentrate intake (kg)	7.67	7.30	7.03	7.33
Partial efficiency (kg/kg)	1.85	1.87	2.01	1.91
Change in liveweight (kg)	.19	-.01	.30	.16

[1]FCM produced/concentrate DM consumed.

100, 97 and 95% of concentrates A, B and C, respectively). Variable animal acceptance of pure LSS was observed in a previous study (5), but this problem was mitigated considerably by the present procedure of incorporating it into a dry concentrate formula.

Partial feed efficiency for lactation (FCM produced/concentrate DM consumed) improved, though not significantly, over the course of the three periods (table 5). This improvement accompanied rising milk fat content and falling concentrate intake, which compensated for the net decrease in milk production. Treatment C showed the best efficiency in two of the three periods and overall. The general mean was 1.91 kg of FCM/kg of concentrate DM. No significant differences among treatments were found in LW response. Summing up, the addition of 3% or 6% of LSS to the concentrate had no significant adverse effects on animal performance, nor did it affect pellet durability or proportion of unpelleted fine material present in the pelleted product[6]. The suitability of this liquid ingredient for use in dry concentrate formulas is, therefore, supported by the results of the present study.

The pasture herbage was of reasonably good chemical composition (table 2) and that of the ingested matter should have been better, because of selective grazing. Estimated herbage DM availability exceeded 40 kg

[6]Pellet quality tests were conducted by the collaborating feed manufacturer.

/animal/day at all but two individual samplings. Means for the four successive periods were 61, 45, 84 and 81 kg. Supplementation of these swards with as much concentrate as the cows were able to ingest in 15 minutes daily resulted in productive responses suggesting that energy and protein requirements of the animals were adequately met; i.e., the net decrease of 1.27 kg in daily milk output over three experimental periods did not exceed the normal rate of decline with advancing lactation nor did loss of LW occur.

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