Ground johnson grass hay and long hay addition to total mixed rations for dairy cows[1]

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ABSTRACT

Two total mixed rations (TMR) were compared; both contained 20% ground hay, of either johnson grass (J) or pajon and star grass (PS); both included 20% coarsely chopped PS hay and 60% concentrates; and both were analyzed to be about 13% crude protein. Treatments I and II consisted of TMR-J without and with addition of 1.5 kg per head daily of long PS hay; III and IV, of TMR-PS without and with said addition, respectively (2 × 2 factorial). Feed was offered between evening and morning milkings only. Ten adult Holstein cows grouped 2 × 2 and 2 × 3 were used in a 4 × 4 Latin square experiment with 2-wk comparison periods. No significant interactions of treatment factors were found. Comparing the effects of TMR-J vs. TMR-PS and no long hay vs. long hay addition, means were: daily dry matter intake (DMI), 19.89 vs. 19.65 and 19.17 vs. 19.77 kg; daily milk production, 18.46 vs. 18.89 and 18.48 vs. 18.87 kg; milk fat percentage, 2.64 vs. 2.71 and 2.60 vs. 2.76; feed efficiency (4% fat-corrected milk/DMI), 0.736 vs. 0.777 and 0.741 vs. 0.772, respectively. Thus, long hay addition increased milk fat content by 0.16%, and TMR-PS exceeded TMR-J in efficiency by 0.041 ($P<0.05$). General mean rectal temperature (RT), shortly past noon, was 39.8° ± 0.3°C (standard deviation, SD); liveweight (LW) mean, 590 ± 43 kg (SD). Milk yield and RT were unrelated. In conclusion, J hay gave satisfactory results in the TMR; long hay addition improved milk fat content; and limiting feeding to the cooler hours helped mitigate animal hyperthermia.

Key words: Johnson grass, hay, total mixed rations, dairy cows

RESUMEN

Heno molido de gramínea johnson y adición de heno largo en raciones completamente mezcladas para vacas lecheras

Se compararon dos raciones completamente mezcladas (TMR), que incluyeron 20% de heno molido, ya sea de gramínea johnson (J) o de pajón y estrella (PS); ambas raciones incluyeron 20% de heno PS picado grueso y 60% de concentrados, con un contenido aproximado de 13% de proteína bruta. Los tratamientos I y II consistieron de TMR-J sin y con la adición de 1.5 kg por cabeza de heno PS largo; III y IV consistieron de TMR-PS sin y con dicha adición, respectivamente (2 × 2 factorial). Se ofreció el alimento solamente durante el intervalo entre el ordeño vespertino y el matutino. Participaron 10 vacas Holstein adultas, confinadas en dos grupos de tres vacas y dos grupos de dos vacas, en un experimento de diseño cuadrado latino 4

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× 4, con períodos comparativos de dos semanas. No se detectó ninguna interacción significativa entre factores de tratamientos. Las medias comparativas de los efectos de TMR-J contra TMR-PS, y la no adición contra la adición de heno largo fueron: ingestión diaria de materia seca (DMI), 19.89 vs. 19.65 y 19.76 vs. 19.77 kg; producción diaria de leche, 18.46 vs. 18.89 y 18.48 vs. 18.87 kg; porcentaje de grasa láctea, 2.64 vs. 2.71 y 2.60 vs. 2.76; eficiencia alimentaría (leche corregida a 4% grasa/DMI), 0.736 vs. 0.777 y 0.741 vs. 0.772, respectivamente. La adición de heno largo aumentó el contenido de grasa por 0.16%, mientras TMR-PS superó a TMR-J en eficiencia por 0.041 ($P < 0.05$). La media general de temperatura rectal (RT), poco después de mediodía, fue 39.8 ± 0.3°C (desviación estándard, DE) y la de peso vivo, 590 ± 43 kg (DE). No hubo relación entre la producción de leche y la RT. Se concluye que el heno de gramínea johnson resultó satisfactorio en las TMR, que la adición de heno largo incentivó el porcentaje de grasa láctea y que la alimentación limitada a las horas de ambiente fresco ayudó a mitigar la hipertermia animal.

INTRODUCTION

Management of dairy cows in semi-confinement is becoming common in Puerto Rico, and commercial bulky concentrate feeds are used with many semi-confined herds. The more intensive system of complete confinement of animals and feeding a total mixed ration (TMR) has been adopted by only a few local dairy farmers so far, but represents a likely future trend.

In previous experiments at the Lajas Substation, TMR usually containing 40% grass hay, in various physical forms, and 60% concentrates, were tested (Randel, 1995; 1993; 1991). Rations of this type permit achieving high levels of dry matter intake (DMI) and sufficient energy input to enable cows with the potential to produce at least 20 kg of milk per day to realize that potential. However, the resulting milk fat percentage tends to be marginal. In an attempt to correct the low milk fat problem, some local operators with herds in semi confinement place long hay in the manger beneath concentrates or other highly palatable feeds, to increase the intake of ruminally effective fiber. Evaluating this alternative under controlled conditions was one objective of the present study.

In previous experimentation only hays made from low-growing, fine-stemmed forages, such as stargrass (*Cynodon nlemfluensis*), which offer the advantage of easy field curing, were used. However, in the Lajas area, stands of stargrass managed for hay production without irrigation are usually invaded and dominated by other species, especially pajon-grass (*Dichantium annulatum*) within a few years. The latter is very competitive, but not a high yielder of herbage mass. A possible alternative is johnson grass (*Sorghum halapense*). This tall-growing, robustly rhizomatous perennial is extremely aggressive in fallow yields, often establishing nearly pure volunteer stands. Although regarded as one of the most noxious weeds in many countries, it can give high yields of good quality hay if fertilized and cut at the proper stage (Spooner et al., 1971). A second objective of this study was to test ground johnson grass (J) hay as a component of TMR. Ground hay per se is not in a physical form that constitutes ruminally effective fiber, yet when finely ground fibrous material is fed together with sufficient coarse fiber to form a floating mat in the rumen, the finer material becomes occluded and in this condition contributes to the total effective fiber. Furthermore, because of the cellulosic nature and slow fermentation of ground hay, its presence helps to counter-balance the high-starch ingredients, thus avoiding extreme peaks of organic acid production; it also contributes to the buffering capacity of the rumen contents (Van Soest, 1994).

In previous studies with cows fed TMR in confinement, thermal stress appeared to be reduced by limiting feeding to the cooler afternoon and nighttime hours, while letting the animals rest under shade during hotter hours. A third objective of the present work was to compare the degree of hyperthermia, as measured by rectal temperature (RT) in the experimental cows with that of control animals subjected to a different diurnal feeding pattern.

MATERIALS AND METHODS

Ten adult Holstein cows were used, one of which was in second lactation and the rest in third or later; the mean number was 3.9 lactations. A 9-day preliminary period was followed by the four 2-wk comparison periods of a 4 × 4 Latin square experiment, balanced for treatment sequences, during July, August and early September 1991. As of the first day of comparison period 1 (13 July), the mean interval postpartum was 108 ± 46 days (standard deviation, SD). The cows were confined to their respective pens in two groups of three, and two groups of two, from after milking at about 3:00 p.m. until roughly 5:30 a.m., and consumed feed during this time only. The four pens were paved, located under a saran shade, and provided with a covered feed bunk and watering through. During the daytime hours between milkings, the cows were maintained in an unpaved lot, with a saran-shaded area adequate to accommodate 10 animals. Water only was available in the rest area.

Two TMR were tested, both of the same formula (Table 1), which included 20% of ground hay (hammer milled), but differing in the source of hay in this form, i.e., either johnson grass (J), harvested from volunteer stands; or pajon and star grasses (PS), harvested at the Lajas Substation or purchased from local producers. Both formulas also in-

TABLE 1.—*Formulas of the total mixed rations.*

Ingredient (% as fed)	TMR-J	TMR-PS
Ground J hay	20.0	—
Ground PS hay	—	20.0
Chopped PS hay	20.0	20.0
Ground yellow maize	30.0	30.0
Wheat middlings	10.8	10.8
Soybean meal	11.2	11.2
Cane molasses	5.0	5.0
Urea	1.0	1.0
Salt	1.0	1.0
Dicalcium phosphate	0.5	0.5
Ground limestone	0.5	0.5

cluded 20% of PS hay in coarsely chopped form. The TMR were mixed at frequent intervals in a manually loaded and unloaded revolving drum mixer[4], by combining a premix of concentrate ingredients with ground and chopped hays in the indicated proportions. In treatment I, TMR-J was fed; in II, the same TMR plus an additional 1.5 kg per head daily of long PS hay (taken from rectangular bales and placed at the bottom of the feed bunk). In treatment III, TMR-PS was fed; in IV, the same plus long hay as in II. Thus, the two treatment factors were type of TMR and addition or non addition of long hay, in a factorial arrangement. Daily offerings were adjusted frequently to permit ad libitum intake without undue wastage of feed. Upon weighing orts left by the groups assigned to II and IV, it was not possible to separate long hay from the other dietary components; both were presumed to be present in the same proportions as were fed.

Individual milk samples were taken toward the end of each comparison period from four consecutive milkings and combined into aliquots according to milk weights at each milking. The aliquots were analyzed for fat and solids-not-fat (SNF) contents by the Babcock (A.O.A.C., 1980) and Watson (1957) procedures, respectively. A sample of each TMR and type of hay was taken per period, oven dried to determine dry matter (DM) content, and subsequently analyzed for crude protein (CP) and acid detergent fiber (ADF) (Goering and Van Soest, 1970).

[4]Roll-A-Mix, Model No. 80 cu. ft., Steiner Corp. (Trade names in this publication are used only to provide specific information. Mention of a trade name does not constitute a warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipment or materials.)

The experimental cows were weighed on a platform scale after morning milking each Friday, which coincided with the first and last day and midpoint of each period of the Latin square design. In early afternoon of the same days, while the animals were gathered in the holding area prior to entering the milking parlor, RT of the experimental cows and of 10 others randomly selected from the rest of the herd (controls) was taken with a clinical thermometer. The control animals were under a management routine that included two daily offerings of supplemental concentrates while stanchioned briefly after morning milking and again about noon. They also received either green chopped forage or hay in an adjacent lot where they spent most of their time, with access to shade and water nearby.

Experimental data were subjected to analysis of variance, in which groups constituted the replications and there were six degrees of freedom (DF) for error. The 3 df for treatments were used to test orthogonally the effects of factor 1 (TMR-J vs. TMR-PS) and factor 2 (addition or non addition of long hay), and the interaction of both factors (Snedecor, 1956).

RESULTS AND DISCUSSION

The treatments had negligible effects on DMI. Mean values for the main effect TMR-J vs. TMR-PS differed by 0.24 kg daily, whereas the difference between treatments without and with addition of long hay was essentially nil (Table 3). These results demonstrate good animal acceptance of ground J hay in the ration. It should be noted that intake of long hay could have been less than assumed if the cows discriminated against it; this appeared to be the case more often than not, judging from the aspect of the orts. The general mean of 19.8 kg of DMI daily, equivalent to 3.36 kg/100 kg liveweight (LW), represents an ingestive level as high as that normally observed in dairy cows fed rations typical of the USA (N.R.C., 1989). Inclusion of part of the hay in ground form probably contributed to the high intake, because of a short retention time in the rumen.

The general mean of milk production was 18.7 kg dairy. Milk yield declined by 1.6 kg daily per 2-wk period. Thus, the expected decrease in yield with advancing stage of lactation, of 5% to 7% monthly (Shingoethe et al., 1988), was accentuated in this experiment. Several cases of clinical mastitis contributed to this loss of production. However, there were no important effects of the treatments. Both of the differences between means representing the main effects were less than 0.5 kg daily (Table 3).

Milk fat percentages were subnormal in this experiment; the general mean, unweighed for milk production, was 2.68 ± 0.24 (SD). However, an increase ($P < 0.05$) was obtained by the inclusion of long hay in the ration, by a margin of 0.16%. This effect of additional long hay (effective fiber) on milk fat content agrees with expectation (Sutton, 1989), but the modest magnitude of the increase suggests that additions of long hay exceeding 1.5 kg per head daily are needed.

Everson et al. (1976) used Holstein cows to compare an addition of 2.3 kg daily of alfalfa-bromegrass hay to TMR composed of low moisture silage of said species and concentrates in constant 60:40 proportions vs. TMR with varying proportions of forage to concentrates (50:50 in early lactation and 65:35 subsequently) without long hay addition, and observed no difference between treatments in milk fat percentage. Those results suggest no need of additional long hay with TMR in which 50-60% of the DM is supplied by unground forage. By contrast, TMR-J and TMR-PS contained only 20% of unground forage DM, exclusive of additional long hay, and analyzed 19.6% and 17.4% ADF on the dry basis, respectively (Table 2). This difference of 2.2% ADF between the two TMR agrees with a 7.8 higher ADF percentage in ground J than in ground PS hay (41.9 vs. 34.1). Mean particle size was not determined in this experiment, but this characteristic was more likely the cause of suboptimal milk fat than ADF level. The latter was theoretically adequate for TMR-J and only slightly low in the case of TMR-PS, relative to the requirements suggested by Woodford et al. (1986). In another study, Briceño et al. (1987) used neutral detergent fiber (NDF) instead of ADF and found that the optimum fiber percentages in TMR varied when the sources differed in fineness of particle. In milk SNF percentage, the individual treatments means ranged from only 8.28 to 8.14, and factors 1 and 2 had minimal effects (Table 3).

Feed conversion efficiency, defined as the ratio of 4% fat-corrected milk (FCM) production to DMI, showed a low general mean of 0.756, whereas in previous work with TMR containing 40% hay of similar relative quality and 60% concentrates, feed efficiency had been 0.82 or higher (Randel, 1995; 1993; 1991). In the present study high feed consumption was not coupled with correspondingly high milk output; also milk fat content was subnormal, both of which findings reduced the FCM/DMI ratio. The superiority of TMR-PS over TMR-J, by a margin of 0.041 (0.777 vs. 0.736) was significant ($P < 0.05$). Inferiority of the latter is understandable, considering that the J hay used in this experiment was obtained from mature volunteer stands that had received no agronomic management, whereas that of PS was from fields cut regularly for hay. The J hay showed a disadvantage of 0.7 percentage unit in CP content (6.1 vs. 5.4; Table 2), in addition to the higher ADF con-

TABLE 2.—*Nutritional composition (dry basis) of total mixed rations and long, chopped and ground hays.*

		TMR-J	TMR-PS	Long PS hay	Chopped PS hay	Ground PS hay	Ground J hay
Dry matter	(%)	86.7	87.6	87.2	87.6		
Ash	(%)	8.1	7.7	7.9	7.2	8.8	8.6
Crude protein	(%)	12.6	13.0	7.4	5.9	6.1	5.4
Acid detergent fiber	(%)	19.6	17.4			34.1	41.9
Net energy for lactation	(Mcal/kg)[1]	1.72	1.74				

[1]Theoretical values based on NRC (1989).

TABLE 3.—*Means of main effects for the principal criteria of animal response.*

		Type of ground hay in ration				Addition of long hay			
		TMR-J		TMR-PS		Without		With	
Response criteria		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Daily DM intake	(kg)	19.89	1.16	19.65	1.23	19.76	1.09	19.77	1.30
Daily milk yield	(kg)	18.46	1.71	18.89	1.87	18.48	1.38	18.87	2.13
Milk fat content	(%)	2.64	0.10	2.71	0.07	2.60[1]	0.10	2.76[2]	0.05
Milk SNF content	(%)	8.21	0.07	8.23	0.06	8.24	0.07	8.20	0.06
Daily FCM yield	(kg)	14.68	1.48	15.28	1.64	14.65	1.22	15.32	1.84
FCM yield/DM intake	(wt/wt)	0.736[1]	0.058	0.777[2]	0.061	0.741	0.051	0.772	0.067
Liveweight	(kg)	592	15	588	18	592	17	587	16
Rectal temperature	(C)	39.77	0.16	39.83	0.07	39.88	0.15	39.72	0.08

[1,2]Main effect significant at $P < 0.05$.

tent mentioned previously. Inclusion of long hay in the diet improved feed efficiency by 0.031 ($P < 0.10$) relative to the treatments without long hay (0.772 vs. 0.741), mainly because of a positive effect on milk fat content and thereby FCM yield. This milk fat effect was presumably the result of differences in intraruminal conditions, such as higher pH and decreased concentration of propionic acid (Grant et al., 1990).

With regard to liveweight, means for the main effects differed by the negligible margins of 4 and 6 kg (Table 3). Judging from these results, it seems that the cows maintained approximate energy equilibrium and synthesized milk from ingested nutrients without need of mobilizing body reserves.

Mean RT of the experimental cows was 39.77° ± 0.35°C (SD). Periods contributed to the variation ($P < 0.05$), successive means being 39.49, 39.79, 39.76, and 40.05°C. The reason for this ascending trend is not clear, as concurrent ambient temperatures showed only slight, inconsistent variation. Mean daily maximum ambient temperatures during the four consecutive periods were 33.1, 33.3, 32.6, and 33.4°C; corresponding minima were 20.0, 19.3, 20.2, and 20.4°C. There was a slight tendency toward an effect of factor 2 (not quite reaching $P < 0.10$), in the 0.16°C higher RT of cows not receiving long hay compared with those receiving it (39.88 vs. 39.72°C; Table 3). An opposite situation might seem more logical, if the postulated longer rumen retention time with long hay addition resulted in greater heat of fermentation. On the other hand, a lower heat increment (increased efficiency of metabolizing absorbed nutrients) could have been a countervening factor favored by long hay addition.

Experimental and control cows showed remarkably similar respective RT means (39.77 vs. 39.76°C), based on 80 observations in each category. The upper limit of normal RT range of the dairy cow under thermal-neutral conditions, as given by Anderson (1977), is 39.3°C. Thus, in general, both management systems resulted in hyperthermia of less than half a degree centigrade. The maximum observed was 0.75°C in the experimental cows in period 4. However, it is interesting that whereas in the control cows there was an appreciable ($P < 0.01$) linear regression of RT on milk production the same day ($b = 0.197$), in the experimental cows (of higher mean production) this regression was essentially zero ($b = -0.009$). Thus, the latter animals did not exhibit greater hyperthermia as their milk yield increased. One interpretation of these results is that the experimental animals were not subjected to much stress and needed not sacrifice production for the sake of thermoregulation. Use of cows of higher productive potential would have provided a more critical test of this relationship. The high ingestive levels observed lend support to the contention that the experimental cows remained comfortable, since cows suffering from thermal stress characteristically reduce their feed intake (McDowell, 1972). Thus, herd management in which feeding of TMR is limited to the cooler hours of the diurnal cycle, seems to favor animal comfort and feed intake in the local tropical environment.

With regard to the objective of evaluating J hay, the present results lend support to its suitability for inclusion in TMR. Although this forage is of outstanding adaptability to local conditions, it is little utilized, perhaps in part because of its ill fame as a hydrocyanic acid (HCN) containing plant. However, HCN toxicity, limited mainly to the green plant under conditions of cold and drought stress, is rarely a problem in hay or silage of this species (Anonymous, 1965). Cold stress is nonexistent in Puerto Rico and the possibility of J hay inclusion in local TMR causing toxicity should be nil. Furthermore, where J is already established, its eradication is extremely difficult and expensive. As Skerman and Riveros (1980) pointed out with regard to the southern United States, "Johnson grass is used for grazing when a decision is made to live with it rather than attempt eradication." Under such conditions it is also cut to provide a coarse hay, the main disadvantage of which is slow drying of the thick stems. However, it responds well to improved management, and in Texas has given hay yields of 17-18 tons/ha under irrigation.

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