The Digestibility of a Bagasse Complete Ration in Comparison with a Conventional Ration for Dairy Cows

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INTRODUCTION

To overcome limitations posed by the scarcity of forages in arid areas of Puerto Rico, research is being conducted to develop complete rations for cattle based upon sugarcane (*Saccharum officinarum*) bagasse and concentrates. Randel (*10*)[2] found that a complete ration composed of 15-percent ground chicken litter bagasse and 85-percent concentrates, fed to Holstein and Brown Swiss cows, supported daily milk production averaging 21.5 kg. Kirk *et al.* (*6*) in Florida obtained liveweight gains averaging 1.15 kg. daily in Brahman steers and heifers with a complete ration containing 20-percent ground chicken litter bagasse and 80-percent concentrates. Beames (*2*) in Australia reported that a complete ration containing 37-percent sorghum meal and 50-percent bagomolases (a mixture of 30-percent unground bagasse and 70-percent cane molasses) gave a satisfactory average daily gain of 1.05 kg. in Hereford steers, whereas two other rations containing only 12- or 15-percent sorghum meal and 70-percent bagomolasses proved unsatisfactory.

Beames (*2*) determined apparent digestibility coefficients (by difference) of 51.7 for dry matter, 16.7 for crude protein, 21.3 for crude fiber, and 65.1 for nitrogen-free extract in bagomolasses using three mature dairy-type steers. However, to the authors' knowledge, there is no published information available on the digestibility of complete rations containing bagasse. The present investigation contributes such information for a complete ration containing 15-percent bagasse.

EXPERIMENTAL METHODS

The digestibility trial reported herein was conducted as a sequel to the experiment reported by Randel (*10*), using 16 Holstein and Brown

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[2] Italic numbers in parentheses refer to Literature Cited, pp. 446–7.

Swiss cows. Each cow was taken out of the previous experiment on her 260th day of lactation, which occurred during the months from June to August 1965, and remained on this digestibility trial from the 260th to the 280th day of her lactation.

As in the preceding experiment, eight cows consumed a complete ration and the remaining eight a control ration; the formulae for both rations are presented in table 1. Consumption of the complete ration was limited to 13.6 kg. per cow daily, the amount considered sufficient to meet the nutritional requirements of the cows in late lactation, while ensuring little feed refusal. The control ration provided whole sugarcane silage to appetite plus individual allowances (minimum 5.45 kg. daily) of a standard concentrates mixture, allotted according to the Maryland Standards (*3*) on milk production and milk fat content determinations effected during the final part of the preceding experiment. All feeds were given in two equal portions daily.

The cows on the complete ration were housed in a shaded barn in individual concrete-floored pens approximately 3 X 3 m. Each pen, equipped with an automatic watering cup and feed bunk, was bedded down with sand. The cows on the control ration were stanchioned in a barn provided with wooden manger partitions, automatic watering cups and sand-bedded floor. Both groups of cows walked a short distance to the milking parlor twice daily.

During the adjustment period, the first 7 days of the trial, the cows became accustomed to the daily routine; observations on the individual voluntary silage-intake rates, continued throughout the trial, were started on the cows on the control ration. The preliminary equilibrium of chromic oxide, the digestibility indicator used in these animals, was established during the second 7-day period. From the eighth day until the end of the trial, each cow was given 10 g. of chromic oxide in a gelatin capsule twice daily, at approximately 6 a.m. and 5 p.m., by means of a balling gun. Collection of fecal samples was effected during the final 7 days of the trial. This period had to be shortened to 5 days for one cow, afflicted with cancer, that became very weak. The digestibility data obtained from this cow appeared to be normal, and were included in analysing the results. To obtain a sufficient number of fecal samples the collection period was extended to 8 or 9 days in four other cows. Fecal samples were obtained from the rectum twice daily at the time when the chromic oxide was administered.

The fecal samples were immediately set to dry at 65° C. in a forced-air oven. Aliquot dried portions of the feces obtained daily from each cow were combined into composite samples during the collection period. The undigested residues present in the feces during the collection period were

considered to originate in the feed consumed beginning 2 days prior to the start of such period. Therefore, feed samples were collected twice daily during the final 2 days of the equilibration period and the first 5 days of the collection period. Samples of feed and feces were subjected to proximate analyses, according to A.O.A.C. procedures (*1*). The fecal samples were also analysed for chromic oxide content by the method of Kimura and Miller (*5*).

The statistical significance of the mean differences between rations in digestibility coefficients was determined by the unpaired t test (*7*). In so far as the forage (bagasse):concentrates ratio was constant for the complete ration, while variable for the control ration, coefficients of linear regression were calculated employing digestibility of the chemical component in question as the dependent variable and the proportion of dry matter consumed in forage to total dry matter consumed, by the cows on the latter ration, as the independent variable. Those regression coefficients, which proved to be statistically significant, were used to adjust the digestibilities observed for the control ration to the proportion 0.15 (forage dry matter), the same as that of the complete ration. After adjustment, the mean differences between both rations were compared by unpaired t test.

RESULTS AND DISCUSSION

The complete ration and the standard concentrates mixture have similar proximate chemical composition, except for the higher crude fiber and lower nitrogen-free extract contents of the complete ration (table 1). Feed refusals were infrequent with either feed. The average consumption figures are shown in table 2. The whole sugarcane silage apparently was not very palatable, and was consumed at the rate of only 2.18 kg. of dry matter per cow daily. Total dry matter consumption averaged 2.86 kg. less for the control than for the complete ration. Consumption of the other proximate components was correspondingly less for the control ration, with the sole exception of ether extract. The average amount of dry matter apparently digested was 2.36 kg. higher for the complete ration. The cows fed the latter ration also digested greater amounts of organic matter, crude protein and nitrogen-free extract, but less ether extract and crude fiber than those of the control group.

The mean digestibility coefficients of the complete ration were higher than those of the control ration for all components except crude fiber (table 3). The mean differences were highly significant ($P < .01$) for organic matter and crude protein, significant ($P < .05$) for dry matter and nitrogen-free extract, but not significant for ether extract, crude fiber, or total digestible nutrients. The mean difference was large for crude fiber,

but there was also a great deal of variation within rations, as indicated by the high standard error.

The two linear regressions relating the digestibility of crude protein and the content of total digestible nutrients in the control ration to the quotient: dry matter from forage over total dry matter consumed were significant,

TABLE 1.—*Percentage formulas of the mixtures containing concentrates and percentage chemical compositions of all feeds*

Item	Standard concentrate mixture	Complete ration	Whole sugarcane silage
	Ingredient		
Ground shelled corn[1]	35.50	45.20	
Hominy feed	35.50	—	
Dehulled soybean oil meal	10.00	22.50	
Tunafish meal	5.00	—	
Cane molasses	12.50	15.00	
Ground dry bagasse[1]	—	15.00	
Dicalcium phosphate	—	1.00	
Salt	1.50	0.75	
Sodium bicarbonate	—	0.50	
Vitamin supplement[2]	—	0.05	
	Component[3]		
Dry matter	89.83	90.00	26.56
Crude protein	16.26	16.25	3.60
Ether extract	3.77	2.19	2.19
Crude fiber	2.58	9.85	34.94
Ash	6.21	5.62	7.17
Nitrogen-free extract	71.70	66.09	53.82

[1] Ground to pass a 0.635 cm. screen.

[2] Supplied through the generosity of Dawe's Laboratories, Inc., and guaranteed to contain 1 million, 100 thousand, and 10 thousand units of vitamins A, D, and E, respectively per 454 g.

[3] All items except dry matter expressed on the dry-matter basis.

at $P < .05$ in the former case and at $P < .01$ in the latter. These regressions are illustrated in figure 1, wherein the dependent variable is expressed in decimal units and the regression equations are plotted within the boundaries of the experimental data. Extrapolation of the regression lines to the Y-intercept gives estimates of 90.3 percent crude protein digestibility and 79.4 percent total digestible nutrients in the standard concentrates alone. The regression coefficients signify that for each increase of, for example, 10 percent in forage dry matter present in the total dry matter

consumed, the digestibility of crude protein decreases by 13.71 percent and the content of total digestible nutrients decreases by 3.98 percent. The standard errors of estimate ($Sy.x$) are .097 and 0.13 for the crude protein and TDN regressions, respectively. The coefficients of determination,

TABLE 2.—*Average amounts (kg.) of the proximate chemical components consumed, eliminated in feces, and apparently digested on each ration*

Item	Dry matter	Organic matter	Crude protein	Ether extract	Crude fiber	Ash	Nitrogen-free extract
Control ration							
Consumed in silage	2.18	2.04	0.08	0.05	0.76	0.16	1.17
Consumed in concentrates	6.26	5.87	1.02	.24	.16	.39	4.49
Total consumed	8.44	7.91	1.10	.28	.92	.55	5.66
Eliminated in feces	2.67	2.33	.48	.09	.48	.34	1.32
Apparently digested	5.76	5.58	.62	.19	.44	.21	4.34
Complete ration							
Consumed	11.31	10.67	1.83	0.24	1.12	0.64	7.48
Eliminated in feces	3.19	2.76	.53	.07	.71	.43	1.45
Apparently digested	8.12	7.91	1.30	.17	.41	.21	6.03

TABLE 3.—*Mean digestibility coefficients and their corresponding standard errors for the complete and control rations and t values of the differences between ration means*

Item	Complete ration	Control ration	Difference	Value of t
Dry matter	71.9 ± 2.9	68.3 ± 1.8	3.6 ± 1.5	2.37[1]
Organic matter	74.3 ± 1.2	69.6 ± 2.2	4.7 ± 0.6	8.39[2]
Crude protein	71.3 ± 1.1	55.1 ± 4.9	16.2 ± 1.6	10.22[2]
Nitrogen-free extract	80.7 ± 0.7	76.6 ± 1.5	4.1 ± 1.7	2.46[1]
Ether extract	70.0 ± 4.5	67.3 ± 5.8	2.7 ± 7.4	.37
Crude fiber	36.6 ± 4.1	47.7 ± 3.1	11.1 ± 5.1	2.18
Total digestible nutrients	72.2 ± 1.3	69.2 ± 1.8	3.0 ± 2.3	1.33

[1] Difference between ration means significant ($P < .05$).
[2] Difference between ration means highly significant ($P < .01$).

indicating the relative proportion of the total variance in the dependent variable explained by the regression, are .575 for crude protein and .337 for TDN.

The extremely adverse effect of increasing proportions of forage on apparent crude protein digestibility in the control ration is notable, and agrees with results reported by Putnan and Loosli (*9*). Increased consump-

tion of the whole sugarcane silage, with its low crude protein and high crude fiber contents (table 1), must have contributed little or no digestible nitrogen, while increasing the excretion of endogenous fecal nitrogen, as discussed by Mitchell (*8*).

Using the regression coefficients of figure 1, to adjust the crude protein

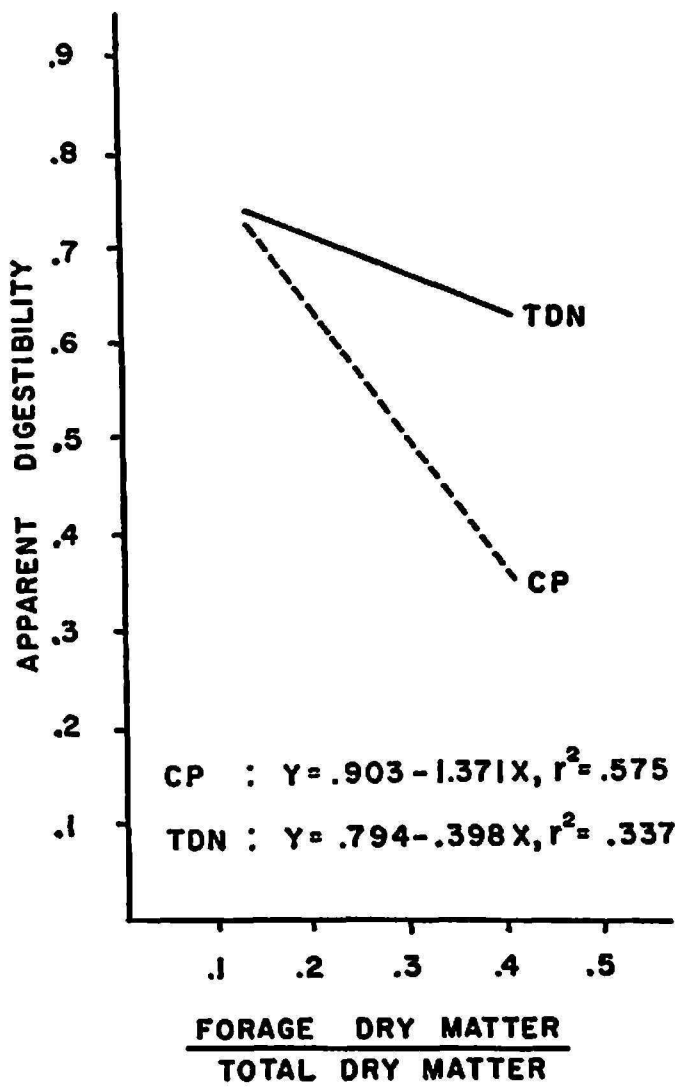

FIG. 1.—Regressions of apparent digestibility of crude protein (CP) and total digestible nutrients (TDN) against proportion of forage dry matter in the total dry matter consumed.

and total digestible nutrient results for the control ration to the basis of 15-percent forage dry matter in the total dry matter consumed, gives a mean crude protein digestibility of 69.8 ± 3.2 and a mean TDN content of 73.4 ± 1.5. These means are higher and their standard errors are lower than the unadjusted values of table 3. Furthermore, the adjusted averages for the control ration differ very little from those of the complete ration.

Thus it is concluded that if the two rations were ingested at the same forage to concentrates dry matter ratio they would have essentially equal crude protein digestibilities and TDN contents.

Though digestibility coefficients for bagasse alone were not obtained in this study, the greatest part of the fiber in the complete ration was supplied by bagasse, thus 36.6 ± 4.1 percent can be considered a rough estimate of the digestibility of the bagasse fiber. This figure is considerably higher than the 21.3 percent reported by Beames (*2*), which might indicate that fine grinding of the bagasse used in the present study improved its crude fiber digestibility. If the latter suggestion should prove true, it would constitute an exception to the usual negative effect of fine grinding on the digestibility of roughages (*4*).

SUMMARY

Sixteen Holstein and Brown Swiss cows in late lactation were used to compare the digestibility of a complete ration containing 15-percent ground sugarcane bagasse and 85-percent concentrates to that of a control ration involving whole sugarcane silage and a standard concentrates mixture. The average amounts of dry matter consumed daily were 11.31, 2.18, and 6.26 kg. for the complete ration, the silage, and the standard concentrates, respectively. The chromic oxide indicator method with 7 days for fecal samples collection was used.

The respective mean apparent digestibility coefficients determined for the complete and control rations were as follows: organic matter, 74.3 and 69.6; crude protein, 71.3 and 55.1; dry matter, 71.9 and 68.3; nitrogen-free extract, 80.7 and 76.6; ether extract, 70.0 and 67.3; crude fiber, 36.6 and 47.7; and total digestible nutrients, 72.2 and 69.2. The mean differences were highly significant ($P < .01$) for the first two components, significant ($P < .05$) for the second two components, but not significant for the final three components.

With data from the control ration, on which individual cows consumed varying proportions of silage-to-concentrates, linear regression coefficients, highly significant ($P < .01$) for TDN and significant ($P < .05$) for crude protein, were obtained employing digestibility as the dependent variable and the proportion of forage dry matter to total dry matter consumed as the independent variable. When adjusted to the basis of 15-percent forage dry matter in the total dry matter consumed, the control ration yielded a mean crude protein digestibility of 69.8 percent and a mean TDN content of 73.4 percent, very similar to the corresponding figures for the complete ration. Thus, at least in crude protein and TDN, the two rations can be considered equally digestible at a common forage-to-concentrates ratio.

RESUMEN

Se usaron 16 vacas Holstein y Suiza Parda en las postrimerías de su lactancia, para comparar la digestibilidad de una ración completa, compuesta de un 15 por ciento de bagazo triturado de caña de azúcar y un 85 por ciento de concentrados, con la de una ración testigo, preparada a base de ensilaje de caña de azúcar entera y un concentrado corriente. El consumo diario de materia seca en la ración completa, en el ensilaje, y en el alimento concentrado corriente promedió 11.31, 2.18 y 6.26 kg., respectivamente. Se usó el óxido crómico como indicador de digestibilidad, esperándose 7 días para recoger las boñigas (muestras fecales).

Se determinaron los coeficientes de digestibilidad aparente para la ración completa y la testigo, siendo los promedios respectivos los siguientes: materia orgánica, 74.3 y 69.6; proteína bruta, 71.3 y 55.1; materia seca, 71.9 y 68.3; extracto libre de nitrógeno, 80.7 y 76.6; extracto etéreo, 70.0 y 67.3; fibra bruta, 36.6 y 47.7; y los totales de nutrimentos digeribles, 72.2 y 69.2. Las diferencias entre los promedios de las dos raciones fueron altamente significativas ($P < .01$) para los dos primeros componentes, significativas ($P < .05$) para los dos componentes siguientes, pero no significativas para los tres últimos componentes citados.

Con los datos obtenidos de la ración testigo, bajo la cual las vacas individuales consumieron proporciones variables del ensilaje en relación con las del concentrado, se obtuvieron coeficientes de regresión lineal altamente significativos ($P < .01$) para el TND y significativos ($P < .05$) para la proteína bruta, al usarse la digestibilidad como una variable dependiente y la proporción de la materia seca procedente del forraje en relación con la materia seca total consumida, como variable independiente. Al hacerse un ajuste a base de un 15 por ciento de materia seca procedente del forraje en relación con la materia seca total consumida, la digestibilidad de la proteína bruta promedió 69.8 por ciento y el contenido del TND promedió 73.4 por ciento, siendo estas cifras muy similares a las cifras correspondientes en el caso de la ración completa. Por tal razón, las dos raciones pueden considerarse igualmente digestibles, a base de una proporción común de forraje a concentrado, al menos en lo referente a la proteína bruta y el TND.

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