THE JOURNAL OF AGRICULTURE
OF THE UNIVERSITY OF PUERTO RICO

Issued quarterly by the Agricultural Experiment Station of the University of Puerto Rico, for the publication of articles by members of its personnel, or others, dealing with any of the more technical aspects of scientific agriculture in Puerto Rico or the Caribbean Area.

Vol. L October 1966 No. 4

# Feeding Lactating Dairy Cows Concentrates and Sugarcane Bagasse As Compared with a Conventional Ration

*Paul F. Randel*[1]

## INTRODUCTION

The traditional method of feeding dairy cattle rations based primarily upon forages is not well suited to certain dairying areas, as for example areas which suffer frequent droughts and do not possess irrigation facilities, and those where land is too expensive to be devoted to forages. Since dairying areas with these limitations exist in Puerto Rico, it would be desirable to find an alternative means of feeding cows and not depend on forages. There is also a need to develop rations which would enable the establishment of large dairying enterprises on farms of limited acerage. The present experiment was therefore undertaken to test one such ration, one based upon concentrate feeds and sugarcane bagasse and not employing forages of any kind. A preliminary evaluation was made of its nutritional merit and of its economic feasibility.

## REVIEW OF LITERATURE

Rations employing very high proportions of concentrate feeds or even all-concentrate rations are now being used successfully for finishing beef cattle (*10,13*)[2]. This type of ration is not suitable for dairy cows, however, because it causes a marked depression in milk-fat percentage, as well as adverse physiological effects which may shift the animal into a fattening type of metabolism and shorten its productive life (*6*). Although the depression in milk-fat percentage can be corrected by the addition of about 1 pound of bicarbonates to the ration (*3*), the other physiological derangements can apparently be rectified only by the inclusion of a certain minimum of fiber. Kesler and Spahr (*6*) have estimated that not less than 13 or 14 percent of the dry matter consumed by the cow should be crude fiber.

[1] Associate Nutritionist, Agricultural Experiment Station, University of Puerto Rico, Lajas Substation, Lajas, P.R. The author wishes to thank Miguel A. Negrón Weber for performing chemical analyses on the feed and milk samples.

[2] Italic numbers in parentheses refer to Literature Cited, pp. 268–9.

The idea of using a single mixture containing some source of fiber as a complete feed for dairy cows has been successfully applied. Olson (*9*) used a mixture consisting of 30-percent coarsely ground hay and 70-percent concentrates containing 16 percent of crude protein. This complete feed was given *ad libitum* and compared with rations of limited concentrates and *ad libitum* hay, or *ad libitum* concentrates and *ad libitum* hay. Twelve cows were used in a double-reversal design with 5-week periods. The cows on the complete feed consumed 36.9 pounds of the mixture daily and produced 43.4 pounds of milk. Though the cows fed *ad libitum* concentrates consumed more feed, they produced no more milk than the cows on the complete feed. The limited-concentrate ration resulted in less milk production and in lower milk-protein content than did the other two rations. Milk-fat percentage was depressed by *ad libitum* concentrates, but not by the complete feed, even though the ratio of concentrates to hay consumed was similar under both treatments. However, Emery *et al.* (*5*) found that 20-percent forage in the form of ground or chopped hay or ground corncobs was insufficient in a complete mixed ration to maintain normal milk-fat percentage.

One possible source of fiber available in great quantities in Puerto Rico is sugarcane bagasse. Though bagasse is not usually fed to dairy cattle, its value as a component in rations for beef cattle has been established. Kirk *et al.* (*7*) mixed 20-percent chicken-litter bagasse ground through a ½-inch screen with concentrate ingredients to make mixtures containing 16.7 percent of crude fiber and 7.7 percent of digestible protein. When these mixtures were fed *ad libitum*, along with only a small amount of hay or silage, to steers and heifers in two trials, the average amount consumed was about 25 pounds daily, and the resulting live-weight gains averaged about 2.5 pounds daily. Since sugarcane bagasse combines well with concentrates in rations for beef cattle there is reason to believe that it might also be well suited to rations for dairy cattle.

## MATERIALS AND METHODS

This experiment consisted of a continuous feeding trial, which was divided into three periods and extended over the greater part of one lactation. It was conducted to compare a conventional ration with a ration based solely upon concentrate feeds and sugarcane bagasse.

### ANIMALS

The animals used in this experiment were seven Brown Swiss and nine Holstein cows from the Lajas Substation herd which calved during the period from September 25 to December 12, 1964. These cows were selected because they fulfilled the requirement of achieving a milk-production level

of at least 35 pounds daily by the third week of lactation. The characteristics—breed, age, and milk production during early lactation were considered in assigning the 16 cows to 2 groups as nearly alike as possible. One group was subjected to each of the two treatments employed in the experiment.

### EXPERIMENTAL PERIODS

Each cow started upon the experiment on the third day of lactation. The period including days 3 to 21 of lactation constituted the preliminary period. At the end of this period the cows were assigned to their respective treatments. The following 4-week period, including days 22 to 49 of lactation, constituted the adjustment period. This was followed by a 30-week comparison period extending from day 50 to day 259 of lactation.

During the preliminary period all of the cows were subjected to the same treatment. They were maintained in stanchions equipped with watering cups in a shade barn between morning milking (6 to 7 a.m.) and afternoon milking (2 to 3 p.m.) and were at pasture during the remaining hours. While in the stanchions they received all but 4 pounds of their daily allowance of concentrates, the rest being given in the milking parlor, and as much harvested forage as they would eat. Each cow was supplied a daily allowance of the standard concentrates mixture (table 1) equal to one-half the number of pounds of milk she had produced the preceding day. The harvested forage consisted of either green chopped sorghum (*Sorghum vulgare*), green chopped merkergrass (*Pennisetum purpureum*), or sorghum silage. The pasture available to the cows was mostly in fields which had been neither fertilized nor irrigated and thus was not of very high nutritive value. It consisted mostly of the native pajongrass (*Andropongon annulatus*).

During the adjustment period the cows of the control group were subjected to the same treatment as during the preliminary period, with the sole exception that the daily allowances of concentrates were adjusted at 10-day intervals employing the Maryland Feeding Standards (*4*). During the same period the cows assigned to the experimental treatment were placed in stanchions for several hours daily while they consumed an allowance of harvested forage which decreased from 15 to 10 to 5 to 0 pounds during the 4 successive weeks. The rest of the time these cows were maintained in a pen which was located under a roof, paved, and provided with watering cups. Here they were offered a mixture of concentrates and ground sugarcane bagasse (table 1) in unrestricted amounts in one manger and loose unground bagasse in another manger. They were also offered 2 pounds of standard concentrates mixture at each milking in accordance with the usual milking procedure.

Throughout the comparison period the control cows continued under the

same conventional treatment as in the preceding period. Of the total 1,680 cow-days of the comparison period under the control treatment, green chopped merkergrass was fed on only 18 days, while sorghum silage and

TABLE 1.—*Percentages of ingredients in the concentrate mixtures and percentages of proximate chemical components (dry-matter basis) in the feeds of the cows on experiment*

| Ingredient | Concentrate mixture | |
|---|---|---|
| | Standard | With bagasse |
| Ground shelled corn[1] | 35.5 | 45.20 |
| Yellow hominy feed | 35.5 | — |
| Dehulled soybean oilmeal | 10.0 | 22.50 |
| Fishmeal | 5.0 | — |
| Cane molasses | 12.5 | 15.00 |
| Ground bagasse[1] | — | 15.00 |
| Dicalcium phosphate | — | 1.00 |
| Salt | 1.5 | .75 |
| Sodium bicarbonate | — | .50 |
| Vitamin supplement[2] | — | .05 |

| Proximate analysis in percentage | Feed | | | | |
|---|---|---|---|---|---|
| | Standard concentrates | Concentrate with bagasse | Green chopped merker-grass | Sorghum silage | Sugarcane silage |
| Number of samples | 6 | 15 | 1 | 4 | 2 |
| Components:[3] | | | | | |
| Dry matter | 87.3 ± 1.4 | 87.2 ± 1.1 | 22.2 | 23.8 ± 1.1 | 24.8 ± 0.3 |
| Crude protein | 16.1 ± 1.3 | 17.7 ± 1.0 | 7.8 | 5.6 ± 1.6 | 3.6 ± 0.1 |
| Ether extract | 3.8 ± 1.1 | 2.6 ± 0.7 | 1.8 | 2.7 ± 0.5 | 2.1 ± 1.0 |
| Crude fiber | 2.0 ± 0.2 | 9.7 ± 0.9 | 38.1 | 38.5 ± 2.4 | 36.1 ± 1.0 |
| Ash | 6.4 ± 1.1 | 6.8 ± 0.7 | 10.4 | 10.6 ± 0.4 | 6.3 ± 0 |
| Nitrogen-free extract | 71.7 ± 1.7 | 63.2 ± 1.5 | 41.9 | 42.6 ± 1.4 | 51.9 ± 1.9 |

[1] Ground to pass a 3/16-inch screen.

[2] Supplied by Dawe's Laboratories and containing 1,000,000 I.U. of vitamin A, 100,000 I.U. of vitamin D, and 10,000 I.U. of vitamin E per pound.

[3] The figures presented are means and standard deviations, except in the case of the single observation for merkergrass.

sugarcane (*Sacharum oficinarum*) silage were fed on 1,189 and 473 days, respectively.

The cows under the experimental treatment were confined to their pen all the time during the comparison period except for two daily trips to the

milking parlor. They were fed the concentrates-bagasse mixture *ad libitum* for several months while they were at or near peak production; later on the amount given was limited to 30 to 40 pounds per head daily.

### FEED SAMPLES AND COSTS

A sample was obtained from each batch of the concentrates-bagasse mixture prepared, while the standard concentrates mixture and harvested forages were sampled at intervals. No attempt was made to sample the pasture forage. The feed samples were subjected to proximate analysis according to A. O. A. C. procedures (*1*).

The feed costs under each treatment were calculated from the daily record of feed consumption and the estimated costs of each feed. The standard-concentrates mixture and the concentrates-bagasse mixture were prepared at the substation from purchased ingredients. To the cost of ingredients was added 20 cents for the standard mixture and 40 cents for the concentrates-bagasse mixture per 100 pounds, to allow for the cost of grinding corn and bagasse and of mixing the various ingredients. The average total cost per 100 pounds was $3.80 for the standard mixture and $4.00 for the concentrates-bagasse mixture. The bagasse used for grinding and mixing with concentrates was chicken-litter bagasse purchased in dried and baled form, whereas the loose bagasse was whole untreated bagasse, and was obtained free of charge. The cost of the harvested forages was estimated as 50 cents per 100 pounds, while that of pasture was estimated as 10 cents per head per grazing day. The latter figure corresponds to that used for the unimproved pastures of the present experiment, and is considerably lower than the cost which would prevail if pasture-improvement practices were followed.

### MILK WEIGHTS AND SAMPLES

The milk produced at each milking was weighed in a milk-metering device to the nearest 0.25 pound. The milk was sold at the price of $7.80 per 100 pounds without regard to its fat content.

A sample of milk from four consecutive milkings was obtained from each cow on days 20 and 21 of lactation (end of the preliminary period), again on days 48 and 49 of lactation (end of adjustment period), and thereafter on seven occasions at 4-week intervals during the comparison period. On each occasion three parts of afternoon milk were combined with five parts of morning milk in order to make the samples approximately aliquot. The contents of fat, protein, and solids-not-fat in the samples were determined by the Babcock (*1*), Kjeldahl (*1*), and Watson lactometer methods (*12*), respectively.

### BODY-WEIGHT DETERMINATIONS

Each cow was weighed before the morning milking on day 50 and again on day 260 of lactation to permit calculation of body-weight change during the comparison period. On both occasions the animals spent at least the preceding 15 hours in an area where neither feed nor water was available. The pounds of milk produced at the milking immediately following the body-weight determination were subtracted from the gross body weight to arrive at the net shrunk weight Each of these weights was recorded to the nearest pound.

### STATISTICAL ANALYSIS

The data from the comparison period pertaining to milk production and percentages of fat, protein, solids-not-fat, and total solids in the milk were subjected to analysis of covariance with adjustment for the corresponding data from the preliminary period. The data pertaining to body-weight change during the comparison period were analyzed by the unpaired *t* test. Both types of analysis were performed according to the procedures of Snedecor (*11*).

## RESULTS AND DISCUSSION

### FEED CONSUMPTION, MILK PRODUCTION, AND BODY-WEIGHT CHANGES

No feed-consumption data were recorded during the preliminary period. During the adjustment period the control cows consumed an average of 22.0 pounds of standard concentrates mixture daily, while the experimental cows gorged themselves on 43.1 pounds of concentrates-bagasse mixture. This demonstrated conclusively that the latter mixture was very palatable. During this period the control cows were offered only 14.6 pounds of harvested forage daily, yet they left forage uneaten, consuming only 9.4 pounds. The low consumption of harvested forages can be ascribed to mediocre palatability and to the fact that these forages were offered during the same hours of the day as was the concentrates mixture, the cows preferring to consume the latter. The amount of pasture forage consumed is unknown. The experimental cows also left harvested forage uneaten, consuming only about 60 percent of that offered.

During the comparison period the control cows consumed 18.5 pounds of standard-concentrates mixture daily (table 2). They were offered 26.1 pounds of harvested forage, but consumed only 19.8 pounds daily.[3] The experimental cows consumed 41.6 pounds of concentrates-bagasse mixture

[3] The amount of harvested forage offered rather than the amount consumed is given in table 2, because, in calculating feed costs, it was assumed that unconsumed forage was wasted.

daily during the comparison period. The average would have been higher if *ad libitum* feeding had not been stopped after slightly more than half of the comparison period had elapsed. The peak daily consumption recorded was 50 pounds per cow. The experimental cows usually consumed either none or only a part of the 4 pounds of concentrates which they were offered daily during milking. The practice of feeding them at this time was apparently unnecessary.

TABLE 2.—*Feed consumption (pounds), feed costs (dollars), and income returned above feed costs (dollars) during the comparison period of cows on experiment*

| Item | Treatment | | | |
|---|---|---|---|---|
| | Control | | Experimental | |
| | Total | Per cow-day | Total | Per cow-day |
| Standard concentrates mixture | | | | |
| Amount consumed | 31,015.2 | 18.5 | 3,360.0 | 2.0 |
| Cost per 100 lb. | 3.80 | 3.80 | 3.80 | 3.80 |
| Total cost | 1,178.58 | .70 | 127.68 | .08 |
| Concentrates-bagasse mixture | | | | |
| Amount consumed | None | None | 69,953.5 | 41.6 |
| Cost per 100 lb. | — | — | 4.00 | 4.00 |
| Total cost | — | — | 2,798.14 | 1.67 |
| Harvested forage | | | | |
| Amount consumed | 43,887.0 | 26.1 | None | None |
| Cost per 100 lb. | .50 | .50 | — | — |
| Total cost | 219.44 | .13 | — | — |
| Pasture | | | | |
| Number of cow-days | 1,680.0 | 1.0 | None | None |
| Cost per cow-day | .10 | .10 | — | — |
| Total cost | 168.00 | .10 | — | — |
| Overall feed costs | 1,566.02 | .93 | 2,925.82 | 1.74 |
| Income from milk | 4,678.36 | 2.78 | 6,204.25 | 3.69 |
| Income above feed costs | 3,112.34 | 1.85 | 3,278.43 | 1.95 |
| Feed costs per 100 lb. milk produced | 2.61 | — | 3.67 | — |

However, since some accounting of the concentrates given to these cows during milking was required, it was assumed that they had eaten half of that offered. After being subjected to their treatment for several weeks the experimental cows developed a decided craving for forage and attempted to steal mouthfuls of it whenever possible. In spite of this they showed very little interest in the loose bagasse offered to them. Bagasse recently brought from the mill, which was still humid, was consumed in small amounts. However, after the same bagasse had dried out, the cows no longer consumed it.

The milk-producing potentials of the two groups were similar, as shown by the average daily productions during the preliminary period when both received the same treatment (table 3). The milk of the experimental cows, however, had a higher content of total solids than did the milk of the control cows. The difference was due mainly to higher fat content in the former. In solids-not-fat content the difference between groups was less pronounced.

The average daily milk production of the control cows increased 3.2 pounds during the adjustment period over the preliminary period. By contrast, the milk production of the experimental cows showed a marked increase of 12.1 pounds daily. Milk composition in the control cows showed

TABLE 3.—*Mean daily milk production and mean percentages of milk components of cows on experiment*

| Treatment and period | Daily milk production | Fat content | Protein content | Solids-not-fat content | Total solids content |
|---|---|---|---|---|---|
| | *pounds* | *Percent* | *Percent* | *Percent* | *Percent* |
| Preliminary period: | | | | | |
| Control | 44.2 | 2.83 | 2.97 | 8.70 | 11.52 |
| Experimental | 41.7 | 3.28 | 3.08 | 8.92 | 12.20 |
| Adjustment period: | | | | | |
| Control | 47.4 | 2.84 | 2.87 | 8.78 | 11.61 |
| Experimental | 53.8 | 3.20 | 3.38 | 9.45 | 12.65 |
| Comparison period: | | | | | |
| Control | 35.7[1] | 3.16 | 3.09[1] | 8.76[1] | 11.92[2] |
| Experimental | 47.4 | 3.32 | 3.59 | 9.37 | 12.69 |

[1] Difference between treatments highly significant ($P < .01$) with covariance adjustment for corresponding data from the preliminary period.

[2] Difference between treatments significant ($P < .05$) with covariance adjustment for corresponding data from the preliminary period.

little difference between the preliminary and the adjustment periods. However, in the experimental cows there occurred a sharp increase in milk solids-not-fat content and in the protein fraction of the nonfat solids during the comparison period, though fat content was essentially unaffected.

During the comparison period the control cows maintained an average daily milk production 11.7 pounds below that of the experimental cows (table 3). This difference was found to be highly significant ($P < .01$) by covariance analysis, using milk production during the preliminary period as the independent variable. Since the comparison period included both a phase when the cows were at peak production and a phase when they were declining in production, an estimate of the effect of treatments on persistency of lactation was desired. Therefore a persistency index was calculated by dividing the amount of milk produced during the second 105 days of the

comparison period by the amount produced during the first 105 days. The same index figure of 0.77 was found for both treatments. Thus the experimental treatment increased peak production, but did not change lactational persistency. Brown *et al.* (*2*) reported nearly the opposite effect of increased concentrates feeding on the lactation curve, *i.e.*, a slight initial increase in production and increased persistency throughout a 260-day experimental period.

The experimental cows showed an average milk-fat content during the comparison period which was 0.16 percent higher than that of the control cows (table 3), but by covariance analysis this difference was not significant. It is interesting that, in this study, the mixture containing 15 percent of bagasse combined with 0.5 percent of sodium bicarbonate maintained normal milk fat content, whereas the complete ration containing 20 percent forage employed by Emery *et al.* (*5*) was unable to do so.

TABLE 4.—*Mean changes in body weight (pounds) of the cows on experiment during the comparison period*

| Treatment | Initial weight | Final weight | Total gain | Gain per day |
|---|---|---|---|---|
| Control | 1,055 | 1,118 | 63 | 0.30[1] |
| Experimental | 1,102 | 1,266 | 164 | .78 |

[1] Difference between treatments significant ($P < .05$).

The difference between treatments in average milk protein and solids-not-fat contents during the comparison period were 0.50 and 0.61 percent, respectively, in favor of the experimental treatment. These differences were highly significant ($P < .01$). The finding that the increased level of net-energy intake under the experimental treatment resulted in production of milk with increased contents of protein and solids-not-fat is in agreement with the results of other investigators (*8*). The difference between treatments of 0.77 percent in average milk total-solids content during the comparison period was significant ($P < .05$).

The experimental cows consumed sufficient net energy to enable themselves to undergo a considerable degree of fattening in addition to giving high milk yields. The difference between treatments of 0.48 pound in average daily live-weight gain during the comparison period (table 4) was significant ($P < .05$).

The beneficial influence of the experimental treatment on milk production was obvious, but an accounting of feed costs is necessary to establish whether the increased production was achieved economically. The over-all feed costs were nearly twice as high under the experimental treatment as

under the control treatment (table 2). When the over-all feed costs were computed per 100 pounds of milk produced it was shown that the experimental treatment constituted a more expensive feeding regimen for milk production than did the control treatment.

However, even though there was less return per unit of milk produced, there were more units produced under the experimental treatment. When the overall feed costs were subtracted from the value of all of the milk produced it was found that the experimental treatment resulted in a slightly greater return. The question as to the economic advisability of feeding the concentrates-bagasse mixture has not been settled conclusively by these results. This system of feeding appears promising for use with cows of high productive potential, but less so for use with cows of low inherent productivity.

There may be means by which the cost of the concentrates-bagasse mixture could be lowered without decreasing its nutritional efficiency. The average crude-protein content of the mixture used in this study was 17.7 percent (table 1). Such a high level should not be needed in a complete ration, and the use of less soybean-oil meal would lower the cost of the mixture. It may be feasible to utilize greater amounts of inexpensive molasses in the mixture.

Furthermore, the bagasse mixed with the concentrate ingredients in the present experiment was purchased at the extremely high price of $2.50 per 100 pounds. It should be possible to find bagasse adequate for this purpose at a lower price. It also appears that a higher percentage of bagasse is needed in the mixture. This would produce two beneficial results, *viz.*, make the mixture less costly and increase the crude fiber content. The latter appears necessary, judging from the marked craving for forage which the experimental cows developed. The average crude-fiber content of the mixture used in this study (9.7 percent) was below the suggested minimum level (*6*).

If a concentrates-bagasse complete ration could be used on a commercial scale it would provide several economic advantages over the conventional system aside from feed costs. It would eliminate the dependence of the feed supply on rainfall, eliminate the machinery and labor needed for planting and harvesting forages, and greatly reduce the land area needed for the maintenance of dairy cattle.

### HEALTH PROBLEMS

Several health problems of various types were encountered in this study. One cow of the control group was removed from the herd with cancer shortly after completing the experiment. The developing disease apparently did not affect her performance on the experiment, however. Her appetite remained normal and her index of lactational persistency was higher than

the group average. Therefore, data from this cow were included in the statistical analysis.

The incidence of clinical mastitis was higher in the experimental than in the control cows. Four of the experimental and only one of the control cows had mastitis during the experiment. These 4 experimental cows contracted mastitis a total of 11 times, with 10 of the cases occurring during the comparison period. A total of 108 days was recorded when some quarter of some of the cows of this group showed mastitis, which represents 6.4 percent of the total number of cow-days in the comparison period. The one control cow was affected on five different occasions during the comparison period for a total of 66 days, representing 3.9 percent of the total number of cow-days for the group. The control cow was the only one to lose a quarter from mastitis.

There was a tendency for the experimental cows to produce loose feces. Cases of true diarrhea or indigestion were encountered in four of the experimental cows. The affected animals were treated with limewater and always returned to normal within a few days. No troubles of this sort were encountered among the control cows.

A condition of stiffness developed in five of the experimental cows. However, it is difficult to decide whether this resulted from the ration or the housing facilities. When a layer of sand was placed over the concrete floor of the pen the stiff animals showed improvement. Even though the experimental cows moved slowly and deliberately most of the time, they sometimes showed excitability during milking, at which time they would shake their hips vigorously. Another effect of the experimental treatment appeared to be that of inducing excessive drinking and frequent urination.

While it did not appear that the health problems encountered in the experimental cows were very serious, it is not known whether any detrimental effects were produced on the liver and rumen of these animals, as often occurs in beef cattle on all-concentrate rations (*13*). The effects on the cow of the concentrate-bagasse ration over a long period of time remain to be determined. The cows of the present experiment are therefore being kept under their respective treatments, and will be used to study the responses during a second consecutive year.

## SUMMARY

Seven Brown Swiss and nine Holstein cows, which attained a milk-production level of at least 35 pounds daily by the third week of lactation, were divided into two groups as nearly alike as possible. During the preliminary period, days 3 to 21 of lactation, all cows received the same standard concentrates mixture: 1 pound per 2 pounds of milk produced, plus green chopped grass or silage *ad libitum*, and nighttime grazing mostly on unim-

proved pastures. During the comparison period, days 22 to 49 of lactation, the control cows continued under the same conventional ration, except that concentrate allowances were adjusted by the Maryland Feeding Standards, while the experimental cows were fed a mixture containing 15 percent of sugarcane bagasse and 85 percent of concentrates *ad libitum*, along with decreasing amounts of harvested forage with no pasture. During the comparison period, days 50 to 259 of lactation, the control cows were treated as in the preceding period, while the experimental cows received only the concentrate-bagasse mixture, plus standard-concentrates mixture (during milking) and loose unground bagasse.

Average daily feed consumptions per cow in the comparison period were, for the control cows, 18.5 pounds of concentrates, 19.8 of harvested forage, and an unknown amount of pasture forage, and for the experimental cows, 41.6 pounds of concentrate-bagasse mixture, an estimated 2 of standard-concentrates mixture, and irsignificant amounts of loose bagasse.

Average daily milk productions by the control and experimental cows, respectively, were as follows: Preliminary period, 44.2 and 41.7; adjustment period, 47.4 and 53.8; and comparison period, 35.7 and 47.4 pounds. Average percentages of components in the milk of control and experimental cows, respectively, during the comparison period were as follows: Fat, 3.16 and 3.32; protein 3.09 and 3.59; solids-not-fat, 8.76 and 9.37; and total solids, 11.92 and 12.69.

The differences in favor of the experimental treatment in milk production, milk-protein content, and milk solids-not-fat content were shown to be highly significant ($p < .01$) and the difference in milk total-solids content was shown to be significant ($P < .05$) by covariance analysis with adjustment for the corresponding data from the preliminary period.

Average daily live-weight gain during the comparison period was 0.30 in the control cows and 0.78 pound in the experimental cows, the difference being significant ($P < .05$).

Overall feed costs per 100 pounds of milk produced during the comparison period were estimated as $2.61 and $3.67 under the control and experimental treatments, respectively. Corresponding cost figures per cow per day were $0.93 and $1.74. However, income from milk produced above feed costs per cow per day was slightly higher under the experimental treatment, $1.95, than under the control treatment, $1.85. The cost of the concentrates-bagasse mixture might be reduced by including less soybean-oil meal and more molasses and bagasse in the mixture, and/or by using a cheaper source of bagasse than was employed in the present experiment.

Health problems encountered in the experimental cows included slightly greater incidence of mastitis, sporadic occurrence of diarrhea, stiff joints,

and excessive drinking and urination. Further studies are needed to establish the long-term effects of this type of ration on the health of dairy cows.

It is concluded that the use of a complete ration for lactating dairy cows, based upon concentrates and sugarcane bagasse, is feasible from a nutritional standpoint, and may be reasonable from a cost standpoint.

## RESUMEN Y CONCLUSIONES

Siete vacas de la raza Pardo Suiza y 9 de la raza Holstein, cuya producción de leche no bajó de 35 libras diarias durante las tres primeras semanas de lactancia, se dividieron en dos grupos similares. Durante el período preliminar, desde el tercer dia hasta el día 21 de lactancia, todas las vacas recibieron la misma ración. Esta consistió de alimento concentrado corriente (a razón de 1 libra por cada 2 libras de leche producidas), más toda la yerba verde cortada o ensilaje que apetecieran los animales, y pastoreo de noche, principalmente en pastos no mejorados. Durante el período de ajuste, desde el día 22 hasta el 49 de lactancia, las vacas del grupo testigo continuaron con la misma ración, salvo que la cantidad de alimento concentrado se reguló según las Guias de Maryland, mientras que las vacas del grupo experimental recibieron una mezcla de un 15 por ciento de bagazo de caña molido y un 85 por ciento de alimentos concentrados según lo apetecieran los animales, más una cantidad de forraje reducida gradualmente y ningún pasto. Durante el período comparativo, desde el día 50 hasta el 259 de lactancia, las vacas del grupo testigo recibieron el mismo tratamiento que en el período anterior, mientras que las vacas del grupo experimental recibieron únicamente la mezcla de alimentos concentrados y bagazo, más alimento concentrado corriente (durante el ordeño) y bagazo suelto, sin moler.

El consumo diario promedio, por vaca, durante el período comparativo fue como sigue: Las vacas del grupo testigo consumieron 18.5 libras de alimento concentrado, 19.8 libras de forraje cosechado, y una cantidad indeterminada de pasto; y las vacas del grupo experimental, 41.6 libras de alimento concentrado con bagazo, alrededor de 2 libras de alimento concentrado corriente y una cantidad insignificante de bagazo suelto. La producción promedio en libras de leche por día, de las vacas del grupo testigo y del grupo experimental, respectivamente, fue como sigue: Durante el período preliminar, 44.2 y 41.7; durante el período de ajuste, 47.4 y 53.8; y durante el período comparativo, 35.7 y 47.4. El porcentaje promedio de los componentes de la leche de las vacas del grupo testigo y del grupo experimental, respectivamente, durante el período comparativo, fue como sigue: Grasa, 3.16 y 3.32; proteína, 3.09 y 3.59; sólidos-no-grasos, 8.76 y 9.37; y sólidos totales, 11.92 y 12.69. Las diferencias a favor del

tratamiento experimental en cuanto a producción de leche, contenido de proteína y contenido de sólidos-no-grasos fueron altamente significativas ($p < .01$), y la diferencia en cuanto al contenido de sólidos totales fue significativa ($P < .05$), cuando se hicieron los análisis de covarianza, haciendo los ajustes correspondientes a los datos del período preliminar. El promedio de aumento en el peso vivo, por día, durante el período comparativo fue de 0.30 libra en las vacas del grupo testigo y 0.78 libra en las vacas del grupo experimental, siendo ésta una diferencia significativa ($P < .05$).

Los costos totales de alimentación por cada 100 libras de leche producidas se estimaron en $2.61 y $3.67 para los tratamientos testigo y experimental, respectivamente. Los costos correspondientes por vaca, por día, fueron de $0.93 y $1.74. Sin embargo, el ingreso por concepto de leche producida, después de descontar el costo de la alimentación por vaca, por día, fue un poco mayor en el caso del tratamiento experimental ($1.95) que en el del tratamiento testigo ($1.85). Es posible que se pueda rebajar el costo de la mezcla de alimentos concentrados y bagazo, usando menos harina de soya y más miel y bagazo en la mezcla, y obteniendo el bagazo de una fuente más barata que la que se usó en este experimento.

La salud de las vacas del grupo experimental fue más afectada por una incidencia de mastitis, casos ocasionales de diarrea, tiesura de las articulaciones, y una tendencia excesiva a beber y orinar. Es necesario hacer otros estudios para determinar los efectos que a la larga pueda tener este tipo de ración sobre la salud de las vacas lecheras.

Se concluye que es posible usar una ración completa para vacas lactantes, a base de alimentos concentrados y bagazo de caña, que reúna los requisitos de una buena nutrición y que además sea económicamente factible.

## LITERATURE CITED

1. Assoc. Offic. Agr. Chem., Official Methods of Analysis, 9th ed., Washington, D.C., 1960.
2. Brown, L. D., Thomas, J. W., Emery, R. S., McGilliard, L. D., Armstrong, D. V., and Lassiter, C. A., Effect of high-level grain feeding on milk production response of lactating dairy cows, *J. Dairy Sci. 45:* 1184–7, 1962.
3. Davis, C. L., Brown, R. E., and Beitz, D. C., Effect of feeding high-grain restricted-roughage rations with and without bicarbonates on the fat content of milk produced and proportions of volatile fatty acids in the rumen, *J. Dairy Sci. 47:* 1217-9, 1964.
4. Davis, R. F., Hemken, R. W., Cason, J. L., Vandesall, J. H., and Caskey, C. D., Maryland Feeding Standards for Dairy Cattle, Md. Agr. Exp. Sta. M.P. 481, 1963.
5. Emery, R. S., Brown, L. D., and Thomas, J. W., Comparison of corn cobs and hay in ground, restricted-roughage rations affecting milk composition, *J. Dairy Sci. 47:* 1322–4, 1964.
6. Kesler, E. M., and Spahr, S. L., Physiological effects of high level concentrate feeding, *J. Dairy Sci. 47:* 1122–8, 1964.

7. Kirk, W. G., Peacock, F. M., and Davis, G. K., Utilizing bagasse in cattle fattening rations, Fla. Agr. Exp. Sta. Bull. 641, 1962.
8. Laben, R. C., Factors responsible for variation in milk composition, *J. Dairy Sci. 46:* 1293–301, 1963.
9. Olson, H. H., A complete feed for dairy cows? *Hoard's Dairyman 110:* 603–11, 1965.
10. Oltjen, R. R., Davis, R. E., and Hiner, R. L., Factors affecting performance and carcass characteristics of cattle fed all-concentrate rations, *J. Anim. Sci. 24:* 192–202, 1965.
11. Snedecor, G. W., Statistical Methods, 5th. ed., Iowa State College Press, Ames, Iowa, 1956.
12. Watson, P. D., Determination of the solids in milk by a lactometric method at 102°F., *J. Dairy Sci. 40:* 394–402, 1957.
13. Wise, M. B., Blumer, T. N., Craig, H. B., and Barrick, E. R., Influence of rumen buffering agents and hay on the performance and carcass characteristics of steers fed all-concentrate rations, *J. Anim. Sci. 24:* 83–8, 1965.