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Molasses, Cassava and Cottonseed Meal as Supplements to Fresh and Ensiled Sugarcane Tops

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Antônio Leandro Estima, Giovani Carício Caldas, Sílvio Parente Viana and Manuel Francisco de Morais Cavalcante; Arthur Roberto L. de Carvalho and Maria Sales Farias; and Glen P. Lofgreen

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MOLASSES, CASSAVA AND COTTONSEED MEAL AS SUPPLEMENTS TO FRESH AND ENSILED SUGARCANE TOPS[1]

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Summary

Experiments were conducted to determine the growth response of Holstein and Zebu cattle to supplemented and unsupplemented fresh or ensiled sugarcane tops. Supplements studied were molasses, cassava and cottonseed meal. Gains made by cattle fed unsupplemented silage were significantly lower than those on unsupplemented fresh cane tops. Data on energy utilization, however, indicated the problem was one of palatability and not nutrient utilization. Fresh cane tops alone maintained body weight while cattle receiving silage lost weight.

Neither molasses nor roots of cassava fed at the rate of 0.5 kg. per 100 kg. of body weight had any stimulatory effect as a supplement to cane tops. Cottonseed meal, on the other hand, caused a stimulation of 0.78 kg. per head per day when fed at the same rate.

Net energy values for maintenance and for production were determined for cane tops and for cottonseed meal by a comparative slaughter technique using the specific gravity of the carcasses of an initial sample group and all animals slaughtered at the end of the study. The net energy for maintenance of cane tops, either fresh or ensiled, was 1.04 megcal. per kg. of dry matter, while the net energy for production was 0.46 megcal. per kg. of dry matter. The corresponding values for cottonseed meal

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were 1.62 and 1.27 megcal. per kg. of dry matter. Thus, for maintenance, cane tops were worth 64% of cottonseed meal as an energy source, but for production cane tops were worth only 36% the value of cottonseed meal.

Introduction

Despite the fact that it is known that sugarcane tops are deficient in protein[6] as a feed for beef cattle, little work has been done to determine the actual quantitative response produced by a given amount of protein supplement. Molasses and cassava roots are readily available in Brazil as carbohydrate supplements for cattle feeding. The quantitative response of cattle fed cane tops and either molasses or cassava roots without a protein supplement has not been determined. It seemed desirable, therefore, to determine if animals can utilize cane tops plus either molasses or cassava without a protein supplement and to determine the quantitative response produced by a protein supplement.

Since the availability of cane tops for cattle feeding is seasonal, it also seemed desirable to determine if ensiled cane tops would produce the same response as fresh cane tops.

It is generally recognized that net energy (NE) expresses the useful energy content of feeds more accurately than any other measure. No information is available, however, on the NE content of cane tops or of cottonseed meal used as a supplement to cane tops. Such information would be of value in comparing the relative usefulness of feeds.

It is often claimed that on low protein rations Zebu animals perform better than animals of European blood. Since fresh or ensiled cane tops alone or with molasses or cassava are low protein rations, the opportunity was available to compare the two types of cattle on low and adequate protein rations.

The objectives of the study herein reported were:

1. To determine the quantitative response produced by a protein supplement fed to beef cattle receiving cane tops.
2. To determine if beef cattle will gain on cane tops plus carbohydrate supplements of molasses or cassava roots.
3. To compare fresh and ensiled cane tops when fed to beef cattle.
4. To determine the net energy of cane tops and of cottonseed meal.
5. To compare Zebu and Holstein cattle on low and adequate protein rations.

Experimental Procedure

The experiment was conducted at the cattle feeding facility at the Cedro Experiment Station in Vitória de Santo Antão from January 31 to May 22, 1966, a period of 112 days. Plate 1 shows a view of the feeding shed and feed room of this facility.

Twenty-four Holstein cattle averaging 264 kg. in

Plate 1. View of the cattle feeding facility at the Cedro Experiment Station.

body weight and 24 Zebu cattle averaging 246 kg. were assigned to the experiment, the design of which is shown in Table 1. One animal in each outcome group of three was a steer, while the other two were bulls. Six representative animals were selected at random within breed for the initial slaughter group. The mean shrunk weight of the Holsteins slaughtered initially was 257 kg., and that of the Zebus was 251 kg.

Fresh cane tops were obtained near the station, and the silage was made with no preservative and stored in trench silos. The chopper used did not do an adequate job of chopping the leaves, and many went into the silo intact or merely shredded, which made packing difficult. The cane tops were also somewhat dry, having usually been allowed to remain in the field at least one day before being brought to the silo. Consequently, the silage was not of top quality. The fresh cane tops were chopped prior to feeding. Twice daily the supplements were fed on top of a small amount of chopped cane tops or silage and the animals allowed to eat this material before more roughage was fed. In this manner the supplements were fed at the predetermined level of 0.5 kg. per 100 kg. body weight, and cane tops or silage was fed *ad libitum*. Adjustments in the quantity of supplements were made at each weigh period of 28 days. Animals were weighed after an overnight stand without feed or water.

Prior to taking of the initial weight, all animals, including those to be slaughtered for initial body composition, were fed for a ten-day standardization period during which the ration consisted of a free-choice mixture of fresh cane tops and silage, 1.0 kg. of molasses, 1.5 kg. of cottonseed meal, 40 g. of bone meal and 40 g. of enriched salt per head per day. Immediately after taking the initial weight, the animals were given their respective rations and the initial slaughter group was slaughtered the morning of the same day. Animals were fed in groups of three according to the outcome groups shown in Table 1. The warm carcass weights were made at the time of slaughter, and the underwater weights for the determination of

Plate 2. Technicians making underwater carcass weights for determination of carcass specific gravity.

specific gravity were taken after the carcasses were chilled for 24 hours. Plate 2 shows technicians making underwater weights of the carcasses of the initial slaughter groups. Calculations of empty body weight, body composition and the net energy values were determined by the comparative slaughter method described in the literature.[1,3]

TABLE 1. Design of experiment.

Roughage	Supplement	Breed: Holstein	Breed: Zebu
		No. of animals	
Ensiled cane tops	None	3	3
	Molasses	3	3
	Cassava roots	3	3
	Cottonseed meal	3	3
Fresh cane tops	None	3	3
	Molasses	3	3
	Cassava roots	3	3
	Cottonseed meal	3	3
Initial slaughter group		6	6

Results and Discussion

Feed Consumption, Weight Gain and Body Composition

Table 2 presents the feed consumption and shrunk weight gains of each outcome group of three animals. Analysis of variance revealed interactions of little consequence, and hence the significance of the main effects is shown in Table 3.

Significantly less dry matter was consumed by the animals eating silage compared with those eating fresh cane tops. This undoubtedly was a reflection of the poor quality of the silage. The lowered consumption of dry matter resulted in a significant reduction in daily gains.

The consumption of molasses and cassava each caused a significant reduction in dry matter intake. The extra nutrients from the supplements, however, were suf-

TABLE 2. Feed consumption and weight gains.

Treatment	Daily feed consumption				Daily shrunk weight gain
	As fed		Dry matter		
	Roughage	Supplement	Roughage	Supplement	
	kg.	kg.	kg.	kg.	kg.
Fresh cane tops					
Holstein					
No supplement	17.4	0	4.50	0	0.06
Molasses	14.9	1.43	3.86	1.06	−0.03
Cassava roots	15.9	1.30	4.14	0.70	0.05
Cottonseed meal	22.6	1.56	5.87	1.42	0.75
Zebu					
No supplement	16.2	0	4.21	0	0.10
Molasses	11.6	1.20	3.01	0.89	−0.04
Cassava roots	13.7	1.22	3.54	0.65	0.08
Cottonseed meal	21.1	1.45	5.49	1.32	0.87
Silage					
Holstein					
No supplement	10.2	0	4.01	0	−0.21
Molasses	8.0	1.34	3.14	1.00	−0.18
Cassava roots	9.0	1.32	3.49	0.71	−0.04
Cottonseed meal	13.1	1.38	5.10	1.26	0.57
Zebu					
No supplement	8.4	0	3.29	0	−0.27
Molasses	6.7	1.22	2.62	0.91	−0.2[illegible]
Cassava roots	7.1	1.21	2.78	0.65	−0.26
Cottonseed meal	12.3	1.33	4.75	1.21	0.60

TABLE 3. Comparison of main effects.

Treatment	Daily feed consumption				Daily shrunk weight gain
	As fed		Dry matter		
	Roughage	Supplement	Roughage	Supplement	
	kg.	kg.	kg.	kg.	kg.
Roughages:					
Fresh tops	16.7[a]	1.02	4.33[a]	0.76	0.23[a]
Silage	9.4[b]	0.98	3.65[b]	0.72	0 [b]
Supplements:					
None	13.0[a]	0	4.00[a]	0	−0.08[a]
Molasses	10.3[b]	1.30[a]	3.16[b]	0.97[a]	−0.12[a]
Cassava roots	11.4[c]	1.27[a]	3.49[c]	0.68[b]	−0.04[a]
Cottonseed meal	17.3[d]	1.44[b]	5.30[d]	1.31[c]	0.70[b]
Breed:					
Holstein	13.9[a]	1.04	4.26[a]	0.77	0.12
Zebu	12.1[b]	0.95	3.71[b]	0.70	0.11

[a,b,c,d] Means in the same comparison group having different superscripts are significantly different ($P < 0.05$).

ficient to offset the drop in roughage consumption so that there was no significant difference in weight gain. Neither of these supplements improved weight gains.

The consumption of cottonseed meal caused a marked increase in roughage consumption and weight gains. It is obvious that the protein deficiency is the primary limitation of cane tops since carbohydrate supplements such as molasses or cassava did not stimulate gains while cottonseed meal caused a marked increase.

The breed comparison indicates a significantly lower dry matter consumption for Zebus with no significant difference in daily gain, thus indicating better feed utilization by the Zebu animals.

Because of the obviously poor performance of the animals supplemented with molasses or cassava, only the check animals receiving no supplement and those supplemented with cottonseed meal were slaughtered at the termination of the experiment to determine empty body weight and energy gains.

Table 4 presents a summary of the main effects from the data accumulated from the comparative slaughter technique. It is of interest to compare the gain in shrunk

TABLE 4. Main effects from comparative slaughter data.

Item of interest	Roughage		Supplement		Breed	
	Fresh	Silage	None	Cottonseed Meal	Holstein	Zebu
Number of animals	12	12	12	12	12	12
Total shrunk weight gain, kg.	50[a]	19[b]	− 9[a]	78[b]	32	37
Total empty weight gain, kg.	35[a]	8[b]	−15[a]	57[b]	12[a]	30[b]
Reticulo-rumen fill, kg.	66	60	54[a]	72[b]	70[a]	56[b]
Energy gain, megcal.	135[a]	69[b]	14[a]	190[b]	55[a]	149[b]
Carcass weight, kg.	144[a]	122[b]	105[a]	160[b]	132	133
Empty body composition, %						
Fat	12.2	12.2	12.0	12.3	11.3[a]	13.1[b]
Protein	19.2	19.2	19.2	19.2	19.2	19.2
Water	63.9	63.9	64.1	63.8	64.8	63.0
Ash	4.7	4.7	4.7	4.7	4.7	4.7

[a,b] Means in the same main effect having different superscripts are significantly different ($P < 0.05$).

body weight and empty body weight. As previously noted, there was no significant difference in the shrunk weight gains made by Holsteins and Zebus. On the other hand, when empty body weight gains were measured, the Zebus gained significantly more. The reason for this is shown in the reticulo-rumen contents at slaughter. Holstein animals had significantly greater fill than Zebus. When shrunk body weight gain is the criterion of measurement, the gain of the Holstein cattle is overestimated in comparison to that of the Zebus. It is also noted that there is a significantly higher fill in the supplemented cattle and hence the shrunk weight gains tend to overevaluate the effects of cottonseed meal. A more valid comparison is the empty weight gains. It is also noted that the Zebu animals had a significantly higher final body fat than the Holsteins. This was not a reflection of the initial condition, as the initial fat was 9.9 and 8.6 percent for the Holsteins and Zebus respectively. These data clearly point out that care must be exercised in making far-reaching conclusions based on gain in shrunk weight, unless some measure of carcass response is also obtainable.

The quantitative response in empty body weight gain obtained from adding cottonseed meal is shown in Table 5. With fresh cane tops, a supplement of 0.5 kg. of cottonseed meal per 100 kg. of body weight brought about an increase of 69 kg. of empty body weight in 112 days, or approximately 0.62 kg. per day. With silage, the increase was equivalent to approximately 0.66 kg. per day. The close agreement in the two values lends confidence

TABLE 5. Quantitative response from a supplement of cottonseed meal.

Roughage	Supplement		Effect of cottonseed meal
	None	Cottonseed meal	
	Gain in empty body weight, kg.		
Fresh cane tops	0	69	69
Silage	−29	45	74
Means	−15	57	72

Plate 3. Zebu cattle fed cane top silage for 112 days.

Plate 4. Zebu cattle fed cane top silage plus cottonseed meal for 112 days.

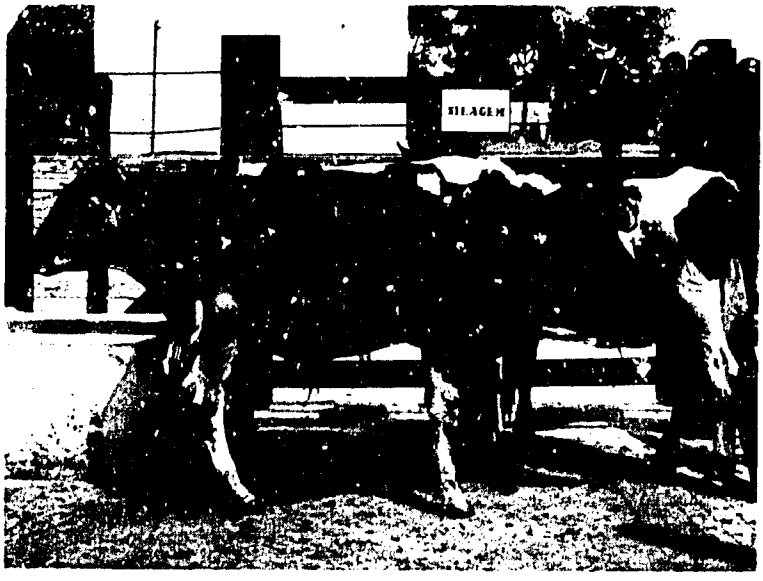

Plate 5. Holstein cattle fed cane top silage for 112 days.

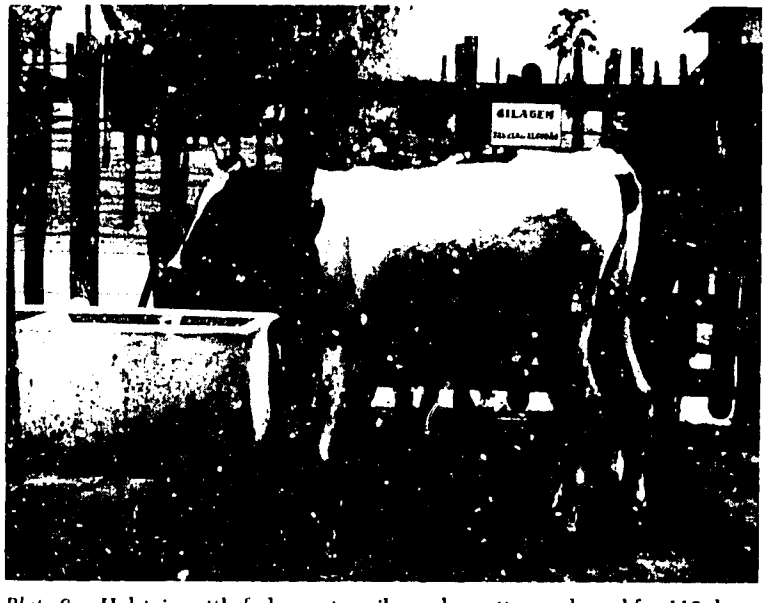

Plate 6. Holstein cattle fed cane top silage plus cottonseed meal for 112 days.

in the use of a value of approximately 0.64 kg. per day as a guide to the expected quantitative response of cottonseed meal when used as a supplement to cane tops at this level. The average amount of cottonseed meal fed per head per day was 1.44 kg. (Table 3). This quantity of meal produced an average of 0.64 kg. of empty body weight gain. Plates 3 through 6 illustrate the appearance of the animals fed silage alone and silage plus cottonseed meal for 112 days. The results on fresh cane tops were similar.

Heat Production and Net Energy

In order to determine the net energy of the feeds used in this study, it is necessary to have an estimate of the heat production of the animals. Heat production (H) is equal to the metabolizable energy intake (ME) minus the energy retained (P), thus:

$$H = ME - P$$

Table 6 illustrates the procedure used to calculate the heat production of the various groups of animals. Since it was not possible to directly determine the metabolizable energy content of the feeds used in this study, the values of 1.83 and 2.84 megcal. per kg. of dry matter for cane tops and cottonseed meal respectively were calculated from literature values by the following procedure: The mean total digestible nutrients (TDN) of fresh and ensiled cane tops shown by Morrison[4] is 50.5 percent on a dry matter basis. It is commonly accepted that one pound of TDN is equal to 2000 kcal. of digestible energy (DE). Therefore, $50.5 \times 2000 = 101000$ kcal. of DE per 100 lb. of dry matter. Approximately 82 percent of DE can be assumed to be metabolizable energy (ME), and therefore 100 lb. of dry matter contains approximately $101 \times 0.82 = 83$ megcal. per 100 lb. Converting to kilograms gives a result of 1.83 megcal. per kg. of dry matter. For cottonseed meal, the National Academy of Science shows a value equivalent to 3.22 megcal. of DE per kg. on a basis of 93 percent dry matter. This is equal to 2.64 megcal. of ME per kg. as fed, or 2.84 megcal. of ME per kg. of dry matter.

TABLE 6. Calculation of heat production.

Item of interest	Fresh cane tops		Silage		Fresh tops and cottonseed meal		Silage and cottonseed meal	
	Holstein	Zebu	Holstein	Zebu	Holstein	Zebu	Holstein	Zebu
Empty body weight, kg.								
Initial	198	190	215	191	228	206	203	191
Final	190	197	180	170	282	289	241	242
Mean (W)	194	194	198	181	255	248	222	217
$W^{0.75}$, kg.	52.0	52.0	52.8	49.4	63.8	62.5	57.5	56.6
Dry matter consumed daily, kg.								
Roughage	4.50	4.21	4.01	3.29	5.87	5.49	5.10	4.75
Cottonseed meal	0	0	0	0	1.42	1.32	1.26	1.21
Metabolizable energy consumed daily, megcal.								
Roughage (1.83 megcal./kg. dry matter)	8.24	7.70	7.34	6.02	10.74	10.05	9.33	8.69
Cottonseed meal (2.84 megcal./kg. dry matter)	0	0	0	0	4.03	3.75	3.58	3.44
Total (ME)	8.24	7.70	7.34	6.02	14.77	13.80	12.91	12.13
Daily energy gain, megcal. (P)	−0.05	1.01	−0.49	0.22	1.34	2.39	1.18	1.77
Daily heat produced, megcal. (ME − P)=(H)	8.29	6.69	7.83	5.80	13.43	11.41	11.73	10.36
$ME/W^{0.75}$, kcal.	158	148	139	122	232	221	225	214
$H/W^{0.75}$, kcal.	159	129	148	117	211	183	204	183

If the log of the heat production per unit of metabolic body size ($W_{kg}^{0.75}$) is plotted against metabolizable energy intake per unit of $W^{0.75}$, the results shown in Figure 1 are obtained. The value of 73 kcal. of heat produced at zero feed intake is in excellent agreement with that obtained by Lofgreen in an earlier report[1] and the commonly accepted value of 70 kcal. per kg. of $W^{0.75}$ for basal metabolism. The close agreement lends strength to the validity of the data.

In Figure 2 the mean heat production per kg. of $W^{0.75}$ for the animals fed fresh or ensiled cane tops, with and without cottonseed meal, has been plotted against the metabolizable energy intake. It is evident that the points representing the mean heat production by the four groups of six animals fed fresh or ensiled cane tops with or with-

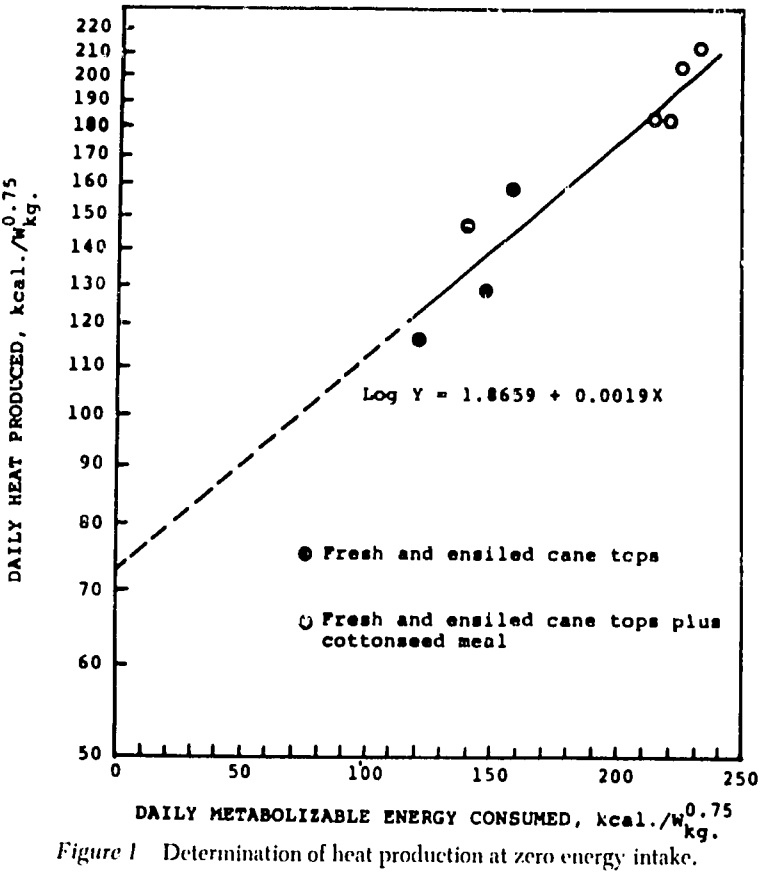

Figure 1 Determination of heat production at zero energy intake.

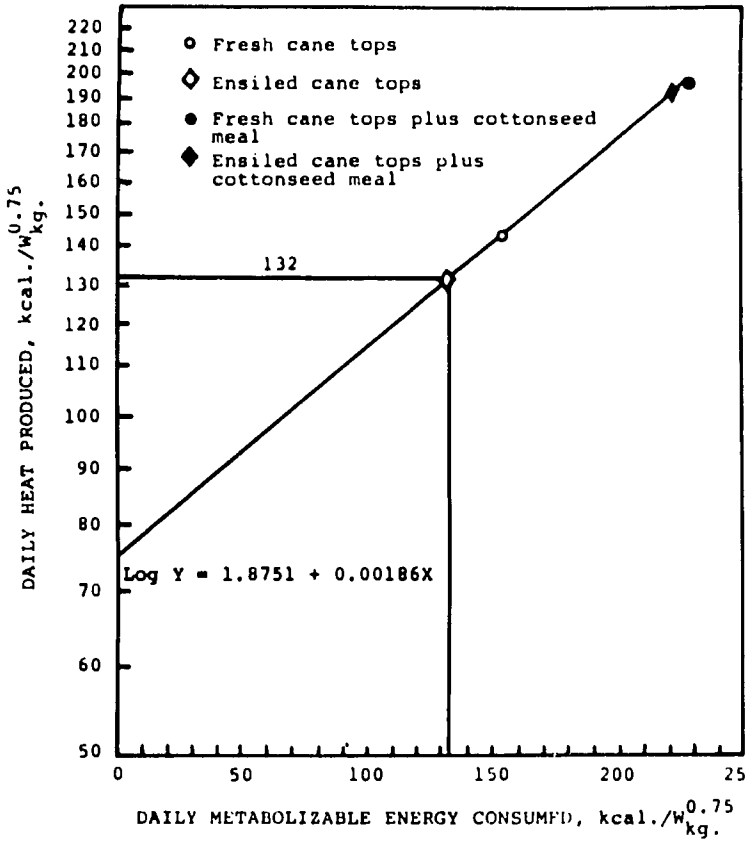

Figure 2. Relationship between heat produced and metabolizable energy intake.

out cottonseed meal are described by the same equation. The fact that the heat produced on the silage rations was no greater than on the fresh cane top rations indicates that nutrient utilization was as good on the silage as on the fresh tops. The poorer response to the silage, therefore, must have been due to the lowered intake caused by poor palatability. One equation was therefore fitted to the data using 75 kcal. per kg. of $W^{0.75}$ as the heat production at zero feed intake[1]. From this equation it is found that energy equilibrium can be achieved at a ME intake of 132 kcal./$W_{kg.}^{0.75}$.

All the information necessary for the determination of net energy is now available. Table 7 shows the determination of the net energy for maintenance (NE_m) of

TABLE 7. The net energy for maintenance (NE_m) of fresh or ensiled cane tops determined by the "difference trial" technique.

Item of interest	Level of feeding	
	Fasting	Equilibrium
Metabolizable energy intake, megcal./day/$W^{0.75}$	0	0.132
Dry matter intake required to supply this level of energy intake, kg./day/$W^{0.75}$ (F)	0	0.0721
Heat produced, megcal./day/$W^{0.75}$ (H)	0.075	0.132
Energy retained, megcal./day/$W^{0.75}$ (P)	−0.075	0
Differences (equilibrium − fasting):		
F, kg.	—	0.0721
P, megcal.	—	0.075
NE_m of the ration, megcal./kg. dry matter	—	1.04

fresh or ensiled cane tops. On a dry matter basis, therefore, the net energy for maintenance of fresh or ensiled cane tops is equal to 1.04 megcal., per kg. of dry matter. From other work[2] it has been shown that for roughages, net energy for production (NE_p) is equal to $NE_m/2.25$. The NE_p of cane tops may be considered, therefore, to be equal to 1.04/2.25 or 0.462 megcal. per kg. of dry matter.

Table 8 shows the results of the difference trial technique of determining the NE_m for the rations containing cottonseed meal. One kg. of dry matter of this ration contained an average of 0.8025 kg. of cane top dry matter and 0.1975 kg. of cottonseed meal dry matter. The

TABLE 8. Net energy for maintenance (NE_m) of fresh or ensiled cane tops supplemented with cottonseed meal.

Item of interest	Level of feeding	
	Fasting	Equilibrium
Metabolizable energy intake, megcal./day/$W^{0.75}$	0	0.132
Dry matter intake required to supply this level of energy intake, kg./day/$W^{0.75}$ (F)	0	0.065
Heat produced, megcal./day/$W^{0.75}$ (H)	0.075	0.132
Energy retained, megcal./day/$W^{0.75}$ (P)	−0.075	0
Differences (equilibrium − fasting):		
F, kg.	—	0.065
P, megcal.	—	0.075
NE_m of the ration, megcal./kg. dry matter	—	1.154

0.8025 kg. of cane top dry matter contributed 0.835 megcal. of NE_m to the 1.154 megcal. (0.8025 × 1.04 = 0.835). The 0.1975 kg. of cottonseed meal therefore contains 1.154 − 0.835 = 0.319 megcal. The NE_m of 1 kg. of cottonseed meal dry matter therefore is equal to 1.62 megcal. At maintenance, therefore, cane top dry matter is worth approximately 64 percent the value of the dry matter from cottonseed meal.

Using essentially the same technique, it is possible to determine the net energy for production (NE_p) of the rations containing cottonseed meal, since the total intake when the rations were fed *ad libitum* was considerably above the energy equilibrium level. Two levels of intake are therefore available for use: one level at equilibrium and one at *ad libitum* feeding. The calculations are presented in Table 9. The 0.8025 kg. of cane tops in 1 kg. of

TABLE 9. Net energy for production (NE_p) of rations containing fresh or ensiled cane tops and cottonseed meal.

Item of interest	Level of feeding	
	Equilibrium	Ad libitum
Dry matter intake, kg./day/$W^{0.75}$ (F)	0.065	0.110
Energy retained, megcal./day/$W^{0.75}$ (P)	0	0.028
Difference (ad libitum − equilibrium):		
F, kg.	—	0.045
P, megcal.	—	0.028
NE_p of the ration, megcal./kg. dry matter	—	0.622

dry matter of this ration contributes 0.371 megcal. of NE_p (0.8025 × 0.462) and the 0.1975 kg. of cottonseed meal dry matter, therefore, contains 0.251 megcal. (0.622 − 0.371). The NE_p of cottonseed meal is, therefore, 0.251/0.1975 or 1.27 megcal. per kg. of dry matter. For production above maintenance, cane top dry matter is worth only 36 percent as much as cottonseed meal dry matter compared to 64 percent at maintenance.

Table 10 presents a summary of the net energy values of the feeds used in this study as determined by the difference trial technique. For purposes of comparison

TABLE 10. Summary of net energy values.

Feed	Net energy for — Maintenance NE_m	Production NE_p
	megcal./kg. dry matter	
Cane tops, fresh or ensiled	1.04	0.46
Cottonseed meal	1.62	1.27
	megcal./kg. as fed	
Cane tops, fresh (26.0% dry matter)	0.27	0.12
Cane top silage (39.1% dry matter)	0.41	0.18
Cottonseed meal (91.1% dry matter)	1.38	1.16

with the values in Table 10, values for other well known feeds are shown below[2]:

	NE_m megcal./kg.	NE_p dry matter
Alfalfa silage	1.33	0.61
Bermudagrass hay	1.01	0.49
Barley grain	2.08	1.22
Corn grain	2.30	1.34

It is evident that fresh or ensiled cane tops are comparable on a dry basis to Bermudagrass hay in energy value. The cottonseed meal used in this trial had a net energy for production comparable to barley or corn but a lower value for maintenance.

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