EFFECT OF MOLASSES ON FEED UTILIZATION BY SHEEP

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UTILIZATION BY SHEEP

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INTRODUCTION

One of the major low cost fattening feedstuffs available in large quantities in Mexico is cane molasses. It represents an energy source that is of increasing importance in livestock feeding. Even though the rate of production is high at the present time, only a small percentage is used in livestock feeding. However the price of grain, such as corn, limits its usage to human consumption for the most part, thus an expanded livestock industry must make use of cane molasses.

In Mexico, the production of meat is influenced by the weather conditions. The main areas devoted to growing cattle and sheep have recurring periods of low rainfall during which time forages are in short supply and the animals usually lose weight and condition. Thus any attempt to gain new information regarding the use of molasses and other industrial by-products, could be reflected in an improvement in the actual feeding practices for livestock during these periods and result in increased production of livestock products.

LITERATURE REVIEW

In a review paper, Foreman and Herman (1953) pointed out that molasses is palatable, slightly laxative, a binding agent, and is rich in niacin and pantothenic acid. It has value as an appetizer and as a dressing for poor quality roughages. Molasses is also a valuable and in many countries an inexpensive source of energy and minerals.

According to Morrison (1959) the average analysis in per cent of cane molasses is as follows:

Total dry matter.................	74.0
Total digestible nutrients.......	54.0
Protein..........................	2.9
Sugars...........................	55.0
N. F. E..........................	62.1
Minerals.........................	9.0

The value of molasses as a source of energy in the ration of the ruminant has long been recognized. Lindsey and associates (1907, 1909) added molasses to hay at the rate of 10 to 15 per cent of total dry matter and found no depression on dry matter digestibility. When they increased the level of molasses to 20 per cent of ration dry matter, a 4.5 per cent depression in digestibility was observed.

Lindsey and Smith (1909) observed that the digestibility depression noted when high levels of molasses were fed appeared to depend upon the character of the feed. They found that there was less depression in digestibility when molasses were added to an all hay ration, than when added to one having hay and concentrate. The level of molasses also played a part. They found that the inclusion of molasses at the rate of 20 per cent of the ration dry matter caused a decrease of 6 per cent in the digestibility of the hay. Lofgreen and Otagaki (1960a) reported that the net energy value of molasses was high when fed at a level of 10 per cent of the ration but had a much lower value when the level was increased to 25 per cent. Lofgreen (1965) found no differences in the net energy value of molasses when fed at levels up to 15 per cent of the ration. There was a slight decline when the level was increased from 15 to 20 per cent.

Bray and associates (1945) found that the feeding value of molasses as compared to corn for fattening steers varied considerably depending on feeding conditions. In their tests molasses had an average replacement value of about 85 per cent of the feeding value of corn. Further experiments at the Louisiana station indicate that molasses is used more efficiently when fed at levels of 3 to 4 pounds per head daily. Their cattle gained faster when fed at the level of 4 pounds daily but were more profitable when fed eight pounds of cane molasses per day. There were no great differences in feeding value of cane molasses fed at the levels of 2.6 or 8 pounds daily in the trials of Foreman and Herman (1953).

Briggs and Heller (1940) ran a series of trials in which large amounts of blackstrap molasses were included in the fattening rations. The digestion of fat was decreased from 55.8 to 30 per cent, while the digestibility of crude fiber was not affected.

Hamilton (1942) investigated the effect of added glucose upon digestibility of protein and crude fiber in rations for sheep. He reported that added glucose increased the apparent digestibility of dry matter from 65.4 to 67.7 per cent, nitrogen free extract from 76.4 to 97.7 per cent and total carbohydrates from 68.9 to 71.9 per cent. Total nitrogen digestibility decreased from 61.9 to 54.1 while that of crude fiber decreased from 43.8 to 31.9 per cent. No significant effect was noted on the apparent digestibility of ether extract or gross energy. He concluded that there was no effect of glucose on true digestibility of total nitrogen since the apparent decrease obtained in digestibility could be accounted for by the estimated increase in metabolic nitrogen in feces of sheep on the sugar ration. He postulated that the marked decrease in digestibility of crude fiber, when sugars were present, was caused by a preference of microorganisms in the paunch for sugar rather than fiber.

Clark and Quin (1951) working with sheep, discovered that the addition of molasses alone to a poor-quality hay had no beneficial effect on weight gains. The addition of ammonium nitrate to the hay-molasses combination caused greater intake of hay, weight loss and better condition. When urea was added to the above combination, the animals gained weight. They postulated that the increased energy source supplied by molasses, and nitrogen furnished by urea, provided for greater bacterial activity resulting in increased cellulose digestion.

Burroughs et al (1951b) added either molasses or its ash to artificial rumen flasks containing cellulose and urea as bacterial substrates. Cellulose digestion and urea utilization were increased significantly by either molasses or the ash from molasses, indicating that molasses supply minerals needed by rumen microflora.

Foreman and Herman (1953) found increased ruminal bacterial populations as molasses intake was increased. They felt that increased digestibility by cattle may be credited to the increased bacterial population up to a level of 2 pounds of molasses daily. They postulated that the continued increase in number of bacteria and the associated decreased digestibility of crude fiber and protein fractions at higher molasses levels would indicate that bacteria are following the path of the least resistance by consuming the soluble carbohydrates in the molasses rather than cellulose.

Williams and associates (1959) ran three experiments using ninety-six Corriedale wethers. In the first trial, forty-eight wethers were fed a ration of milled oat-straw, which was supplemented with urea and molasses. The supplemented animals ate more hay and lost significantly less weight than the controls. In the second trial they found that the addition of different levels of sodium sulfate, vitamins of the B complex or ethyl alcohol to the urea-molasses mixture resulted in no further improvement. Replacing urea with sodium nitrate resulted in no improvement. In the third trial, digestibilities of dry matter, crude fiber and ether extract were determined. The digestibility of neither dry matter nor crude fiber was improved by the addition of the urea and molasses; however, the digestibility of the crude protein was improved.

In view of these observations, and in an attempt to better define those mechanisms affecting energy utilization, two lamb trials were run at the National University of Mexico (Merino and Raun, 1965) to ascertain the effect of cane molasses level on ruminal fermentation patterns and growth performance. Forty-eight wether lambs were utilized and molasses levels at 10, 20, 30 and 40 per cent were tried. The results indicated that in this type of ration, containing approximately 45 to 55 per cent roughage, cane molasses had its highest productive value when fed at a level of 20 per cent of the ration.

The purpose of the studies described herein were to study the effect of different levels of molasses upon the performance of growing sheep.

EXPERIMENTAL

Two separate trials were conducted to determine the effect of levels of cane molasses upon the performance of growing lambs.

In the first trial, thirty sheep weighing an average of 26.4 kg. were divided at random into five groups of six per group and fed the rations shown in Table I for 56 days. A 16-hour shrink period, during which time the sheep did not have access to feed or water, preceded the weighings taken initially and at 14-day intervals during the trial.

The feeds were mixed weekly and kept in covered containers until fed. The animals were handfed daily but there was always some feed left in the trough. Excess feed was removed when it began to accumulate and was weighed and discarded. Water was supplied *ad libitum*.

The sheep were treated with a phenothiazine preparation and vaccinated for enterotoxemia 14 days prior to the initiation of the experiment. They were kept in individual pens, which were 90 X 130 cm. in size and equipped with slatted floors, for the duration of the trial. The experiment was conducted indoors.

Blood samples were taken from all animals on the 40th day after the initiation of the experiment. Sodium

TABLE I

PERCENTAGE AND PROXIMATE COMPOSITION OF RATIONS

Item	Rations				
	1	2	3	4	5
Molasses	0.0	10.0	20.0	30.0	40.0
Corn	27.6	20.7	13.8	6.9	----
Cottonseed meal	11.0	11.2	11.4	11.6	11.8
Urea	0.7	0.7	0.7	0.7	0.7
Alfalfa	10.0	10.0	10.0	10.0	10.0
Corn cobs	48.8	45.7	42.6	39.5	36.4
Calcium carbonate	0.8	0.6	0.4	0.2	----
Dicalcium phosphate	0.5	0.5	0.5	0.5	0.5
Trace mineral mix[a]	0.1	0.1	0.1	0.1	0.1
Salt	0.5	0.5	0.5	0.5	0.5
Vitamins A and D[b]	+	+	+	+	+
	Proximate Composition				
Dry matter	95.64	96.00	95.95	96.00	96.00
Crude protein	10.12	10.25	10.14	10.62	10.81
Nitrogen free extract	53.64	53.95	53.91	55.08	55.50
Crude fiber	24.56	23.50	22.42	20.50	18.82
Ash	4.14	5.20	6.04	6.70	7.86
Ether	3.28	3.10	3.14	3.10	3.01

[a] The mineral mix contained the following amounts of minerals per Kg. of ration: Iron, .012 gm.; manganese, .023 gm.; zinc, .005 gm.; copper, .004 gm.; cobalt, .001 gm.; iodine, .001 gm.

[b] All sheep received daily 2,000 and 250 International units of vitamins A and D respectively.

citrate was used as the anticoagulant. Blood samples were analized for calcium, copper, magnesium, potassium, sodium and zinc by atomic absorption spectrophotometry (Perkin-Elmer, 1964) and phosphorus by the method of Fiske and SubbaRow (1925).

The feed samples were analyzed for proximate components by the method of A.O.A.C. (1960). For the mineral determinations, the feed samples were ashed and dissolved in 6 N HCl. Aliquots were taken for mineral determinations as described previously.

Rumen samples were taken by stomach tube near the end of the trial for the determination of pH and buffering capacity. The pH determinations were made immediately after each sample was taken using a portable pH meter. Buffering capacity was determined by titrating 10 ml. of strained rumen fluid with 0.1 N HCl to a pH of 4.0 and by titrating another 10 ml. of rumen fluid with 0.1 N NaOH to a pH of 9.5.

In the second trial, fifteen wether sheep, five per treatment, were fed three levels of molasses (0, 20 and 40%) in a digestibility and retention experiment. The diets were identical to rations 1, 3, and 5, compositions of which are shown in Table I. A ten-day collection period was preceded by a 30-day adjustment period during which time feed intakes of each animal were established. Metabolism stalls similar to those described by Briggs and Gallup (1949) permitted separation of feces and urine, which were kept under refrigeration until the trial was completed. The feces were then removed, weighed and aliquots taken dried, and analyzed for proximate components (A.O.A.C., 1960). The mineral analyses on feed and feces were conducted as described in the first trial.

Analyses of urine for nitrogen was conducted by the method of A.O.A.C. (1960). Urinary cations and phosphorus were determined by atomic absorption spectrophotometry (Perkin-Elmer, 1964) and by the method of Fiske and SubbaRow (1925), respectively.

RESULTS AND DISCUSSION

Trial 1. Table II exhibits the effects of treatments upon gain, feed consumption and feed efficiency. Level of molasses did not affect ($P > .05$) gains of the sheep. Gains on the different levels of molasses were tested for linear and quadratic effects (Table III) and neither was significant ($P > .05$). Feed consumption increased ($P < .01$) with increasing levels of molasses, the effect did not differ ($P < .01$) from linearity. Feed efficiency expressed as units of feed required to produce a unit of gain, decreased ($P < .05$) as level of molasses increased; this effect also did not differ from linearity. When feed efficiency was related to level of molasses in the diet, a correlation coefficient of 0.47 was found. The prediction equation was

$$Y = 8.45 + 0.113 X \text{ (Table IV)}$$

Where Y = Feed efficiency and X = Level of molasses.

Results of the present trial were similar to those reported by Merino and Raun (1965); however, they found that animals consuming 10 and 20% molasses gained faster ($P < .05$) than those receiving 30 or 40% molasses. Possible explanation for these divergent results concern different method of feed assignment. Merino and Raun

TABLE II

EFFECT OF LEVEL OF MOLASSES UPON GAIN, FEED CONSUMPTION AND FEED EFFICIENCY

Item	Rations 1	2	3	4	5	std. error
Avg. initial wight, kg.	24.61	26.70	27.20	25.00	28.60	
Weight gain, kg.	5.41	5.85	5.83	4.97	5.33	0.12
Avg. daily gain, kg.	0.091	0.098	0.097	0.083	0.089	0.10
Feed, total consumption, kg.	46.13	56.78	63.11	59.33	69.63	0.76
Feed efficiency, feed/gain, kg.	8.56	9.69	10.81	11.93	13.06	1.31

TABLE III

ANALYSIS OF VARIANCE OF DAILY GAIN, TOTAL FEED CONSUMPTION AND FEED EFFICIENCY DATA

Source	df	Mean square		
		Total gain	Feed consumption	Feed efficiency
Total	29			
Treatment	4	3.99	1748.02**	19.94
Linear effect	1	3.00	62061.54**	74.81*
2 vs. 3, 4, 5	1		1557.75**	48.69*
4 vs. 5	1		1731.61**	11.56
1 vs. 2, 3, 4, 5	1		3452.91**	
Error	25	3.07	112.28	10.34

*P<.05

**P<.01

TABLE IV

EFFECT OF FIVE LEVELS OF MOLASSES ON FEED EFFICIENCY OF SHEEP

Analysis of variance of Feed efficiency data

Source	df	mean square	EMS	F	
Total	30				
Mean	1				
Regression	1	75.16**	8.14	7.64	.01
Residual	28	9.36			

Prediction equation Y = 8.45 + .113 X

Correlation r = .47** > .463 .01

fed their sheep three times daily and allowed them two hours to consume the offered feed during which time water was not available to the animals. Feed and water were available at all times in the present experiment and could account for the better feed consumption and gain.

As molasses contain less net energy than corn (Lofgreen, 1965), the sheep ate more feed and required more total feed to produce a unit of gain. However the comparative price of molasses and corn in some countries, would still make it profitable to feed molasses, at high levels in lamb-fattening diets. Level of molasses did not affect significantly the pH or buffering capacity of rumen fluid (Tables V and VI).

Plasma mineral levels are shown in Tables VII and VIII. Level of molasses did not affect plasma levels of sodium, potasium, magnesium or copper. Plasma calcium level of sheep consuming the diet containing no molasses was lower ($P < .01$) than those from treatments containing molasses. Also molasses level exerted a linear effect ($P < .01$) on plasma calcium level; plasma levels increased with increased level of molasses.

Levels of zinc and phosphorus were significantly higher ($P < .01$) in sheep fed the diet containing no molasses. Significant linear effects ($P < .01$), in the opposite direction to that found for calcium were detected for plasma levels of phosphorus and zinc. Correlation coefficients of -.982 ($P < .01$) and -.950 ($P < .01$) existed

TABLE V

EFFECT OF LEVEL OF MOLASSES ON BUFFERING CAPACITY AND pH VALUES OF RUMEN FLUID

	Molasses %					
	0	10	20	30	40	std. error
pH	5.77	5.93	5.37	5.47	5.57	0.24
ml.[a] of 0.1 N. NaOH	7.0	7.5	7.0	7.5	7.3	0.63
ml.[b] of 0.1 N. HCl	11.3	14.0	12.5	15.0	14.2	0.90

[a] ml. of 0.1 normal solution of NaOH required to bring the rumen fluid to a constant pH.

[b] ml. of 0.1 normal solution of HCl required to bring the rumen fluid to a constant pH.

TABLE VI

ANALYSIS OF VARIANCE OF pH VALUES AND BUFFERING CAPACITY OF RUMEN FLUID

		Mean square		
Source	df	pH	NaOH	HCl
Total	14			
Treatment	4	0.16	0.29	6.44
Linear		.11	.26	6.66
Quadratic		.03	.01	.96
Error	10	0.19	1.22	2.43

TABLE VII

EFFECT OF LEVEL OF MOLASSES ON PLASMA MINERAL LEVELS

Mineral	Molasses level %					
	0	10	20	30	40	std. error
Sodium mg./100 ml.	766.78	696.77	689.79	785.48	785.57	138.56
Potassium mg./100 ml.	23.26	28.29	24.21	24.64	22.58	2.84
Calcium mg./100 ml.	9.94	10.48	10.65	10.37	10.62	0.15
Phosphorus mg./100 ml.	5.04	5.14	4.12	4.46	3.94	0.29
Magnesium mg./100 ml.	1.82	1.91	1.84	1.91	1.70	0.11
Copper ppm.	1.36	1.34	1.36	1.36	1.30	0.05
Zinc ppm.	0.73	0.60	0.68	0.38	0.54	0.05

TABLE VIII

EFFECT OF LEVEL OF MOLASSES ON PLASMA MINERAL LEVELS

Analysis of variance of plasma mineral levels data

Source	df	Mean square						
		Sodium	Potassium	Calcium	Phosphorus	Magnesium	Copper	Zinc
Total	29							
Treatment	4	19304.3	35.60	0.57**	1.62**	0.046	.005	.109**
Linear effect	1	9568.5	14.93	1.11**	4.99	0.040	.006	.208
Quadratic effect	1	25317.1	40.06	0.34	0.01	0.090	.005	.016
0 vs. 10, 20, 30, 40	1			1.66**	3.61*			.146**
0, 10, 20 vs. 30, 40	1				5.63**			
0, 10, 20 vs. 30, 40	1							.310**
Error	25	11535.6	48.25	0.13	0.51	0.076	.015	.012

*P<.05

**P<.01

between plasma calcium and plasma phosphorus and zinc levels, respectively. These data indicate that level of dietary calcium affected both plasma phosphorus and zinc levels. These relationships will be considered in more detail when the results of the second trial are discussed.

Trial 2. Digestibilities of proximate feed components are shown in Tables IX and X. As the sheep were fed to appetite in accord with levels of intake established during the 30-day adjustment period, intakes of components differed among the rations. Molasses levels did not affect ($P > .05$) apparent percentage digestibilities of dry matter, protein, nitrogen-free extract, ether extract or ash. Crude fiber digestibility was reduced ($P < .05$) when the molasses level was increased to 40% of total ration; differences between the 0 and 20% levels of molasses were not significant. Briggs and Heller (1940) also found that molasses, within the levels used in their experiment, did not affect the digestibility of crude fiber. When Hamilton (1942) added glucose to sheep diets, he found a reduction in crude fiber digestibility. It is difficult to compare the results of Hamilton to those obtained in the present experiment because of differences in levels of soluble carbohydrates, also molasses contain minerals and possible other factors which could under some conditions stimulate fiber digestion. As far back as 1864, Henneberg and Stohmann demonstrated that the

TABLE IX

EFFECT OF LEVEL OF MOLASSES UPON DIGESTIBILITY OF PROXIMATE FEED COMPONENTS

Item	Molasses %	Intake kg.	Feces kg.	Digestibility %
Dry matter	0	7.432	2.595	66.34
	20	10.070	3.756	65.04
	40	11.789	4.435	61.98
	Std. error	1.32	0.46	2.92
Crude protein	0	0.836	6.307	63.28
	20	1.204	0.489	59.39
	40	1.453	0.549	62.21
	Std. error	0.24	0.86	3.66
Nitrogen-free extract	0	4.432	1.277	71.19
	20	6.220	1.887	69.66
	40	6.759	2.028	70.00
	Std. error	0.76	0.25	2.64
Ether extract	0	0.271	0.085	68.63
	20	0.362	0.177	67.68
	40	0.370	0.144	61.08
	Std. error	0.14	0.50	4.10
Crude fiber	0	2.029	0.741	63.48
	20	2.586	0.941	63.53
	40	2.331	1.328	43.02
	Std. error	0.32	0.12	3.57
Ash	0	0.342	0.188	45.03
	20	0.696	0.307	55.89
	40	0.964	0.386	55.96
	Std. error	0.89	0.41	3.97

TABLE X

EFFECT OF LEVEL OF MOLASSES UPON DIGESTIBILITY OF PROXIMATE FEED COMPONENTS

Analysis of variance of apparent digestibility

Source	df	Crude pro.	Dry matter	N.F.E.	Ether extract	Ash	Crude fiber
Total	14						
Treatment	2	70.92	25.06	11.96	97.02	214.03	780.97**
1, 3, vs. 5	1						5844.80**
Error	12	66.79	42.68	34.90	83.87	78.80	63.65

**P < .01

addition of sugar or molasses to the diet depressed the digestibility of crude fiber and many workers have confirmed these earlier results. Starch has a like effect as was shown by Burroughs et al (1951b). When they added four lb. of starch to a cattle roughage diet, fiber digestibility was reduced from 60 to 13%, however, the addition of two lb. of casein restored the digestibility of fiber. It is pertinent to point out, that Kane et al (1959) added 6 lb. of starch to an alfalfa-containing dairy cow diet, and found that the added starch exerted a depressing effect on fiber digestibility if no preliminary period was used prior the collection of feces; however, if a 20-day preliminary period was employed, the added starch had no effect upon fiber digestibility. In the present trial, a 30-day adjustment period preceded the collection period.

Further work by Hoflund et al (1948) showed that a low level of glucose actually stimulated cellulose digestion by rumen microorganisms but that higher levels depressed it. They suggested that the higher levels offered the microorganisms a readily available energy source. Arias et al (1951) and Belasco (1956) observed similar effects when starch was added and postulated that the rumen microorganisms need small amounts of readily available carbohydrates to promote cellulose digestion. The results of the present experiment indicate that no depression in digestibility in the high roughage diets, used in Mexico, was found until the level of molasses exceeded 20% of the diet.

Many workers (Foreman and Herman, 1953) have found that high level of molasses decreases the apparent digestibility of protein; however, it was not affected in the present trial. No reason is offered for the apparent discrepancy of these results with those of other workers except to point out that the present diets were approximately isonitrogenous and the animals were allowed to consume greater amounts of the molasses-containing diets. It will be noted (Table X) that those animals assigned diets 1, 3, and 5 respectively consumed 83.6, 120.4, and 145.3 gm. of protein daily. It is also possible that molasses contributed factors needed for bacterial activity and prevented the usual decline noted in protein digestibilities when soluble carbohydrates are added.

The retention of minerals including nitrogen, are shown in Table XI. Level of molasses did not affect percentage of nitrogen retained but the data indicated that more protein was retained by sheep fed the molasses containing diets: sheep fed the control diet stored 2.40 gm. of nitrogen daily, while those fed 20 and 40% molasses stored 5.19 and 5.16 gm. daily, respectively. As indicated earlier, the sheep ate more of the molasses-containing rations.

Potassium intake increased with level of molasses in the diet, however, percentage retention was inverse to

TABLE XI

EFFECT OF LEVEL OF MOLASSES UPON PERCENTAGE RETENTION OF MINERALS AND NITROGEN

Item	Molasses %	Intake[a] gm.	Feces % intake	Urine % intake	Retention % intake
Potassium	0	63.05	13.75	55.90	30.35
	20	120.65	8.00	81.24	10.76
	40	205.70	5.75	87.39	6.86
	Std. error	19.27	1.22	4.87	3.98
Sodium	0	21.57	37.34	79.24	- 16.58
	20	41.88	14.77	68.54	16.69
	40	50.35	12.80	78.54	8.66
	Std. error	4.92	4.31	15.09	13.68
Calcium	0	56.69	84.42	0.67	14.65
	20	108.22	73.23	0.29	26.48
	40	136.43	73.81	0.24	25.95
	Std. error	12.87	7.87	0.25	7.98
Phosphorus	0	27.16	81.42	0.60	17.98
	20	37.85	93.71	0.45	5.84
	40	38.80	88.98	0.42	10.60
	Std. error	4.63	7.50	0.12	8.58
Magnesium	0	13.14	57.21	29.16	13.63
	20	26.65	59.58	18.77	21.65
	40	35.98	63.61	17.61	18.78
	Std. error	3.17	5.88	2.19	7.32
Zinc	0	0.34	83.14	15.11	1.74
	20	0.56	84.29	6.79	8.92
	40	0.39	120.30	6.09	- 26.39
	Std. error	0.07	20.03	2.19	10.55
Copper	0	0.21	31.13	8.49	60.37
	20	0.16	245.00	12.50	-157.75
	40	0.29	160.84	6.29	- 67.13
	Std. error	0.06	36.80	2.21	64.85
Nitrogen	0	133.88	36.65	45.42	17.90
	20	192.70	40.67	32.38	26.95
	40	212.43	41.35	24.43	24.22
	Std. error	23.67	3.82	7.63	5.70

[a] ten-day period

intake. Level of molasses exerted a negative effect upon percentage potassium retention and this effect did not differ from linearity ($P < .01$) Table XII.

Sodium retentions were affected by treatment ($P < .01$) and the effect of molasses did not differ ($P < .01$) from linearity; sodium retention increased with molasses level. There was an inverse relationship between the percentage retention of potassium and sodium; however, the significance of this is not known. As plasma levels of sodium were not affected by treatment (Table VII), it is possible that the negative retention found when no molasses were fed represents a temporary condition in which the animals were adjusting to the higher retention of potassium (Wynn, 1957); sheep fed ration 1 retained 1.91 gm. of potassium daily while those on rations 2 and 3 retained 3.2 and 1.41 gm.

The effect of molasses level on copper retention was quadratic ($P < .01$); however, the significance of this is not known, particularly, since treatments had no effect upon plasma copper levels (Table VII).

Level of molasses did not affect ($P > .05$) percentage zinc retention; however, the trend toward decreased retention with increasing molasses level approached significance ($P < .10$). That this trend is real is supported by the plasma values shown in Table VII, in which plasma zinc levels decreased ($P < .01$) with increasing molasses levels. Also the animals fed molasses

TABLE XII

EFFECT OF LEVEL OF MOLASSES UPON PERCENTAGE RETENTION
OF MINERALS AND NITROGEN

Analysis of variance of percentage retention data (trial 2)

Source	df	Mean square			
		Potassium	Sodium	Copper	Zinc
Total	14				
Treatment	2	850.39**	1666.89	86546.08**	1610.13
Linear effects	1	1385.25**	2174.33**	38500.47	1269.79
Quadratic effects	1	36.86	598.21	119816.36**	1413.76
1 vs. 3, 5	1		3321.58**		
1 vs. 3				173027.72**	
3 vs. 5	1	554.73**			3945.72
Error	12	79.11	318.57	21030.04	557.35

Source	df	Mean square			
		Magnesium	Calcium	Phosphorus	Nitrogen
Total	14				
Treatment	2	186.12	139.74	221.41	36.44
Linear effects	1	288.41	214.80	131.01	42.31
Quadratic effects	1	21.79	18.05	216.33	16.16
Error	12	268.27	318.57	368.35	163.49

*P<.05

**P<.01

stored less zinc ($P < .05$) when actual values are considered. These data are also in accord with the idea (Lewis et. al., 1956) that high levels of calcium interfere with non-ruminants utilization of zinc. The results of Ott et al (1964) indicate that the addition of phosphorus to sheep diets lessened the severity of zinc deficiency symptoms indicating that level of calcium is also an important factor in determining the utilization of zinc by ruminant animals.

Magnesium retention was not affected by molasses level and these results are in accord with plasma values (Table VII).

Level of molasses did not affect percentage retention of calcium or phosphorus; however, the trends are in the same direction as found in trial 1 in which plasma, calcium and phosphorus values (Table VII) were response criteria. It is well known that high levels of calcium affect the retention of phosphorus (Maynard and Loosli, 1962) and that the long-time effects are in accord with the blood values found in trial 1. It is comforting, even though the results of the retention trial were not significantly different, that the trends are in the same directions and add support to the earlier results.

SUMMARY

Two separate trials were conducted to determine the effect of five levels of cane molasses (0, 10, 20, 30 and 40%) in diets of sheep upon gains, feed utilization, plasma mineral levels, digestibility of ration components, ruminal fluid pH and buffering capacity, and retention of nitrogen, calcium, phosphorus, magnesium, sodium, potassium, copper and zinc.

Level of molasses did not affect daily gains; however, feed efficiency was affected in a manner that did not differ from linearity; efficiency decreased as molasses level increased. When molasses level was related to units of feed required to produce a unit of weight gain, a significant coefficient of correlation of 0.47 was found. Neither ruminal fluid pH nor buffering capacity was affected by level of molasses.

Plasma calcium level increased significantly with increasing levels of molasses, while that of phosphorus and zinc decreased significantly. Correlation coefficients of -0.982 and -0.950 were found when plasma calcium was related to plasma phosphorus and zinc respectively.

Digestibilities of proximate components were not affected by molasses level except for a significant

reduction in the digestibility of crude fiber when the level of molasses increased to 40% of the diet. Nitrogen retention expressed as percentage of intake, was not affected by level of molasses; however, the sheep receiving molasses in the diets ate more feed and stored more nitrogen than those receiving the control diet.

Level of molasses exerted a negative effect upon percentage retention of potassium and the effect did not differ from linearity. Sodium retention increased with level of molasses and, when expressed as a per cent of intake, the effect did not differ from linearity. Level of molasses did not affect, significantly, the percentage retention of calcium, phosphorus and zinc; however there were trends toward increased retention of calcium and decreased retentions of phosphorus and zinc with increasing levels of molasses.

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