STUDIES ON MIXTURES OF LIQUID HEMICELLULOSE AND CANE MOLASSES IN DIETS FOR SHEEP

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STUDIES ON MIXTURES OF LIQUID HEMICELLULOSE AND

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INTRODUCTION

The exploding increase in world population is creating a mounting deficit and an urgent demand for more food. While total food production is inadequate, the most severely limiting nutrient in mankind's diet is protein, and animal products are an excellent source.

According to most forecasters, the need to grow crops on land now used to maintain animals will lead to a decline in meat consumption, and the essential disappearance of meat is sometimes predicted. Although the decline is probable, the disappearance is not. There are millions of acres of land that are suitable for forage and not for tillage and, of course, there is a great deal of plant residue that can most conveniently be used as animal feed.

Utilization of industrial by-products in ruminant nutrition is another method by which animal protein can be produced. In many parts of the world cane molasses is so abundant that some countries spread it on dirt roads to lay the dust, and wood manufacturers have found that in the processing of pressed wood products about 10 percent of the hemicellulose of the wood is extracted. Any new information which could lead to the use of these waste products in animal production could help alleviate the world's protein shortage.

REVIEW OF LITERATURE

The value of cane 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 and found no depression of dry matter digestibility at the rate of 10 to 15 percent of total dry matter. When they increased the rate to 20 percent of ration dry matter, however, a depression in digestibility of 4.5 percent was observed.

Lindsey and Smith (1909) found that the composition of the ration had an effect on the apparent digestibility depression by molasses. They found there was less depression when molasses was added to an all-hay ration than when added to one having hay and concentrate. The diet effect was also noted by Briggs and Heller (1940), who fed a diet composed of alfalfa hay, 50 percent, molasses 25 percent, and either corn or oats, 25 percent. Crude fiber and nitrogen free extract digestibility was lowered, but not significantly, in both the corn and oat diets. Fat digestibility was lowered by 18 percent in the corn diet and 17 percent in the diet containing oats. Crude protein digestibility in the diet containing corn was lowered by a non-significant amount, but in the oat diet by 4.6 percent, a highly significant amount.

Hamilton (1942) investigated the effect of added glucose upon the apparent digestibility of nutrients in sheep. He reported that the apparent digestibility of dry matter, nitrogen free extract, and total carbohydrates increased, ether extract and gross energy were changed insignificantly, while total nitrogen and crude fiber were decreased.

He concluded that there was no change in the true digestibility of total nitrogen when glucose was added since the apparent decrease could be accounted for by the estimated increase in metabolic nitrogen in the feces of sheep on the sugar ration. He postulated that the decrease in digestibility of crude fiber was caused by a "preference" of the micro-organisms in the paunch for glucose rather than fiber.

Colovos <u>et. al.</u> (1949) compared wood molasses to cane molasses as feed for dairy cattle. They, too, found an apparent depression in total nitrogen digestibility, but using the factor of 5.5 mg for metabolic nitrogen in the feces per gram of dry matter consumed, as worked out by Harris and Mitchell (1941), they concluded that the true digestibility of protein was not lowered by cane molasses or by wood molasses, and that the metabolizable energy per gram of dry matter for both cane and wood molasses was essentially the same.

Several trials have been run to compare wood molasses with cane molasses in growing or fattening rations. Most of these rations include the two ingredients at the level of from 7 to 10 percent. Perry and associates (1964), Boren <u>et. al</u>. (1965) and Algeo and Putnam (1966) concluded that there was no significant differences in the feeding value of cane and wood molasses.

Both wood and cane molasses have been utilized in rations for lactating dairy cattle. Jones (1949) reported that the dry matter of wood molasses was as well utilized as that of cane molasses. Waugh <u>et. al.</u> (1954) fed wood molasses to lactating dairy cows in amounts up to 6 pounds per day and found that one pound of wood molasses was worth at least one half pound of grain in dairy cattle rations. Virtanen (1967) fed a purified diet to lactating milk cows and found that when a sufficient amount of urea is used, wood molasses can replace about thirty percent of the total feed of the cows.

The Masonite Corporation (1965) reported the carbohydrate distribution of the liquid hemicellulose product used in this experiment was as follows: glucose 15 percent, galactose 6 percent, mannose 25 percent, arabinose 5 percent and xylose 49 percent. About 10 percent of the carbohydrate existed as the simple sugar and the balance as heavier molecular weight sugars. Gross energy content was determined to be 4.03 Calories per gram of dry matter by bomb calorimetry.

The carbohydrate distribution of cane molasses varies widely. Fort et. al. (1952) analyzed samples of Louisiana cane molasses from 23 factories in 1950 and reported the carbohydrate distribution of dry solids to be as follows: true sucrose values ranged from 36.6 to 50.6 percent with an average of 44.5 percent, reducing sugars ranged from 21.8 to 38.9 percent with an average of 26.1 percent and total sugars ranged from 63.8 to 80.1 percent with an average of 70.6 percent. About 10 to 20 percent of the value of reducing sugars was reported to be due to non-sugar reducing substances. Gross energy content, as determined by Hugot (1960), ranged from 3.78 to 4.25 Calories per gram of dry substance.

Williams and Tillman (unpublished data) studied the performance of lambs fed a diet composed of 94.2 percent cane molasses, 4 percent urea and 1.8 percent minerals to determine the value of molasses as the sole source of carbohydrates in the diet. They found that those sheep fed only the liquid diet lost an average of 0.09 pounds a day and consumed 0.73 kilograms of molasses mixture. When one pound of cottonseed hulls was added to the diet, the lambs gained 0.11 pounds per day and increased their consumption of the liquid portion of the diet to 1.05 kilograms per day. Upon autopsy, the lambs which had not received cottonseed hulls in the diet were found to have large amounts of wool in their rumens. Since only the study by Williams and Tillman has been directed towards determining the ability of cane molasses to supply carbon chain fragments for protein metabolism, this study was initiated to compare wood and cane molasses as precursors to protein elaboration in lambs.

EXPERIMENT

Responses obtained during recent years with wood molasses used as a substitute for cane molasses in ruminant diets indicate that wood molasses is equally effective as a source of readily digestible carbohydrates as cane molasses. As it was not known how wood molasses compared with cane molasses as a source of carbon chain fragments for protein anabolism, this experiment was designed to supply information on this question.

EXPERIMENTAL PROCEDURE

Forty western ewe lambs averaging 62.6 pounds in weight initially were divided at random into 10 groups of four lambs per group and fed the rations shown in Table I for 60 days. A 24 hour shrink period, during which times the lambs did not have access to feed or water, preceded the initial and final weighings. Each lamb was weighed at 15 day intervals.

The feeds were mixed and stored in 55 gallon metal drums and kept covered until fed. Water was supplied _ad libitum_. Each sheep was provided with a feed bunker divided into two parts. One section held the daily ration of either cottonseed hulls or wood fiber while the other section contained a plastic bucket capable of containing about 12.5 pounds of liquid feed. The bucket was secured so that the sheep could not overturn it. Based on the observations of Williams and Tillman, it was planned to offer once daily 1.5 pounds of the cottonseed hulls and

TABLE I

PERCENTAGE COMPOSITION OF LIQUID PORTION OF DIET

INGREDIENTS	DIETS 1,6	2,7	3,8	4,9	5,10
Cane Molasses	0	23.6	47.1	70.7	94.2
Liquid Hemi-cellulose[a]	94.2	70.6	47.1	23.5	0
Urea	4.0	4.0	4.0	4.0	4.0
$NaH_2PO_4.H_2O$	1.5	1.5	1.5	1.5	1.5
Trace Minerals[b]	0.3	0.3	0.3	0.3	0.3

Lambs on Treatments 1, 2, 3, 4 and 5 were allowed 1.5 pounds of cottonseed hulls per day and had access to the appropriate liquid diet, while those on Treatments 6, 7, 8, 9 and 10 were allowed free access to wood fiber[c] and the appropriate liquid diet.

[a]Liquid hemicellulose was presented by the Masonite Corporation, Chicago, Illinois.

[b]Composition of the trace mineral mixture; (grams per 100 lb. diet)
Copper, 1.36; Iron, 13.6; Manganese, 4.08; Zinc, 8.16 Cobalt, 0.02772; Potassium iodide, 0.0544.

[c]The wood fiber was an acid-washed wood product containing a high level of lignin. It was presented by the Masonite Corporation, Chicago, Illinois.

TABLE II

PROXIMATE COMPOSITION OF LIQUID PORTION OF DIET

ITEM	TREATMENT				
	1,6 %	2,7 %	3,8 %	4,9 %	5,10 %
Dry Matter	60.75	63.61	66.45	69.32	72.17
Crude Protein[a]	0.68	1.14	1.60	2.05	2.51
Nitrogen Free Extract	50.49	51.65	52.84	54.01	55.18
Crude Fiber	0.12	0.17	0.21	0.26	0.30
Ash	4.88	6.18	7.48	8.78	10.08
Ether Extract	0.58	0.47	0.32	0.22	0.10

[a]Urea was added at a level of 4% in all Diets

TABLE III

PROXIMATE COMPOSITION OF ROUGHAGE PORTION OF DIET

	Cottonseed Hulls %	Wood Fiber %
Dry Matter	91.3	89.7
Crude Protein	4.2	3.1
Nitrogen Free Extract	36.6	7.6
Crude Fiber	46.5	76.2
Ash	3.3	2.8
Ether Extract	0.7	0

TABLE IV

MINERAL COMPOSITION OF DIET COMPONENTS

MINERAL	ITEM %			
	Liquid Hemicellulose	Cane Molasses	Cottonseed Hulls	Wood Fiber
Calcium	0.3897	0.6932	0.1056	0.1334
Phosphorus	0.0633	0.0663	0.0360	0.0040
Potassium	0.4329	1.6744	2.8199	0.5700
Sodium	0.4570	0.2212	0.0228	0.0299
Magnesium	0.1563	0.2324	0.1882	0.0517
	ITEM PPM			
Iron	436.40	293.70	25.44	490.80
Manganese	339.47	20.50	8.48	63.10
Copper	20.69	18.89	4.86	14.79
Zinc	28.52	12.67	7.04	47.06

the wood fiber. This plan was followed in the case of the cottonseed hulls but it was found that the animals consumed lesser amounts of the wood fiber, thus they were fed this product ad libitum.

A one inch thick pine disk floated on the molasses mixture. Four holes 3/4 inch in diameter were bored through the float equidistantly around the perimeter and one 3/4 inch diameter hole was bored through the center. The disk had 1/8 inch clearance from the sides of the bucket. This feeding arrangement allowed the sheep to press down on the float and force liquid feed through the holes to collect on top of the disk. This arrangement permitted the sheep free access to the liquid feed and yet was prevented from immersing its head in the mixture.

The sheep were treated with a phenothiazine drench and vaccinated for enterotoxemia 14 days prior to the experiment. They were housed indoors in individual pens, which measured 90 by 130 centimeters and were equipped with slatted floors.

Blood samples were taken from all animals at the end of the experiment. Sodium citrate was used as the anti-coagulant. Blood samples were analyzed for calcium, iron, copper, magnesium, potassium and zinc by atomic absorption spectrophotometry (Perkin-Elmer, 1964) and phosphorus by the method of Fisk and SubbaRow (1925). The feed samples were analyzed for proximate components by the method of A.O.A.C. (1960). For mineral determinations the feed samples were ashed and dissolved in 6N HCL. Aliquots were taken for mineral determinations as described previously.

Artificial rumen studies were made on the various diets to determine if there were differences in the rate between diets in which microbial protein is elaborated. A modification of the technique described by Tilley and Terry (1963) was used. "Artificial sheep saliva" prepared according to the formula by McDougal (1948) was mixed with rumen fluid so that each ml. of the mixture contained 0.1 mg. trichloracetic acid precipitatable microbial protein. To each 100 ml. of buffer solution was added 1.0 gm. of a liquid molasses mixture and 0.65 gm. of either cottonseed hulls or wood fiber. Each artificial rumen unit contained 200 ml. aliquots of these mixtures and were incubated at 39° C for 8, 16, 20 or 24 hours. Microbial protein was precipitated by adding 20 ml. of 50 percent trichloracetic acid to each aliquot. Nitrogen determinations were made on the precipitate using the Kjeldahl procedure and the amount of protein precipitated calculated by the formula used in crude protein determinations (A.O.A.C., 1960).

RESULTS AND DISCUSSION

Table V exhibits the effects of treatments on animal performances. All sheep readily consumed the allowed 1.5 pounds of cottonseed hulls and gained more ($P < .01$) than those fed wood fiber. As intake of the wood fiber was so low, no attempt was made to regulate intake and the product was provided *ad libitum*. However, all the animals, regardless of the composition of the liquid portion of the diet, ate the same amount of the fiber. Daily feed intake of those animals receiving cottonseed hulls was greater ($P < .01$) than those fed wood fiber and the difference was accounted for by the differences in roughage consumption.

Feed efficiency also favored ($P < .01$) the animals receiving cottonseed hulls, and the lowest efficiencies were found in the diets containing high levels of the liquid hemicellulose.

Those sheep which received cottonseed hulls (Rations 1-5) exhibited linear ($P < .05$) and quadratic ($P < .05$) effects of the different liquids on gains; the quadratic effect approached significance at the $P < .01$ probability level. The poorest gains were made by the animals receiving liquid hemicellulose as the only liquid energy source and even the lowest addition of cane molasses (25%) resulted in increased ($P < .05$) gains. Further increases in the proportion of cane molasses, except for the 50:50 mixture which resulted in a highly significant improvement in gains, resulted in no further improvement.

When wood fiber was the roughage source over the same liquid sources (Rations 6-10), sheep gains did not differ from linearity

$(P < .01)$ and exhibited a quadratic effect $(P < .05)$. The replacement of 25% of the liquid hemicellulose with cane molasses resulted in highly significant improvement; another replacement of 25% of the liquid hemicellulose with cane molasses to produce Ration 8 gave a further highly significant increase in gains. Further increases in the proportion of cane molasses beyond the 50:50 mixture resulted in no further improvement and, in fact, there appeared to be a tendency toward a decrease as compared to gains on Ration 8. However both Rations 9 and 10 supported gains $(P < .05)$ greater than Ration 7.

Feed consumption was affected by the liquid proportions in a manner described by a quadratic equation $(P < .01)$. When cottonseed hulls was the roughage source, rations containing either liquid hemicellulose or cane molasses were consumed at lower levels $(P < .05)$ than the mixtures of the two. When wood fiber was the roughage source, the lowest consumption was obtained on the ration containing only liquid hemicellulose as the energy source; however, the ration containing cane molasses as the sole liquid energy source was consumed at a higher $(P < .05)$ level than the one containing only hemicellulose. Replacement of the liquid hemicellulose with the lowest level of cane molasses (25%) resulted in a great $(P < .01)$ increase in liquid feed consumption and when there was further replacement up to a level of a 50:50 mixture, liquid feed consumption was increased to 3.0 pounds per day: this was not significant unless a probability of $P < .10$ is accepted. A further increase in cane molasses replacement of liquid hemicellulose (75%, 100%) resulted in a decrease $(P < .01)$ in feed consumption, thus explaining why the quadratic effect was found.

TABLE V

EFFECT OF ROUGHAGE SOURCE AND PROPORTION OF CANE MOLASSES TO LIQUID HEMICELLULOSE UPON SHEEP GAINS AND EFFICIENCY OF SHEEP

	COTTONSEED HULLS						WOOD FIBER						
Ration	1	2	3	4	5	Mean	6	7	8	9	10	Mean	S.E.[a]
Cane Molasses	0	25	50	75	100		0	25	50	75	100		
Liquid Hemi-cellulose	100	75	50	25	0		100	75	50	25	0		
ITEM													
Final Wt. lb.	68.4	76.2	77.2	77.5	76.3	75.1	64.1[d]	65.9	70.0	67.8	70.5	67.6	
Initial Wt. lb.	66.3	61.6	58.9	67.3	62.8	62.7	70.6	64.8	58.6	62.9	63.4	64.1	
Daily Gain, lb.[b]	0.04	0.24	0.30	0.23	0.23	0.21*	-0.11	0.02	0.17	0.08	0.12	0.06*	0.06
Daily Feed, lb.													
Liquid[c]	2.0	2.8	2.8	2.8	2.3	2.5	2.0	2.7	3.0	2.4	2.5	2.5	0.16
Roughage	1.5	1.5	1.5	1.5	1.5	1.5*	0.3	0.3	0.3	0.3	0.3	0.3*	
Feed/Gain, lb.[e]	96.4	17.6	14.1	18.6	16.8	32.7*	-	156.3	18.8	32.7	23.6	57.9*	12.12
Feed Components													
Liquid %	57.1	65.1	65.1	65.1	60.5	62.6*	87.0	90.0	90.9	88.9	89.3	89.2*	
Roughage %	42.9	34.9	34.9	34.9	39.5	37.4*	13.0	10.0	9.1	11.1	10.7	10.8*	

a Standard Error

b Treatment effects on Rations 1-5 were linear ($P < .05$) and quadratic ($P < .05$); on Rations 6-10 the effects were linear ($P < .01$) and quadratic ($P < .05$).

c Treatment effects on Rations 1-5 and 6-10 were quadratic ($P < .01$).

d Two lambs refused to eat this diet and were removed from the experiment.

e Treatment effects on Rations 1-5 were linear and quadratic ($P < .05$); on Rations 6-10 the effects were linear ($P < .01$) and quadratic ($P < .05$).

* Denotes that differences between means of sheep fed cottonseed hulls versus sheep fed wood fiber were highly significant.

Liquid hemicellulose has a bitter taste which appears to be improved by the addition of even a small amount of cane molasses. The combination of unpalatable wood fiber and liquid hemicellulose appeared to be very distasteful and was totally rejected by two ewes. In an attempt to obtain some consumption by these ewes, which were later removed from the experiment, alfalfa hay was soaked in the liquid hemicellulose and fed to the animals. They ate some of this mixture, but still refused to consume any of Ration 6.

When cottonseed hulls was the roughage source, feed efficiency over the liquid energy sources was described by both linear ($P < .05$) and quadratic ($P < .05$) equations. Explanations for both the effects are found in the difference between Rations 1 and 2. When wood fiber was the roughage source, feed efficiency was described by linear ($P < .01$) and quadratic ($P < .05$) effects. Feed efficiencies on Rations 6 and 7 were poorer ($P < .01$) than all other treatments; differences between Rations 8, 9, and 10 were not significant.

Mills _et. al._ (1944) found that by including a small amount of corn in a diet of molasses, urea and roughage, more efficient growth response in heifer calves could be obtained. Bohman and associates (1954) in one experiment observed this phenomenon, but in another, the inclusion of corn gave only a slightly greater response than molasses, urea and roughage alone. Thus there is evidence that the inclusion of a more insoluble, but fermentable, carbohydrate than molasses in the diet may facilitate ruminal protein production.

Arias _et. al._ (1951) and Belasco (1956) observed that the addition of a small amount of starch stimulated cellulose digestion by ruminal microorganisms but that large amounts of starch depressed it. It was postulated that rumen microorganisms need small amounts of readily available carbohydrates to promote cellulose digestion.

Results in the present trial tend to support the thesis that a mixture of fermentable carbohydrates is a more efficient diet than either cane molasses or liquid hemicellulose alone. However, in the case of these two feeds, it would appear that the proportion of the mixture is important to the efficiency of the diet.

The effect of including wood fiber in the diet is not known. It was noted earlier in an experiment by Williams and Tillman that sheep on an all liquid diet ingested large amounts of wool, evidently in an effort to provide bulk for the rumen. The addition of wood fiber in the diet was an attempt to provide this bulk. The amount of time this fiber remained in the rumen and whether or not it affected the digestion process was not determined.

Since the wood fiber in this experiment had been subjected to both alkaline and acid hydrolysis, it is assumed that very little, if any, nutritional value remained in the fibers. As no wool consumption was observed in any of the sheep, the level of wood fiber consumed apparently was sufficient to satisfy their desire for dietary bulk.

Blood plasma mineral values are shown in Table VI. Neither the roughage source nor the mixtures of liquids in the diets affected ($P < .05$) any blood plasma mineral levels.

Results of a series of in vitro trials are indicated in Figures 1 and 2. Microbial elaboration of protein was most rapid when cane molasses was the liquid energy source and least rapid when liquid hemicellulose was the only energy source. Microbial growth patterns in Rations 4 and 9 parallel those in Rations 5 and 10 and at the end of

TABLE VI

EFFECT OF ROUGHAGE SOURCE AND PROPORTION OF CANE MOLASSES TO LIQUID HEMICELLULOSE UPON BLOOD PLASMA MINERAL LEVELS

Mineral	Treatment 1	2	3	4	5	Mean	S.E.[a]	6	7	8	9	10	Mean
Calcium mg./100 ml.	10.13	9.86	9.83	9.80	10.04	9.93	0.41	9.89	9.58	9.75	9.51	10.99	9.94
Phosphorus mg./100 ml.	3.82	3.56	4.14	3.98	5.13	4.13	0.52	3.94	3.11	3.21	4.17	3.76	3.64
Magnesium mg./100 ml.	3.51	3.96	4.38	3.37	4.39	3.92	0.49	3.69	4.10	4.03	3.16	3.93	3.78
Potassium meq/100 ml.	5.35	5.77	5.20	5.61	5.92	5.57	0.33	5.61	5.84	5.29	5.61	5.79	5.63
Copper ppm.	0.80	0.89	0.86	1.02	0.86	0.89	0.09	0.92	0.77	0.90	0.75	0.87	0.84
Iron ppm.	4.25	4.21	4.19	3.83	3.56	4.01	0.51	5.48	4.46	3.24	4.93	4.13	4.45
Zinc ppm.	0.74	0.74	0.77	0.81	0.77	0.77	0.05	0.73	0.67	0.73	0.71	0.80	0.73

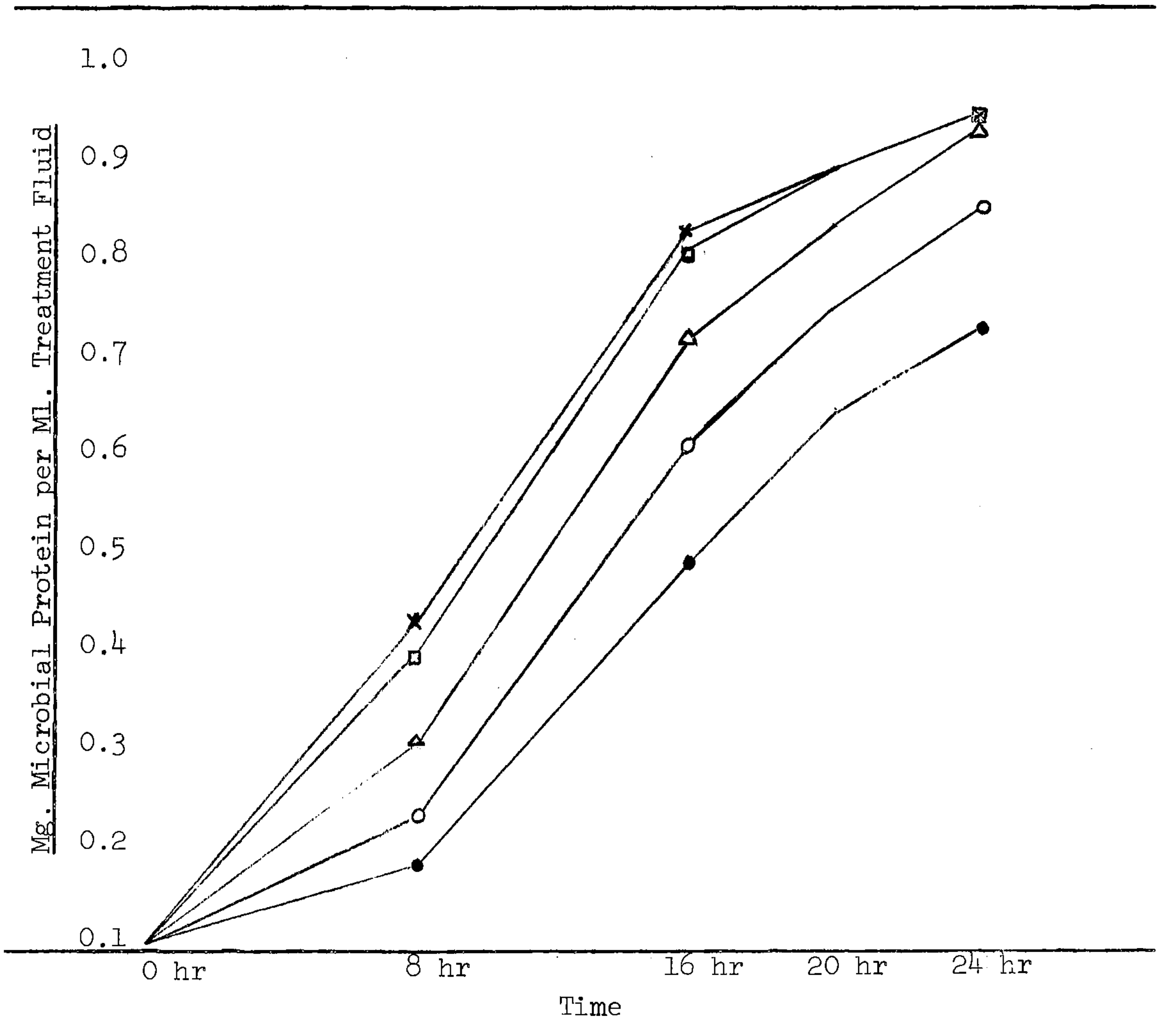
[a] Standard Error

the 24 hour period equalled Rations 5 and 10. These results support the idea that Rations 4 and 9 were equal to Rations 5 and 10 and, indeed, there was less than one standard error between these rations when daily gains are considered.

At the end of the 24 hour period Rations 3 and 8 were approaching Rations 4 and 9 while Rations 1 and 6 were well below Rations 2, 3, 4, 5, 7, 8, 9 and 10 in protein formation. By the end of 24 hours the period of growth decline had started. Since diets 1 and 6 evolved less than 0.2 mg./ml protein than treatments 3, 4, 5, 8, 9, and 10 when growth rate began to decline, this may be an indication that liquid hemicellulose is not as efficient a donor of carbon chain fragments as cane molasses.

When comparing the sheep results, those lambs on Rations containing cottonseed hulls showed less than one standard error of difference in average daily gain between Rations 2, 4 and 5. These results agree with the findings of Mills et. al. (1944) who found that a mixture of fermentable carbohydrates facilitates ruminal protein synthesis more than does a single carbohydrate source. The poor growth response from sheep on Rations 1 and 6 may be due not only to lowered intake but also because the liquid hemicellulose did not release as much carbon fragment material as cane molasses.

None of these speculations, however, account for the superiority of Treatments 3 and 8 over the other treatments. It is possible that in the analysis of variance the null hypothesis that there is no difference between the treatment means on Treatments 2, 3, 4, and 5 or Treatments 7, 8, 9 and 10 should not have been rejected. It may be that the slightly lower initial weights of the lambs on these Rations



Legend:

Treatment:

1 = ● 100% Liquid Hemicellulose - 0% Cane Molasses

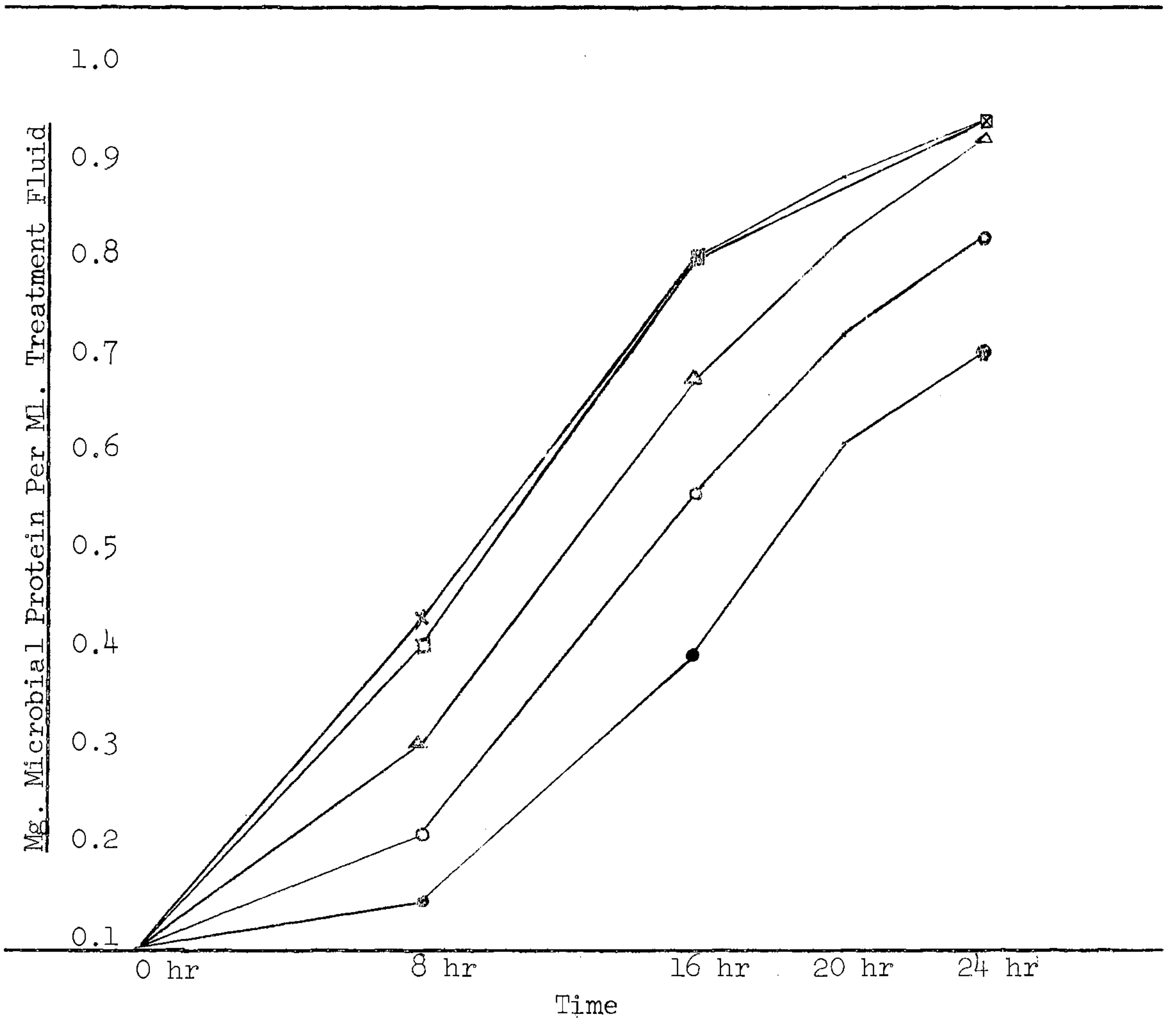
2 = ○ 75% Liquid Hemicellulose - 25% Cane Molasses

3 = △ 50% Liquid Hemicellulose - 50% Cane Molasses

4 = □ 25% Liquid Hemicellulose - 75% Cane Molasses

5 = × 0% Liquid Hemicellulose - 100% Cane Molasses

Figure 1. Effect of Liquid Energy Source, when fed with Cottonseed Hulls, Upon Microbial Protein Synthesis *In Vitro*



Legend:

Treatment:

6 = ● 100% Liquid Hemicellulose - 0% Cane Molasses

7 = ○ 75% Liquid Hemicellulose - 25% Cane Molasses

8 = △ 50% Liquid Hemicellulose - 50% Cane Molasses

9 = □ 25% Liquid Hemicellulose - 75% Cane Molasses

10 = × 0% Liquid Hemicellulose - 100% Cane Molasses

Figure 2. Effect of Liquid Energy Source, when fed with Wood Fiber, Upon Microbial Protein Synthesis *In Vitro*

indicate that the average age of these lambs was slightly less than the average age of the other sheep on test. If this is true, slightly faster rates of gains could be expected, and these would affect the final results.

Figures 1 and 2 indicate there is a more even elaboration of microbial protein in Treatments 3 and 8 than in the other rations. This may indicate that there is a more even release of energy in the rumen and therefore a more effective utilization of these diets by sheep than the others. If this is true, then there may be a real difference in diet efficiency and the null hypothesis may, in truth, be rejected.

SUMMARY

Forty ewe lambs were divided into 10 treatment lots to compare cane molasses with liquid hemicellulose as a source of carbon chain fragments for protein production in sheep. Response criteria were growth rate, feed consumption and feed efficiency. Lambs on a mixture of the two fluids gained more rapidly than lambs on diets of all-wood product hemicellulose or all-cane molasses. The most efficient diet was found to be an equal mixture of cane molasses and liquid hemicellulose.

Treatments had no significant effect on blood plasma mineral levels.

In vitro tests determined that cane molasses promoted faster microbial protein synthesis than did liquid hemicellulose.

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