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RUMINAL AND BLOOD CONSTITUENTS IN SHEEP FED DIFFERENT AMOUNTS OF MOLASSES

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Sugarcane molasses replaced sorghum grain on an equal weight basis in four experimental diets which contained 4% (control), 10%, 15% and 20% molasses, and were offered to Desert sheep. There was no treatment effect on average daily gain, feed conversion ratio (feed/gain)or feed intake.

The inclusion of molasses in the diets resulted in significantly lower elevation of ruminal ammonia and blood urea at 3h post-feeding. Total ruminal volatile fatty acid concentration was significantly ($P < 0.05$) higher in the control ration at both 3h and 6h post-feeding. Rumen pH was elevated in the molasses treatments at both 3h and 6h post-feeding; however, the increase was only significant ($P< 0.05$) at 6h post-feeding. Blood glucose was significantly higher ($P< 0.01$) in the 15% and 20% molasses treatments at 3h after feeding. Six hours post-feeding, blood glucose was highest in the 15% molasses treatment which was different ($P< 0.05$) from the control and 10% molasses treatment. There was no treatment effect on blood cholesterol at both 3h and 6h post-feeding. However, fasting decreased and feeding increased serum cholesterol across all treatments.

Key words: Molasses, sheep, rumen concentrations, blood concentrations, liveweight gain.

Sugarcane molasses have been used as livestock feed for several years. The proportion used for livestock feeding varies because of its cost. Use of large amounts of this feedstuff in rations has been reported to have certain limitations. The net energy value of sugarcane molasses for fattening and milk production decreased when molasses constituted more than 10% of the diet (Lofgreed and Otagaki 1960). Molasses have been reported to cause a decrease in digestibility of crude fibre (Bohman et al 1954) and crude protein (King et al 1957). Large amounts of molasses have also been reported to influence rumen fermentation (Marty et al 1970) producing a higher than normal molar proportion of both butyric and valeric acids at the expense of acetic acid. Elias and Preston (1969) and Karalazos and Swan (1977) reported that molasses diets cause a reduction in ruminal ammonia concentration and an increase in pH. The volatile fatty acid concentration decreased, but the decrease was not statistically significant (Karalazos and Swan 1977). The objective of the present work was to study the effects of increasing amounts of molasses in a complete mixed diet on some blood and ruminal constituents that reflect sheep performance. Sugarcane molasses were substituted for sorghum grain on equal weight basis.

Materials and Methods

Experimental procedure: Four diets containing increasing percentages of sugarcane molasses were offered ad libitum to yearling male Desert sheep in fattening trials for an 84-day period. The diets were isonitrogenous

and isocaloric. The detailed composition of the diets is given in Table 1. Molasses and the other concentrate portions were thoroughly mixed to preclude selection of the more palatable components.

Table 1:
Ingredients and chemical composition of the experimental diets fed to sheep

Molasses, %[a]	4	10	15	20
Ingredient, %				
Ground nut cake	10	10	10	10
Wheat bran	20	20	20	20
Sorghum grain	40	34	29	24
Alfalfa hay	15	15	15	15
Ground nut hulls	10	10	10	10
Common salt	1	1	1	1
Dry matter	94.3	93.8	93.3	92.2
Analysis, %[b]				
Crude protein	17.4	17.1	17.1	16.9
Ether extract	3.6	3.0	2.8	2.8
Crude fibre	10.0	10.2	10.2	10.6
Nitrogen free extract	61.6	61.5	60.5	59.9
Ash	6.9	8.2	9.4	9.4

[a]Molasses replaced sorghum grains on equal weight basis

[b]Analysis on a dry matter basis

Forty male Desert sheep were divided into four groups which were allocated at random to each of the four experimental diets. The diets contained 4%, 10%, 15% and 20% molasses. Sorghum grain was substituted by molasses on an equal weight basis. The diets will be referred to as treatments 1, 2, 3 and 4, respectively.

At the end of the fattening trials the sheep were fasted for 48h, then they were offered their normal diet ad libitum. Samples of rumen liquor were obtained by means of a stomach tube immediately before feeding, 3h and 6h after feeding. The rumen liquor samples were strained through 4 layers of cheesecloth after they were centrifuged at 3000 rpm for 5 minutes and kept for immediate analysis. Total volatile fatty acids (VFA) were determined by steam distillation as described by Kromann et al (1967). Ruminal ammonia nitrogen (NH_3-N) was determined as described by Conway (1957). Rumen pH was determined on a pH meter - Electronic Instruments Ltd model 7030.

Blood samples were withdrawn from the jugular vein immediately before feeding, 3 and 6h after feeding. The blood samples were allowed to clot and the serum was separated by centrifugation and stored at -20°C until assayed for blood glucose (Somogyi 1952), blood cholesterol (Praney and Amador 1968) and blood urea (Robert 1968).

The results were tested for statistical significance by analysis of variance (Steel and Torrie 1960).

Results

Growth, feed intake and feed efficiency as affected by molasses level in the concentrate diet are presented in Table 2. There was no significant treatment effect on the average final weight, average daily gain, daily feed intake or feed conversion ratio.

Table 2:
Growth and feed efficiency of sheep fed different molasses levels[1]

Item	Molasses level,%			
	4	10	15	20
Number	10	10	10	10
Initial weight, kg[2]	19.2 ± 2.7	19.6 ± 3.7	19.7 ± 3.7	20.2 ± 2.7
Final weight, kg	32.1 ± 5.6	35.8 ± 4.8	36.1 ± 7.5	31.8 ± 5.3
Average daily gain,kg	0.15± 0.06	0.19± 0.08	0.21 ± 0.11	0.14± 0.07
Daily intake, kg[3]	1.1 ± 0.1	1.2 ± 0.2	1.2 ± 0.2	1.2 ± 0.1
Feed/gain[3]	6.81	6.02	6.11	8.40
TDN/gain	4.97	4.25	4.11	5.59

[1] Molasses replaced sorghum grains on equal weight basis

[2] Values are means ± SD of 10 animals

[3] On dry matter basis

Ruminal VFA: Ruminal VFA concentrations at various times after feeding are presented in Table 3. Within each treatment, there were no significant differences ($P > 0.05$) in the concentrations of the VFA at 3h and 6h after feeding. However, as would be expected, VFA concentrations after 48h fasting were significantly lower ($P < 0.01$) than at either 3 or 6h after feeding treatments.

Substitution of as little as 6% of the sorghum grain with molasses (10% molasses) was associated with significantly lower ($P < 0.05$) rumen VFA concentrations when sampled at 3 and 6h after feeding. Further substitution of sorghum grain with molasses had no significant ($P > 0.05$) effect on rumen VFA concentration.

Ruminal - NH_3-N: Ruminal -NH_3-N concentrations (Table 3) were affected by both time after feeding and by diet. Ruminal - NH_3-N

Table 3:

Effect of fasting and refeeding different amounts of molasses on ruminal VFA, NH_3-N and pH of sheep

Molasses %	Time after feeding h	VFA mEq/100 ml	NH_3-N mg/100 ml	pH
	- 48	1.0 ± 0.2^{A}	10.6 ± 2.0^{A}	7.2 ± 0.1^{A}
4	3	8.3 ± 1.2^{b}	35.3 ± 1.4^{b}	$5.4 \pm 0.3^{b,c}$
	6	7.8 ± 1.8^{b}	18.7 ± 0.4^{C}	5.3 ± 0.1^{c}
	- 48	1.3 ± 0.1^{A}	10.7 ± 0.6^{A}	7.2 ± 0.2^{A}
10	3	5.9 ± 0.5^{c}	30.3 ± 0.5^{d}	5.7 ± 0.2^{b}
	6	5.8 ± 0.1^{c}	18.8 ± 4.9^{C}	5.7 ± 0.3^{b}
	- 48	1.4 ± 0.2^{A}	15.5 ± 1.1^{E}	6.9 ± 0.3^{A}
15	3	5.8 ± 0.5^{c}	24.6 ± 2.0^{f}	6.0 ± 0.5^{b}
	6	5.7 ± 0.2^{c}	18.5 ± 1.5^{c}	5.9 ± 0.5^{b}
	- 48	1.5 ± 0.3^{A}	$16.4 \pm 1.2^{E,g}$	7.0 ± 0.1^{A}
20	3	5.8 ± 0.5^{c}	28.7 ± 4.6^{d}	5.9 ± 0.4^{b}
	6	6.1 ± 1.0^{c}	$20.1 \pm 2.6^{C,g}$	5.8 ± 0.4^{b}

[1] Values are mean $\pm$ SD of 10 animals

a,b,c,d,e,f,g
Values in the same category with common superscripts are not significantly different. Lower case $P < 0.05$, capital letters $P < 0.01$

concentrations three hours after feeding were significantly higher ($P<0.01$) than 6h after feeding in all treatments. Within each treatment, ruminal - NH_3-N was significantly higher ($P < 0.01$) 6h after feeding than the fasting level except in treatment 4.

Ruminal - NH_3-N concentrations were also affected by the amount of molasses in the concentrate mixture. Three hours after feeding, ruminal - NH_3-N was significantly higher in treatment 1 than in the other molasses treatments. At 6h after feeding, all treatments showed very similar ruminal - NH_3-N concentration. The fasting ruminal -NH_3-N was significantly higher ($P < 0.01$) in treatments 3 and 4 compared to treatments 1 and 2.

To test the effect of the diet on ruminal - NH_3-N, it is more realistic to compare the increase in ruminal- NH_3-N above the initial values at feeding time rather than their absolute values. The comparison of such differences is justified since only these differences can be ascribed to the action of the food. Using this as a criterion, ruminal - NH_3 -N was maximally increased ($P < 0.01$) in treatment 1 (24.8) compared to the higher molasses treatments. Treatment 2 had less effect (19.7) but the effect was significantly greater ($P < 0.01$) than treatment 3 (9.1) and treatment 4 (12.4).

Ruminal pH: Ruminal pH (Table 3) was significantly affected by time after feeding ($P < 0.01$) and by diet ($P < 0.05$). The inclusion of molasses at 10% or more in the diet resulted in a significantly higher ($P < 0.05$) ruminal pH compared with treatment 1 when sampled at 6h after feeding.

Blood urea nitrogen: Blood urea (Table 4) was also affected by time after feeding. Three hours after feeding, blood urea, like ruminal $-NH_3-N$ increased significantly ($P < 0.01$) in all treatments. At 6h after feeding blood urea decreased significantly ($P < 0.01$) in all treatments except in treatment 4. Within each treatment, blood urea at 6h after feeding was not significantly different from the fasting values. Treatment 1 had the lowest ($P < 0.01$) fasting blood urea compared with the other treatments. Treatments 2 and 3 had intermediate values, while treatment 4 had the highest ($P < 0.01$) fasting blood urea value. These differences in blood urea concentration may be related to increased tissue catabolism during fasting.

Table 4:

Effect of fasting and refeeding different amounts of molasses on blood urea, glucose and cholesterol in sheep

Molasses %	Time after feeding h	Urea mg/100 ml	Glucose mg/100 ml	Cholesterol mg/100 ml
	- 48	36.6 ± 8.6^{A}	28.4 ± 4.6^{a}	27.7 ± 5.6^{a}
4	3	69.7 ± 9.4	36.5 ± 7.3^{a}	34.7 ± 3.1^{b}
	6	42.7 ± 6.7^{A,c}	54.1 ± 4.3^{B,c}	26.8 ± 3.9^{a}
	- 48	49.8 ± 8.9^{c}	29.0 ± 6.3^{a}	26.0 ± 4.9^{a}
10	3	70.3 ±12.6^{b}	36.7 ± 3.4^{a}	37.7 ± 7.2^{b}
	6	46.3 ± 9.4^{c}	48.8 ± 6.8^{B}	30.4 ± 6.5^{a}
	- 48	57.1 ±13.7^{c}	29.3 ± 6.6^{a}	31.1 ± 3.5^{a}
15	3	72.3 ±12.2^{b}	44.5 ± 5.2^{B}	36.4 ± 4.7^{b}
	6	53.6 ±10.2^{c}	62.0 ± 5.8^{c}	26.1 ± 7.7^{a}
	- 48	72.7 ±13.9^{b}	25.7 ± 3.1^{a}	31.1 ± 5.0^{a}
20	3	80.2 ±15.3^{b}	44.5 ± 4.7^{B}	37.1 ± 5.8^{B}
	6	68.9 ± 9.2^{b}	57.2 ± 7.3^{c,e}	27.2 ± 3.9^{a}

[1] Values are mean ± SD of 10 animals

Values in the same category with common superscripts are not significantly different, lower case $P < 0.05$, capital letters $P < 0.01$

Since the fasting blood urea was significantly different across the treatments, it is more appropriate to compare the effects of the diets on blood urea increase above the initial values found at feeding time rather than their absolute values. The maximum increase in blood urea after feeding was attained in treatment 1 (31.1 ± 4.6), followed by treatment 2 (20.8 ± 6.2), then by treatment 3 (12.2 ± 5.5) and last by treatment 4 (10.3 ± 4.5). The rank of the treatments based on increasing blood urea is the same as their rank based on increasing ruminal $- NH_3-N$.

Blood glucose: Blood glucose (Table 4) was also affected by time after feeding and by the amount of molasses in the diet. The fasting glucose was very low in all treatments. Three hours after feeding, blood glu

cose concentrations increased in all treatments; however, the increase was only significant ($P < 0.01$) in treatments 3 and 4. At 6h post-feeding, blood glucose was significantly higher ($P < 0.01$) compared to 3h after feeding in all treatments.

Blood glucose was also affected by the amount of molasses in the diet at both 3h and 6h after feeding. Three hours after feeding, blood glucose was significantly lower ($P < 0.01$) in treatments 1 and 2 compared to treatments 3 and 4 which had similar blood glucose concentration. At 6h after feeding treatment 3 had the highest blood glucose which was significantly greater ($P < 0.01$) than treatments 1 and 2.

Blood cholesterol: Blood cholesterol (Table 4) was affected by time after feeding but not by diet. In all treatments, blood cholesterol was significantly greater ($P < 0.05$) three hours after feeding compared to either 6h after feeding or to fasting concentrations. Blood cholesterol decreased with time after feeding in all treatments and reached the fasting concentration 6h after feeding.

Discussion

The results of the growth study indicate that the substitution of sorghum grain by molasses on an equal weight basis is economical. Sheep fed treatment 2 (10% molasses) and treatment 3 (15% molasses) appeared to perform better than those fed treatment 1 (4% molasses), efficiency were not significant. Fawzi and Mukhtar (1968) reported that replacing 10, 20 and 30% of legume hay by molasses had no significant effect on average daily gain and feed efficiency. Butler (1974) reported that replacing a portion or all of the barley with molasses in hay-supplemented diet had no significant effect on liveweight gain of growing dairy heifers.

One of the major factors influencing the loss of ammonia across the rumen wall following the rapid degradation of soluble protein is the availability of carbohydrate for microbial fermentation (Wohlt et al 1973 Waldo and Goering 1979). In the present study, although the average dry matter intake was approximately similar, the inclusion of molasses in the diet, particularly at 10% and 15% levels, caused a significant decreased ($P < 0.01$) in ruminal ammonia when sampled at 3h after feeding. Elias and Preston (1969) studied aspects of rumen fermentation in Holstein calves when changed from an all-concentrate diet to one containing high molasses urea and forage given ad libitum for one or two weeks during the change over. They reported that the inclusion of ground maize in the diet resulted in significantly higher ($P < 0.05$) ruminal ammonia concentration compared to high molasses urea and forage only.

The increase in rumen pH with the increase in molasses content of the diet reported here was accompanied by a significant drop ($P < 0.01$) in VFA concentration in the rumen liquor with 10% or more molasses. This finding is in line with the results of Karalazos and Swan (1977). These authors reported that the concentration of VFA decreased as barley was replaced by molasses; however, the depression was not significantly different from the control diet.

Lewis (1957), Abou Akkada and Osman (1967), Tagari et al (1964) and Preston et al (1965) had reported highly significantly linear relationships between ruminal ammonia and blood urea. Our data are in line with the

above conclusion, particularly if the increase in ruminal ammonia and blood urea above the initial values found at feeding time are compared rather than their absolute values. In the results reported here, the increase in ruminal ammonia and blood urea were highly correlated (R^2 = 0.87) at 3h after feeding.

The higher blood glucose, 3h after feeding, observed in this study when 15% and 20% molasses treatments were fed may possibly be attributed to an increase in the proportion of propionic acid at the expense of acetic acid as the molasses content of the diet was increased (Marty et al 1970; Ndumbe et al 1964).

The effect of feeding and fasting as well as the nature of the diet on serum cholesterol is controversial. Staub and Thiessen (1968) reported that an increase in dietary sucrose was accompanied by increased serum cholesterol in rats. Arave et al (1975) reported that cows receiving more than normal rations had lower serum cholesterol than cows receiving a normal or subnormal ration. The data reported here suggests that fasting decreases and refeeding increases serum cholesterol while dietary molasses has no effect.

References

Abou Akkada A R and Osman H E 1967 The use of ruminal ammonia and blood urea as an index of the nutritive value of protein in some feedstuffs. Journal of Agricultural Science Cambridge 69:25-31

Arave C W, Miller R H and Lamb R C 1975 Genetic and environmental effects on serum cholesterol of dairy cattle of various ages. Journal of Dairy Science 58:423-427

Bohman V R, Trimberger G W, Loosli J K and Turk K L 1954 The utilization of molasses and urea in the rations of growing dairy cattle. Journal of Dairy Science 37:284-293

Butler T M 1974 Comparison of sugarcane molasses and barley as energy feeds for dairy cattle. Irish Journal of Agricultural Research 13:197-202.

Conway E J 1957 Microdiffusion Analysis and Volumetric Error. 4th edition London: Crosby-Lockwood and Son Ltd

Elias A and Preston T R 1969 A note on some aspects of rumen fermentation in Holstein calves changed from an all-concentrate diet to high levels of molasses/urea and forage. Animal Production 11:565-568

Fawzi H F O and Mukhtar A M S 1968 The use of industrial by-products in animal feeding in the Sudan: I Cane molasses for growing calves. The Sudan Journal of Veterinary Science and Animal Husbandry 9:260-265

Karalazos K and Swan H 1977 The nutritional value for sheep of molasses and condensed molasses solubles. Animal Feed Science and Technology 2:143-152

King W A, O'Dell G D and Roderich O B 1957 Utilization of blackstrap molasses, urea in molasses and ammoniated molasses by dairy heifers. Journal of Dairy Science 40:810-817

Kromann R P, Meyer J H and Stileau W J 1967 Steam distillation of volatile fatty acids in rumen ingesta. Journal of Dairy Science 50:73-76

Lewis D 1957 Blood-urea concentration in relation to protein utilization in the ruminant. Journal of Agricultural Science. Cambridge 48:438-446

Lofgreen G P and Otagaki K K 1960 The net energy of blackstrap molasses for lactating dairy cows. Journal of Dairy Science 43:220-230

Marty R, Benavides M, Ly J and Preston T R 1970 Rumen fermentation in bulls given sucrose as the main carbohydrate source. Proceedings of the 5th Symposium at Vitzau, Switzerland, September 1970 p 57

Ndumbe R D, Runsie K V and McDonald P 1964 The effect of early weaning on the blood sugar and rumen acid levels of growing calves. British Journal of Nutrition 18:29-38

Praney R J and Amador E 1968 Serum cholesterol measurement based on ethanol extraction and ferric chloride-sulphuric acid. Clínica Chimica Acta 21:255-163

Preston R L, Schnakenbery D D and Pfander W H 1965 Protein utilization in ruminants:I Blood urea nitrogen as affected by protein intake. Journal of Nutrition 86:281-288

Robart T E 1968 Manual and automated methods for measuring urea based on a modification of its reaction with diacetyl monoxime and thiosemicarbazide. Journal of Clinical Pathology 21:527-532

Somogyi M 1952 Notes on sugar determination. Journal of Biological Chemistry 195:19-27

Staub H W and Thiessen R Jr 1968 Dietary carbohydrate and serum cholesterol in rats. Journal of Nutrition 95:633-638

Steel G D and Torrie J H 1960 Principles and Procedures of Statistics McGraw-Hill Book Company Inc, New York

Tagari H, Dror Y, Ascarelli I and Bondi A 1964 The influence of levels of protein and starch in rations of sheep on the utilization of protein. British Journal of Nutrition 18: 333-356

Waldo D R and Goering H K 1979 Insolubility of proteins in ruminant feeds by four methods. Journal of Animal Science 49:1560-1568

Wohlt J E, Sniffen C J and Hoover W H 1973 Measurement of protein solubility in common feedstuffs. Journal of Dairy Science 56:1052-1057

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