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Influence of Level of Addition on the Feeding Value of Cane Molasses in Growing-Finishing Diets for Feedlot Cattle

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Abstract: A metabolism trial and a growth-performance trial were conducted to evaluate the influence of level of supplementation (6, 12, 18 and 24%, DM basis) on the replacement feeding value of cane molasses in a steam-flaked corn-based finishing diet. Molasses replaced steam-flaked corn in the diet. Four Holstein steers (317 kg) with cannulas in the rumen and proximal duodenum were used to evaluate treatment effects on digestive function. There were no treatment effects ($p>0.20$) on ruminal digestion of OM, NDF and feed-N. Ruminal microbial efficiency (g microbial N passing to the small intestine per kg OM fermented) decreased (linear effect, $p<0.10$) with increasing molasses level. Increasing molasses level did not affect ($p>0.20$) total tract OM digestion, but decreased total tract digestion of starch (linear effect, $p<0.01$), N (linear effect, $p<0.05$) and DE (linear effect, $p = 0.06$). The DE value of cane molasses was not affected by level of addition, averaging 2.98 Mcal kg^{-1}. Sixty-four medium-frame crossbred heifers (447 kg) were used in a 61-d trial to evaluate treatment effects on growth performance. Increasing dietary molasses level decreased (linear effect, $p<0.05$) ADG, DMI (linear effect, $p<0.05$), gain efficiency (linear effect, $p<0.01$) and dietary NE_m and NE_g (linear effect, $p<0.01$). Given that the NE_m and NE_g values of steam-flaked corn are 2.38 and 1.68 Mcal kg^{-1} respectively, then the corresponding values for cane molasses were 1.30 and 0.73 Mcal kg^{-1}, respectively. These NE values are considerably less (24 and 32%, respectively) then expected based on tabular values and observed dietary DE value.

Key words: Cane, molasses, cattle, digestion, performance

INTRODUCTION

Molasses is usually added to growing-finishing diets at low levels (2-6%, DM basis) to enhance adhesiveness, palatability or condition of the diet (Lane, 1990). From time to time, molasses may compete with grain as a lower-cost energy alternative. However, Kunkle *et al.* (1997) observed that the feeding value of molasses decreased when added at more than 10% of the diet. Likewise, Lofgreen and Otagaki (1960) and Heinemann and Hanks (1977) observed that the energy value of molasses decreased markedly in going from 10-25% of dietary DM. Other detrimental effects of high-level molasses supplementation included depressed fiber digestion (Garret *et al*., 1989), decreased N utilization (Potter *et al*., 1971; Hatch and Beeson, 1972) and mineral imbalance (Potter *et al*., 1985).

The objective of this study was to further evaluate the influence of level of supplementation on the feeding value of cane molasses in finishing diets for feedlot cattle.

MATERIALS AND METHODS

All procedures involving animal care and management were in accordance with and approved by the University of California, Davis, Animal Use and Care Committee.

Animals and sampling: Four Holstein steers (317 kg) with cannulas in the rumen and proximal duodenum were used to evaluate the influence of dietary molasses level (6, 12, 18 and 24% cane molasses) on digestive function. Experimental diets are shown in Table 1. Chromic oxide was added to the diets as a digesta marker. Steers were maintained in individual pens (3.9 m^2) with access to water at all times. Diets were fed at 0800 and 2000 daily. Experimental periods consisted of a 10 day diet adjustment period followed by a 4 day collection period. During the collection period duodenal and fecal samples were taken from all steers, twice daily as follows: day 1, 1050 and 1650; day 2, 0900 and 1500; day 3, 0730 and 1330

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and day 4, 0600 and 1200. Individual samples consisted of 750 mL duodenal chyme and 200 g (wet basis) fecal material. Samples from each steer and within each collection period were composited for analysis. During the final day of each collection period, ruminal fluid samples were obtained from each steer at 1200 (4 h after feeding) via the ruminal cannula. Upon completion of the trial, ruminal fluid was obtained from all steers and composited for isolation of ruminal bacteria via differential centrifugation (Bergen *et al*., 1968).

Sample analysis and calculations: Feed, duodenal and fecal samples were subjected to all or part of the following analysis: DM (oven drying at 65° C until no further weight loss); ash, Kjeldahl N, ammonia N (AOAC, 1975); purines (Zinn and Owens, 1986); chromic oxide (Hill and Anderson, 1958) and starch (Zinn, 1990). Microbial Organic Matter (MOM) and N (MN) leaving the abomasum was calculated using purines as a microbial marker (Zinn and Owens, 1986). Organic Matter Fermented in the rumen (OMF) was considered equal to OM intake minus the difference between the amount of total OM reaching the duodenum and MOM reaching the duodenum. Feed N escape to the small intestine was considered equal to total N leaving the abomasum minus ammonia-N and MN and, thus, includes any endogenous contributions.

Table 1: Composition of experimental diets (DM basis, Experiments 1 and 2)

	Cane molasses (% DM basis)			
Item	6	12	18	24
Ingredient composition (%)				
Steam-flaked corn	75.6	69.6	63.6	57.6
Limestone	1.6	1.6	1.6	1.6
Urea	1.25	1.25	1.25	1.25
Magnesium oxide	0.15	0.15	0.15	0.15
Trace mineral salt[a]	0.4	0.4	0.4	0.4
Laidlomycin, ppm	12	12	12	12
Yellow grease	3.0	3.0	3.0	3.0
Sudangrass hay	12.0	12.0	12.0	12.0
Cane molasses[b]	6.0	12.0	18.0	24.0
Nutrient composition (DM basis)[c]				
DE (Mcal kg^{-1})	3.82	3.77	3.71	3.65
NE_m (Mcal kg^{-1})	2.22	2.18	2.14	2.10
NE_g (Mcal kg^{-1})	1.55	1.52	1.48	1.45
Crude protein (%)	12.0	11.8	11.6	11.4
NDF (%)	14.7	14.2	13.6	13.1
Calcium (%)	0.71	0.77	0.83	0.88
Phosphorus (%)	0.28	0.27	0.25	0.24
Magnesium (%)	0.27	0.29	0.31	0.33
Potassium (%)	0.75	0.97	1.19	1.41
Sulfur (%)	0.14	0.16	0.18	0.20

[a]Trace mineral salt: $CoSO_4$, 0.068%; $CuSO_4$, 1.04%; $FeSO_4$, 3.57%; ZnO, 1.24%; Mn SO_4, 1.07%; KI, .052% and NaCl, 92.96%; [b]Composition: DM, 73%; brix, 79.5°; total sugars (as invert), 43%; [c]Based on tabular values for individual feed ingredients (NRC, 1984) with the exception of yellow grease which was assigned NE_m and NE_g values of 6.00 and 4.50 Mcal kg^{-1}, respectively (NRC, 1996)

Statistical analysis: Data were analyzed as a 4×4 Latin square experiment (Hicks, 1973). Treatment effects were tested by means of orthogonal polynomials.

Animals and diets: Sixty-four crossbred yearling heifers (447 kg) were used to evaluate treatment effects on feedlot growth-performance. Heifers were injected with 500,000 IU vitamin A (Vita-jec7 A and D 500, RXV Products, Porterville, CA) heifers were blocked by weight and assigned within blocks to 16 pens (4 heifers/pen). Pens were 5.48×9.14 m, with 26.7 m^2 of shade and were equipped with automatic waterers and fence-line feed bunks (4.27 m in length). Upon initiation of the trial, heifers were implanted with Synovex-H (Fort Dodge Animal Health, Fort Dodge, IA) and weighed on two consecutive days. Treatments were the same as in (Table 1). Diets were prepared at weekly intervals and stored in plywood boxes located in front of each pen. Heifers were allowed ad libitum access to dietary treatments. Fresh feed was provided twice daily. Estimates of heifer performance were based on pen means. Hot carcass weights were obtained from heifers at time of slaughter.

Estimation of dietary NE: Energy Gain (EG) was calculated by the equation (NRC, 1984):

$$EG = (0.0806\ W^{.75})\ ADG^{1.119}$$

Maintenance energy expended (Mcal day^{-1}, EM) was calculated by the equation (NRC, 1984):

$$EM = 0.077W^{.75}$$

The NE value of the diets for maintenance and gain were obtained by means of the quadratic formula (Zinn and Shen, 1998):

$$Ne_m, \text{ Mcal kg}^{-1} = (-b - \sqrt{b^2 - 4ac})/2c$$

Statistical design and analysis: For calculation of heifer performance, live weight was reduced 4% to account for digestive tract fill. Pens were used as experimental units. Data were analyzed as a randomized complete block design experiment, with four treatments and four blocks (Hicks, 1973). Treatment effects were tested by means of orthogonal polynomials.

RESULTS AND DISCUSSION

Ruminal digestion of OM, NDF and feed-N were not affected ($p>0.20$) by treatments (Table 2). Increasing the

level of molasses addition decreased (linear effect, $p<0.10$) ruminal microbial efficiency (g MN/kg OM fermented), ruminal N efficiency (non-ammonia N entering the small intestine/N intake) and ruminal starch digestion. Potter *et al*. (1971), also observed decreased ruminal N efficiency as dietary molasses level increased from 2.5-10% of the dietary DM.

Dietary molasses level did not affect ($p>0.20$) total tract OM digestion. Nevertheless, increasing molasses level decreased (linear effect, $p<0.01$) total tract digestion of starch, N (linear effect, $p<0.05$) and DE (linear effect, $p = 0.06$). The decrease in DE with level of supplementation was closely associated ($r^2 = 0.99$, $p<0.01$) with expected DE based on diet formulation (Table 1). The replacement DE value of cane molasses can be determined from changes in DE with level of cane molasses replacement for steam-flaked corn. However, because tabular DE values are based on measures at maintenance level of intake, it is necessary first to adjust the DE values of the diet in Table 1 for this differential (Zinn *et al*., 1997). The expected DE value of the diet containing 6% cane molasses is 3.82 Mcal kg^{-1} (Table 1). Accordingly, the observed values in Table 2 may be standardized by dividing by 0.895. Regressing these standardized values on cane molasses as a percentage of cane molasses plus steam-flaked corn in the respective diets (PCM), the following relationship is obtained: DE = 3.877-0.00729 PCM ($r^2 = 0.993$, $p<0.01$). Given that steam-flaked corn has a DE value of 4.19 Mcal kg^{-1} (NRC, 1984) and 81.6% of the diet is cane molasses plus steam-flaked corn (Table 1), the comparative DE value of cane molasses would be 2.98 Mcal kg^{-1} (3.877-0.729/0.816). This value agrees closely (94%) with the tabular value (3.17 Mcal kg^{-1}, NRC, 1984). Thus, level of cane molasses supplementation, per se, did not affect the DE value of cane molasses. Furthermore, the DE value of cane molasses used in this study is consistent with tabular values.

The effects of increasing dietary molasses level on total tract digestion have not been consistent. Wing and Fowell (1966) did not observe an effect of increasing molasses level from 6-18% on total tract DM digestion. In contrast and Nino-DuPonte *et al*. (1992) observed decreased total tract DM, OM and NDF digestion when dietary molasses was increased from 12-25%. Hatch and Beeson (1972) observed a 9% decrease in total tract DM digestion when molasses level was increased from 10-15% of dietary DM in a corn-based finishing diet. Garret *et al*. (1989) observed decreased apparent total tract N digestion with increasing level of molasses supplementation.

The influence of level of molasses supplementation on growth performance is shown in the Table 3. Increasing molasses level decreased ADG (linear effect, $p<0.05$), DMI (linear effect, $p<0.05$) and gain efficiency (linear effect, $p<0.01$). For every percentage unit increase in molasses level above 6% of dietary DM, ADG decreases 1.7% ($r^2 = 0.93$). Heinemann and Hanks (1977) reported an 8% decrease in ADG and 7% decrease in feed efficiency by increasing dietary molasses level in a barley-based finishing diet from 10-20%. Niekerk and Voges (1976) observed decreased feed efficiency with

Table 2: Influence of dietary treatments on characteristics of ruminal and total tract digestion (Experiment 1)

	Molasses (%)				
Item	6	12	18	24	SEM
Intake (g/day)					
DM	5,980	5,841	5,902	5,772	
OM	5,668	5,522	5,547	5,378	
NDF	920.9	841.1	873.5	883.2	
N	105.8	104.6	102.1	99.3	
Starch	2,942	2,816	2,662	2,315	
GE (Mcal[a])	24.9	24.2	24.3	23.6	
Ruminal digestion (%)					
OM	69.5	68.6	67.9	68.0	1.3
NDF	33.7	31.5	23.5	39.0	5.1
Feed N	62.5	58.1	62.8	61.5	3.3
Starch[b]	86.5	86.3	85.2	79.4	1.9
Microbial efficiency[c]	18.5	16.08	17.6	16.3	1.0
N efficiency[de]	1.1	1.0	1.0	0.9	0.1
Total tract digestion (%)					
OM	83.8	83.8	83.5	82.8	6.2
NDF	46.7	47.8	55.1	55.5	2.2
N[b]	77.1	77.1	72.9	71.1	1.2
Starch[a]	98.3	98.4	97.9	97.0	1.0
DE ([e]Mcal kg^{-1})	3.42	3.38	3.32	3.28	0.03

[a]Linear effect, $p<0.01$; [b]Linear effect, $p<0.05$; [c]Microbial N, g/kg OM fermented; [d]Nonamonia N flow to the small intestine/N intake; [e]Linear effect, $p<0.10$

Table 3: Influence of dietary treatments on growth-performance oh heifers in a 61-day feeding (Experiment 2)

	Molasses (%)				
Item	6	12	18	24	SEM
Days on test	61	61	61	61	
Pen replicates	4	4	4	4	
Weight (kg)					
Initial	452	443	448	444	
28 day[a]	490	475	474	462	5
Final[b]	527	503	506	493	8
ADG (kg)					
1-28 day[a]	1.35	1.15	0.92	0.62	0.12
1-61 day[b]	1.23	0.99	0.95	0.80	0.09
DMI (kg/day)					
1-28 day[b]	7.53	6.84	6.61	6.17	0.04
1-61 day[c]	7.75	7.08	6.95	6.60	0.37
DMI/ADG					
1-28 day[a]	5.6	6.5	7.2	11.8	1.3
1-61 day[a]	6.3	7.4	7.3	8.3	0.4
Dietary NE (Mcal kg^{-1})					
Maintenance[a]	2.37	2.24	2.25	2.15	0.05
Gain[a]	1.67	1.56	1.57	1,48	0.05
Dietary NE (Observed/expected)					
Maintenance	1.07	1.02	1.05	1.02	0.03
Gain	1.08	1.04	1.07	1.03	0.03

[a]Linear effect, $p<0.01$; [b]Linear effect, $p<0.05$; [c]Linear effect, $p<0.10$

increasing dietary molasses levels. However, decreased gain efficiency is expected when molasses is substituted for grain due to differences in tabular energy values.

Observed dietary NE_m and NE_g based on growth performance decreased (linear effect, $p<0.01$; Table 3) with increasing cane molasses level. However, as was observed in Experiment 1 with respect to dietary DE, the ratio between observed and expected dietary NE was not affected ($p>0.20$). Thus, most of the decrease in ADG with molasses supplementation was due to decreased DMI and hence, energy intake. Given that the NE_m and NE_g value of steam-flaked corn are 2.38 and 1.68 Mcal kg^{-1}, respectively, then the corresponding NE_m and NE_g values for cane molasses are 1.30 and 0.73 Mcal kg^{-1}, respectively. Tabular Ne_m and Ne_g values for cane molasses are 1.70 and 1.08 Mcal kg^{-1}, respectively.

Thus, the observed NE_m and NE_g values for cane molasses were considerably less (24 and 32%, respectively) then expected based on tabular values. But, these NE values are nevertheless, higher than earlier values reported by Lofgreen and Otagaki (1960) and Heinemann and Hanks (1977). Lofgreen and Otagaki (1960) observed that increasing dietary molasses level from 10-25% decreased dietary DE by 3%, but decreased dietary NE by 45% (1.52 vs 0.833). This differential between DE and NE was thought to have been due, in part, to increased energy loss in the urine, combustible gas and/or increased heat increment (Lofgreen and Otagaki, 1960). In contrast, Heinemann and Hanks (1977) observed that at 10% of dietary DM beet molasses had an NE_m value of 1.11 Mcal kg^{-1} (54.5% TDN). Increasing the level of molasses to 20% of dietary DM decreased its NE_m to 0.46 Mcal kg^{-1} (34% TDN).

CONCLUSION

High levels of cane molasses supplementation has a detrimental effect on feed intake and hence, energy intake and ADG (for every percentage unit increase in dietary molasses level above 6% of dietary DM, ADG decreased 1.7%). The DE and NE values, per se, of cane molasses are not affected by level of inclusion. The observed DE value of cane molasses is consistent with tabular values. However, its Ne_m and Ne_g values may be considerably lower (24 and 32%, respectively) than currently tabulated. Increasing level of molasses supplementation may depress ruminal N efficiency due to decreased net ruminal microbial N synthesis.

REFERENCES

AOAC, 1975. Official Methods of Analysis. 12th Edn. Association of Official Analytical Chemists, Washington, DC.

Bergen, W.G., D.B. Purser and J.H. Cline, 1968. Effect of ration on the nutritive quality of rumen microbial protein. J. Anim. Sci., 27: 1497.

Garret, J.E., F. Guessous and A. Eddebbarh, 1989. Utilization of sugar beet molasses and monensin for finishing dairy bullocks. Anim. Sci. Technol., 25: 11-21.

Hatch, C.F. and W.M. Beeson, 1972. Effect of different levels of cane molasses on nitrogen and energy utilization in urea rations for steers. J. Anim. Sci., 35: 854-858.

Heinemann, W.W. and E.M. Hanks, 1977. Cane molasses in cattle finishing rations. J. Anim. Sci., 45: 13-17.

Hicks, C.R., 1973. Fundamental Concepts in the Design of Experiments. Holt, Rinehart and Winston, New York.

Hill, F.N. and D.L. Anderson, 1958. Comparison of metabolizable energy and productive energy determinations with growing chicks. J. Nutr., 64: 587.

Kunkle, W.E., J.E. Moore and O. Balbuena, 1997. Recent research on liquid supplements for beef cattle. 8th Annual Florida Ruminant Nutrtiton Syposium. Gainesville, Fl., January 16-17.

Lane, A., 1990. Use of molasses as a vehicle for liquid supplement of nutrients in total mixed dairy rations. 1st Florida Ruminant Nutrition Syposium, Gainesville, Fl., January 23-24.

Lofgreen, G.P. and K.K. Otagaki, 1960. The net energy of blackstrap molasses for fattening steers as determined by a comparative slaughter technique. J. Anim. Sci., 19: 392-403.

Niekerk, B.D.H. and D.J. Voges, 1976. Cane molasses as a replacement for maize meal in beef fattening rations. South Afric. J. Anim. Sci., 6: 67-72.

Nino-DuPonte, R.Y., J.R. Carpenter, C.M. Campbell, M. Kaheiki and C. Rice, 1992. The effects of altering molasses and fiber levels on nutrient digestibility and energy efficiency of feedlot rations. Proceedings, 43: 243-246.

NRC, 1984. Nutrient Requirement of Beef Cattle. 6th Rev. Edn. National Academy of Sciences, Washington, DC.

NRC, 1996. Nutrient Requirement of Beef Cattle. 7th Rev. Edn. National Academy of Sciences, Washington, DC.

Potter, G.D., C.O. Little, N.W. Bradley and G.E. Mitchell, Jr., 1971. Abomasal nitrogen in steers fed soybean meal, urea or urea plus two levels of molasses. J. Anim. Sci., 32: 531-533.

Potter, S.G., A. Moya, P.R. Henry, A.Z. Palmer, H.N. Becker and C.B. Ammerman, 1985. Sugarcane condensed molasses soluble as a feed ingredient for finishing cattle. J. Anim. Sci., 60: 839-846.

Wing, J.M. and G.W. Fowell, 1966. Response of lactating cows to 2 levels of mill-run blackstrap molasses from cane grown on organic soil I. J. Dairy Sci., 52: 1413-1414.

Zinn, R.A. and F.N. Owens, 1986. A rapid procedure for purine measurement and its use for estimating net ruminal protein synthesis. Can. J. Anim. Sci., 66: 157.

Zinn, R.A., 1990. Influence of flake desity on the comparative feeding value of steam-flaked corn for feedlot cattle. J. Anim. Sci., 68: 767.

Zinn, R.A. and Y. Shen, 1998. An evaluation of ruminally degradable intake protein and metabolizable amino acid requirements of feedlot calves. J. Anim. Sci., 76: 1280-1289.

Zinn, R.A., M. Montano, E. Alveraz and Y. Shen, 1997. Feeding value of cottonseed meal for feedlot cattle. J. Anim. Sci., 75: 2317-2322.