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CALCIUM SOAPS IN LOW OR HIGH ROUGHAGE RATIONS: 1- EFFECT ON DIGESTION, RUMEN METABOLISM, BLOOD PLASMA LIPIDS OF GROWING-FINISHING BULLS

T.M. El-Bedawy, M.A.I. Salem and A.S. Sami

Department of Animal Production, Faculty of Agriculture, Cairo University, Giza, Egypt

SUMMARY

The present experiment was conducted to determine the effect of calcium soaps of long chain fatty acids (Magnapac®) on diet digestibility, basic pattern of rumen fermentation and blood plasma lipid metabolites and cations of growing-finishing Baladi bulls. Eighteen bulls were divided into three similar groups and fed either an un-supplemented control (18 % roughage) diet or 5% Magnapac® supplemented rations containing 17% roughage (FLR) or 27 % roughage (FHR) roughage for 165 days. Rations were almost iso-nitrogenous containing 12.11, 11.69 and 11.37 % CP for control, FHR and FLR rations, respectively. The corresponding EE contents were 2.66, 6.89 and 7.14 %. Fat supplement in the high roughage ration decreased (P<0.05) the digestion of CP, CF and EE which resulted in lower OM and DM digestibility. However, no significant differences were detected between control and FLR diets in all nutrients digestion. Dry matter intake was comparable for the control and FHR groups but (P<0.05) lower values were recorded for the FLR group. However, no significant differences in TDN intake were detected among the experimental groups. The lowest DCP intake was recorded for the group fed FLR diet.

Inclusion of calcium soaps of long chain fatty acids fat either in high or low roughage diets did not change ruminal pH, ammonia concentrations, total VFA's concentrations or proportions of the individual VFA. Plasma concentrations of total lipids, triglycerides, low density and high density lipoprotein as well as total cholesterol (P<0.05) increased but plasma calcium, magnesium and phosphorus were not affected by feeding calcium soap either in high or low roughage diets.

Keywords : beef cattle, calcium soaps, digestion, rumen metabolism, plasma lipids

INTRODUCTION

Fat is often added to growing-finishing diets of beef cattle to increase energy density and energy intake specially when the low fat diets are fed. Responses to dietary fat supplement are variable among studies (Ngidi *et al.*, 1990). Adding 4.8% protected tallow improved the performance of finishing cattle than those fed control or 8.7% protected tallow diets (Haaland *et al.*, 1981). Based on the nutrients

digestibility, Moore et al. (1986) concluded that 2 to 4% added fat may stimulate feed intake and increase DE intake by steers.

Calcium salts of long chain fatty acids (calcium soaps) have been widely utilized as an energy source in diets of lactating cows but ruminal pH of beef cattle fed finishing high concentrate diets is different from the normal pH conditions of dairy cows where the calcium soaps has been reported to remain relatively inert in the rumen and then to be completely dissociated in the acidic condition of the abomasum (Jenkins and Palmquist, 1984). Milk production increased in dairy cows supplemented with calcium soaps (West and Hill, 1990) but the utilization of calcium soap as an alternative to conventional dietary fat sources by beef cattle is not evident or consistent. Palmquist (1984) suggested that dissociation of calcium soaps occurred at low ruminal pH if it was prepared from unsaturated fats. Finishing rations of beef cattle often contain high concentrates, and ruminal pH is lower than that of dairy cows.

The Objectives of the present study were to determine effects of calcium soaps on nutrient digestibility, rumen metabolism, blood plasma lipids of growing-finishing bulls fed either high or low roughage diets.

MATERIALS AND METHODS

Eighteen Baladi bulls of 215 Kg average body weight were randomly allotted into three similar groups each of six bulls for 165 day experimental period. Three growing-finishing rations were fed ; control, fat high roughage (FHR) ration and fat low roughage (FLR) ration, for group 1, 2 and 3, respectively. Feed and chemical composition of the three rations are presented in Table 1. Dietary fat was added from calcium soaps of palm oil (Magnapac®, trademark of Norel, S.A. Spain).

Bulls were individually fed according Ghoneim (1967) allowance and rations were adjusted to the biweekly change in body weight. Rations were offered once a day at 8:00 a.m. and any refusals were quantitatively collected to determine actual intake. Bulls were watered twice a day at 9:00 and 14:30.

Two sets of digestion trails were carried out at middle and end of the experimental period. Fecal grab samples were collected from the rectum of all bulls two times daily at 8:00 and 20:00 for consecutive 8 days. Acid insoluble ash (AIA) technique (Van Kueulen and Young, 1977) was applied to determine nutrient digestibilities. Daily individual fecal samples were kept frozen at 20°C. Samples were pooled in one composite sample for each bull to be oven dried and ground for later chemical analysis. Chemical composition of feeds and feces were determined according to A.O.A.C. (1990) methods. Acidic ether extract was determined according to Drackley *et al.* (1985).

Rumen fluid samples were immediately collected from the rumen of four-24 hrs-fasting bulls, just after slaughtering. Ruminal pH was immediately measured using pH meter, ruminal ammonia-N concentrations were determined in duplicates according to Conway (1963). Total VFA's concentrations were determined using steam distillation (Kromann, 1967) and molar proportions of VFA were analyzed according to Erwin *et al.* (1961).

Blood samples were withdrawn from the left jugular vein of all bulls before feeding at the end of each digestion trail and samples were pooled for each animal. Samples were collected in heparinzed tubes, spent at 5,000 rpm for 10 minutes and

kept frozen for analysis at -
used to determine total lipids (Cal-test Diagnostics Inc., Chino, CA 91710 USA), total cholesterol (Bio-Merieux 69280 Marcy-L Etoile/ France) triglycerides (Stanbio Laboratory, Inc., No. 2100, San Antonio, Texas, USA), high density lipoprotein and low density lipoprotein, calcium, magnesium and phosphorus (Quimica Clinica Aplicada, QCA, S.A. 43870, Amposta, Spain).

Data collected were subjected to one- way analysis of variance (Mstat C, 1989). Duncan's Multiple Range Test (Duncan, 1955) was used to separate means at ($P<0.05$) whenever the treatment effect was significant.

RESULTS AND DISCUSSION

Feed and chemical composition of the experimental rations are shown in Table 1. The FHR contained 15% yellow corn less and 10% more roughage than control or FLR ration (Table 1). However, rations were almost iso-nitrogenous containing 12.11, 11.69 and 11.37 % CP for control, FHR and FLR rations, respectively. The rations differed in EE content, being 2.66, 6.89 and 7.14 % for the three rations, correspondingly.

Table 1. Feed and chemical composition of the experimental rations

Item	Control	Fat-high roughage (FHR) ration	Fat-Low roughage (FLR) ration
Ingredient, %			
Concentrate mixture[1]	54.72	55.37	52.08
Yellow corn	26.84	11.86	25.37
Rice straw	18.44	16.61	17.16
Berseem hay	0	10.40	0
Magnapac®[2]	0	5.76	5.39
Roughage %	18.44	27.01	17.16
Chemical composition, %			
Dry matter	91.18	92.03	91.44
Dry matter composition, %			
Organic matter	88.63	86.74	88.43
Crude protein	12.11	11.69	11.37
Crude fiber	14.24	16.70	13.48
Ether extract	2.66	6.89	7.14
N-free extract	59.62	51.46	56.44
Ash	11.37	13.26	11.57

1- Concentrate mixture was composed of 25% undecorticated cottonseed meal, 30% yellow corn, 35% wheat bran, 3% cane molasses, 2% limestone and 1 common salt.
2- Magnapac is a clcium soap of long chain fatty acid of palm oil, trademark of Norel, S.A. Spain.

Feeding FHR rations significantly ($P<0.05$) decreased the digestion of CP, CF and EE which resulted in lower ($P<0.05$) OM and DM digestibilities (Table 2).

However, no significant differences were detected between control and FLR diets in all nutrients digestion. The lowest nutrient digestibilities were recorded for FHR ration but the highest values were found for the control. The FLR rations showed intermediate values. Calderon-Cortes and Zinn (1996) found that increasing forage level in feedlot steers diets from 8 to 16% decreased (P<0.05) total tract digestibility of OM (5%) , nitrogen (5.7%) and ME (8.7%). Supplemental fat was reported to linearly decrease (P<0.01) total tract digestion of OM and NDF (Plascencia *et al.*, 2003). Higher (P<0.05) TDN values were recorded for FLR than FHR ration. Meanwhile, no significant differences were found between FLR ration and the control (Table 2). The DCP content of the fat containing rations were lower than that of the control because of the adverse effect of dietary fat on protein digestibilities (Table 2). El-Bedawy *et al.* (2003) found that digestibility of EE ,OM, DM and energy increased but digestibility of crude protein, crude fiber and nitrogen free extract had not been affected by calcium soap supplement.

Table 2. Nutrient digestibilities and nutritive value of the experimental rations

Item	Control	FHR ration	FLR ration	SE
Digestibility,%				
Dry matter	72.55^{a}	64.61^{b}	70.64^{a}	1.23
Organic matter	74.96^{a}	67.65^{b}	73.57^{a}	1.14
Crude protein	73.86^{a}	66.38^{b}	70.44^{ab}	2.15
Crude fiber	45.95^{a}	36.56^{b}	41.68^{ab}	2.78
Ether extract	87.69^{a}	81.95^{b}	83.60^{ab}	1.80
N-free extract	79.15^{ab}	75.34^{b}	81.06^{a}	1.72
Nutritive value, %				
TDN	69.23^{ab}	66.25^{b}	72.03^{a}	1.08
DCP	8.90^{a}	7.96^{b}	7.93^{b}	0.26

$^{a, b}$ Means in the same row having different superscripts significantly differ (P<0.05)

Actual dry matter intake was comparable for the control and FHR groups, but (P<0.05) lower values were recorded for the FLR group. Sackmann *et al.* (2003) reported that increasing forage level from 12 to 24% in diets containing 2 or 4% sunflower oil increased followed by a decrease in DM intake when 36% forage diet was fed to Hereford steers. However, no significant differences were detected in TDN intake among the experimental groups. This might be due to that the DM intake was compensated by higher TDN percentage for FLR ration (Table 2).

The digestibility of CP of fat containing rations (Table 2) was depressed sufficiently to reduce DCP intake (Table 3) to less than the control group. El-Bedawy *et al.* (2003) found that TDN and DE intakes increased (P<0.05) by about 15% and 25% by feeding 4% and 8% calcium soap to finishing Friesian bulls

Feeding fat either in high or low roughage diets did not change ruminal pH, ammonia concentrations, total VFA's concentrations or proportions of the individual VFA's (Table 4). El-Bedawy *et al.* (2003) found no significant differences in ruminal parameters among 0, 4 and 8% calcium soap supplemented finishing Friesian bulls. Ngidi *et al.* (1990) found comparable results for feedlot steers fed diets containing from 0 to 6% calcium soaps. The relative decrease in VFA's concentrations, acetic molar proportions and acetic: propionic ratio for FHR group (Table 4) was associated

with low CF digestibility (36.56 %; Table 2) suggesting that cellulolytic activity was reduced (Chalupa *et al.*, 1986 and Ngidi *et al.*, 1990).

Table 3. Nutrient intake from the experimental rations

Item	Control	FHR ration	FLR ration	SE
Dry matter				
Kg/h/day	8.57	8.58	8.16	0.23
Kg/100 Kg body weight	2.87[a]	2.90[a]	2.72[b]	0.03
g/Kg $W^{0.75}$	119[a]	121[a]	113[b]	1.62
TDN				
Kg/h/day	5.93	5.85	5.87	0.15
Kg/100 Kg body weight	1.99	1.92	1.96	0.04
g/Kg $W^{0.75}$	82.5	80.3	81.7	1.60
DCP				
g/h/day	763[a]	702[a]	649[b]	27
Kg/100 Kg body weight	256[a]	231[a]	216[b]	8
g /Kg $W^{0.75}$	10.8[a]	9.67[ab]	9.00[b]	0.40

[a, b] Means in the same row having different superscripts significantly differ (P<0.05)

Table 4. Basic pattern of rumen fermentation of bulls fed protected fat

Item	Control	FHR ration	FLR ration	SE
pH	5.93	6.65	6.40	0.23
Ammonia N, mg/100 ml	20.56	22.75	17.50	2.12
	8.14	7.95	8.50	0.65
Acetate (A)	41.44	39.05	41.81	2.51
Propionate (P)	28.23	28.61	27.99	1.43
Butyrate	25.72	26.24	25.25	2.95
Iso-butyrate	0.88	1.34	0.90	0.31
Valerate	2.15	2.59	2.17	0.57
Iso-valerate	1.56	2.16	1.87	0.36
A: P ratio	1.47	1.37	1.49	0.02

Feeding calcium soap either in high or low roughage diets increased (P<0.05) plasma concentrations of total lipids, triglycerides, low density and high density lipoprotein as well as total cholesterol but had no significant effect on plasma calcium, magnesium and phosphorus (Table 5).

Hill and West (1991) found no significant differences in plasma triglycrides and cholesterol of beef feedlot steers fed 0 or 4.5% calcium salts of fatty acids. However, Palmquist and Conrad (1978) found higher blood cholesterol for dairy cows fed diets containing 5.9 or 6.8% fat and higher triglycerides concentrations when dietary EE increased to 10.8% in fat supplemented diets.

Table 5. Blood plasma lipids and minerals (mg/100 ml) of bulls fed protected fat

Item	Control	FHR ration	FLR ration	SE
Total lipids	190[b]	322[a]	361[a]	30
Triglycerides	20.1[b]	29.8[a]	30.4[a]	1.9
Total cholesterol	128[c]	274[a]	222[b]	16
High density lipoprotein (HDL)	73.5[b]	120.6[a]	90.1[ab]	8.2
Low density lipoprotein (LDL)	23.2[c]	100.7[a]	70.7[b]	11.1
Calcium	8.15	8.95	9.34	0.43
Magnesium	1.86	1.77	1.78	0.03
Phosphorus	5.33	5.09	5.52	0.53

[a,b,c] Means in the same row having different superscripts significantly differ (P<0.05)

Supplementation of dairy cow diets with calcium soap resulted in variable effects on blood plasma lipids. Addition of 5% calcium soap to dairy cows diets (West and Hill, 1990) increased serum cholesterol but triglycerides were unaffected. Canale *et al.* (1990) reported increased plasma triglycerides of dairy cows fed calcium soap supplemented diets.

Implications

Supplementation of a 27% roughage (berseem hay) growing bulls finishing diet with 5.76 % protected fat will permit the TDN value (66.25%) comparable to that of bulls fed a 17 % roughage without fat supplement (69.23%) . With the higher DM intake of FHR group, intake of TDN and DCP intakes were comparable to those of the control but DCP intake was significantly higher than the FLR group. Feeding fat in high roughage ration could maintain rumen pH (6.65) with no deleterious effects on rumen fermentation. Fat in high or low roughage diets have no adverse effect on blood plasma minerals. There were no significant differences in plasma lipid metabolites between the FHR and FL groups except the higher total cholesterol and LDL of the FLR group.

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الدهن المحمى فى العلائق المنخفضة أو المرتفعة المادة الخشنة ١- التأثير على الهضم و تخمرات الكرش و ليبدات بلازما الدم فى عجول التسمين

طه محمد البداوى، محمد على ابراهيم سالم و أحمد سعد سامى

قسم الإنتاج الحيوانى ــ كلية الزراعة ــ جامعة القاهرة ــ الجيزة ــ مصر

صممت التجربة لدراسة تأثير صابون الكالسيوم للأحماض الدهنية طويلة السلسلة فى مستحضر تجارى مسجل تحت اسم ماجناباك على معاملات الهضم ومقاييس الكرش و نواتج تمثيل الليبدات و أيضا الكاتيونات فــى بلازمــا الدم فى ١٨ عجل تسمين بلدي . قسمت الحيوانات إلي ثلاث مجاميع متساوية غذيت إما علي عليقة عالية (٢٧%) أو منخفضة (١٨%) مادة خشنة مضافا إليهما ٥% ماجناباك أو عليقة مقارنة (١٧% مــادة خشــنة) غير مضاف إليها ماجناباك لمدة ١٦٥ يوما . كانت العلائق متساوية البروتين الخام تقريبا و تحــتوى على ١٢,١١ و ١١,٦٩ و ١١,٣٧ % بروتين خام و تختلف في نسبة مستخلص الأثير حيث كانت ٢,٦٦ و ٦,٨٩ و ٧,١٤ % فــي العليقة الكنترول و المحتوية على دهن ــ عالية المادة الخشنة و المحتوية على دهن – منخفضة المادة الخشنة على الترتيب.

خفضت إضافة الدهن إلى العليقة عالية المادة الخشنة معنويا من معامل هضم البروتين الخام و الألياف الخــام ومســتخلص الأثير مما أدى إلى انخفاض معاملات هضم المادة الجافة والمادة العضوية بها بينما لم تظهر فروق معنوية بين معامل هضم المركبات الغذائية بين عليقة الكنترول و العليقة المحتوية على دهن ــ منخفضة المادة الخشنة.

لــم يختلف المأكول من المادة الجافة بين مجموعة الكنترول و المجموعة المغذاة على العليقة المحتوية على دهن ــ عالية المادة الخشنة، بينما سجلت المجموعة المغذاة على العليقة المحتوية على دهن ــ منخفضة المادة الخشنة قيما أقل للمأكول من المادة الجافة ولم تؤد هذه الفروق إلى اختلافات فى المأكول من المركبات المهضــومة الكلية بينما أدت إلى انخفاض فى المأكول من البروتين الخام المهضوم للمجموعة المغذاة على العليقة المحتوية على دهن ــ منخفضة المادة الخشنة.

لــم تغــير إضافة الدهن إلى العلائق مرتفعة أو منخفضة الألياف معنويا من درجة حموضة الكرش أو تركيز الأمونيا أو تركيز الأحماض الدهنية الطيارة الكلية أو المنفردة ، كما أدت التغذية على الدهن المحمى ســواء فــى العلائــق عالية او منخفضة المادة الخشنة الى زيادة معنوية فى الليبدات الكلية و الجلسريدات الثلاثــية و الليبوبروتيــن عــالى أو منخفض الكثافة و الكوليسترول الكلى، بينما لم تؤثر على الكالسيوم و الماغنسيوم و الفوسفور في بلازما الدم.

وعمومــا لــم تظهــر اضافة الدهن المحمى سواء للعلائق المنخفضة أو العالية فى المادة الخشنة تأثيراً معاكسا على هضم العلائق او تخمرات الكرش أو ليبدات و كاتيونات بلازما الدم.