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CALCIUM SOAPS IN LOW OR HIGH ROUGHAGE RATIONS: 2- EFFECT ON GROWTH PERFORMANCE, CARCASS CHARACTERISTICS AND MEAT QUALITY OF GROWING-FINISHING BALADI BULLS

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SUMMARY

Eighteen Baladi bulls (215 Kg) were used in a 165-d growth performance trial to study the effect of feeding 5% calcium soaps of fatty acid in 18 roughage vs. 27% roughage growing-finishing diets. The experimental rations were control, fat-high roughage (FHR) ration and fat-low roughage (FLR). Twelve bulls, heaviest four from each group, were slaughtered after 12 hrs fasting. Average slaughter weights were 419, 437 and 434 Kg for control, FHR, and FLR diets, respectively. Carcass and meat quality were measured.

Bulls fed FHR diets gained about 12 Kg (7%) more than the control and FLR groups. Dry matter, TDN ($P>0.05$) and DCP ($P<0.05$) required for 1 Kg gain improved by calcium soap supplement to high roughage (FHR) group.

Dressing percentage had not affected but greater area and fat thickness were recorded for eye muscle of fat supplemented bulls. No significant effect of dietary treatments on external offals (legs, head and hide) weights but there was a tendency for its percentage of body weight to be decreased for calcium soap supplemented groups. On the other hand, Fat supplement specially with high roughage level increased ($P<0.05$) internal offal weight and its percentage of body weight

Weights of tissue and content of the digestive tract were not significantly affected. However, feeding FHR rations caused a slight increase in tissue weights and percentage (8%). The stomach content and the content of whole digestive tract were higher for FLR groups.

Abdominal, intermuscular, intramuscular and total body fat were slightly higher for group fed FHR rations. Physical composition of the best ribs showed no significant differences among the experimental groups. However, higher fat and bone but lower lean percentages were recorded for FHR group

Muscle from bulls fed fat supplemented rations tended to contain higher percentages of dry matter and protein. Physical characteristics of eye muscle (pH, cooking loss, expressible fluid and fiber diameter) were not significantly affected by the dietary treatments.

Keywords: Beef cattle, calcium soaps, growth performance carcass characteristics and meat quality

INTRODUCTION

Finishing diets of beef cattle are characterized by its high grain content which usually results in lower ruminal pH and other metabolic disorders. Unsaturated fatty acids in calcium soaps of palm fatty acids have been shown to partially resist biohydrogenation (Wu *et al.*, 1991). However, resistance of calcium soaps to bacterial hydrogenation may be dependent on their unsaturation and the ruminal fluid pH (Sukhija and Palmquist, 1990).

Increasing forage level in fat supplemented diets could maintain ruminal pH needed for calcium soaps to remain relatively inert in the rumen and then to be completely dissociated in the acidic condition of the abomasum (Jenkins and Palmquist, 1984).

Improving the quality of animal products could be possible by moving the saturated/unsaturated fatty acid ratio within the lipid fraction in favor of the latter, is undoubtedly a valid aim (Piva, 1988), considering the prevention and therapeutic functions essential fatty acids carry out in heart and circulatory disorders (Menotti, 1987, and Fidanza, 1988). The use of coated fats, as Ca salts, besides permitting a significant lipidic integration would avoid the hydrogenation of unsaturated fatty acids at ruminal level, allowing intestinal absorption as for monogastrics (Doreau *et al.*, 1989).

The aim of this study is to verify if the use of calcium soaps in low or high roughage diets influences the growth performance, carcass quality and qualitative and dietetic characteristics of the meat.

MATERIALS AND METHODS

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

Bulls were weighed at biweekly intervals before morning feeding. The final body weight was 383, 395 and 384 Kg for control, FHR and FLR groups, respectively. Average daily gain and feed efficiency were calculated.

Twelve bulls, heaviest four from each group, were slaughtered. Average slaughter weights were 419, 437 and 434 Kg for control, FHR, and FLR diets, respectively. Bulls were slaughtered after 12 hrs fasting and were left for complete bleeding. Head, legs and hide were removed and weighed. Digestive tract was removed, full and empty ruminant stomach and intestine were weighed. Weights of internal offals including heart, liver, spleen and tests were recorded. Kidney, heart and abdominal fats were separated and weighed. Carcass was weighed to calculate dressing percentage and split into two equal halves and each half was cut into fore and hind

quarter. Each quarter of the left half was weighed and dissected into boneless meat and bone.

Best (9, 10 and 11th) ribs of the left side of carcass were weighed and kept chilled at 4 °C for 24 hrs. Ribs were dissected into lean, fat and bone. Fat thickness over the ribs was also measured using Vernier caliper. Dry matter, ether extract and ash was determined (A.O.A.C., 1990) and crude protein was calculated by difference (O'Mary *et al.*, 1979).

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
[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 calcium soap of long chain fatty acid of palm oil, trademark of Norel, S.A. Spain.

Eye muscle area was measured using a planimeter (TAMAYA planix 5, Tamaya Technic Inc., Japan) and pH was measured by using checker pH meter.

Cooking loss % was determined for 100 g samples from eye muscle was boiled in water for 45 minutes, left to be cool at room temperature and weighed again to determine the loss in weight and its percentage.

Expressible fluid percentage was determined by weighing 0.3 g of meat in a Wattman 1 filter paper and was subjected to a pressure of 1 Kg for 10 minutes. Sample was weighed again and the difference was calculated as a percentage of related to the initial weight.

Fiber diameter of eye muscle samples μm. Samples of eye muscle were cut in cubic of (1 x 1 x 2) cm and placed in 10% Formalin. Samples were placed in 20% Nitric acid for five days, washed and placed in a watch glass with a buffer of glycerol and distilled water. Fifty fibers per each animal were randomly selected to be measured according to Gravert (1965).

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

Total and average daily weight gain are shown in Table 2. Bulls fed FHR diets gained about 12 Kg (7%) more than control and FLR groups during 165 days fed but these differences were not statistically significant. Zinn and Plascencia (1996) found that addition of fat to low forage diet did not significantly affect ADG whereas the addition of fat to high forage diet ($P<0.05$) increased ADG by 13.3 %, suggesting that this effect was largely due to the influence of added fat on the energy density of the high forage diet.

Table 2. Effect of calcium soaps in low or high roughage rations on growth performance of growing-finishing bulls during 165 day experimental period

Item	Control	FHR ration	FLR ration	SE
No. of animals	6	6	6	
Initial body weight, Kg	214	214	216	5
Final body weight, Kg	383	395	384	10
Gain, Kg	169	181	168	8
Gain, g/day	1024	1097	1018	47
Nutrient intake, Kg/h/day				
DM	8.57	8.58	8.16	0.23
TDN	5.93	5.85	5.87	0.15
DCP	0.763[a]	0.702[a]	0.649[b]	0.027
Feed efficiency, Kg/kg gain				
DM	8.37	8.07	8.02	0.28
TDN	5.79	5.33	5.77	0.25
DCP	0.745[a]	0.640[b]	0.638[b]	0.033

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

Dry matter and TDN intakes were not affected by dietary treatments but DCP intake of the FLR group was ($P<0.05$) less than the control by 8 % and FHR by 15%. Because of the low digestibility of CP of groups fed fat supplemented rations as shown in the first part of this study (El-Bedawy *et al.*, 2003)

Feed DM to gain ratio was not significantly different among the three groups but slight improvement were found for fat fed groups. On energy basis, group fed fat-high roughage rations was the better by 8% than control or FLR group, suggesting that the energy of calcium soap was utilized more efficiently for gain than to that of the other feeds in the FHR diet. This trend was not evident for low FLR diet Ngidi *et al.* (1990) found that feed to gain ratio tended to ($P<0.05$) improve with added soap. Efficiency of dietary protein utilization was ($P<0.05$) improved by fat feeding either in high or low roughage ration. Similar results were found by El-Bedawy *et al.* (2003) for Friesian bulls fed finishing diets containing calcium soaps. Zinn and Plascencia (1996) attributed the improved steer performance to increased diet energy density and positive associative effects of supplemental fat on protein utilization and

Wu *et al.* (1991) suggested that dietary fat could compensate and save dietary protein. In the present study the protein utilization efficiency improved even though the protein digestibility (as shown in the first part of this study, El-Bedawy *et al.* (2004) and DCP intake (Table 1) were not improved by fat supplement.

Figure 1 showed that the increase in body weight was almost linear against days fed. During the first 45 day, the three groups showed comparable body weight, from 75 day to 120 day, fat supplemented groups showed higher body weight than the control group. Group fed fat supplemented high roughage ration was superior to either control or FLR group. This result was confirmed the findings of El-Bedawy *et al.* (2003) that the diurnal difference in body weight among calcium soap supplemented and unsupplemented groups was not obvious before 45 days fed , then the 8%-Ca-SFA group showed heaviest body weight, followed by the 4%-Ca-SFA group and control in order. Plascencia *et al.* (1999) found that the ADG of Holstein steers during the first 56 days was (0.86-1.16 kg/day) lower than 1.22-1.33 Kg/day during the period from 56 - 144 day.

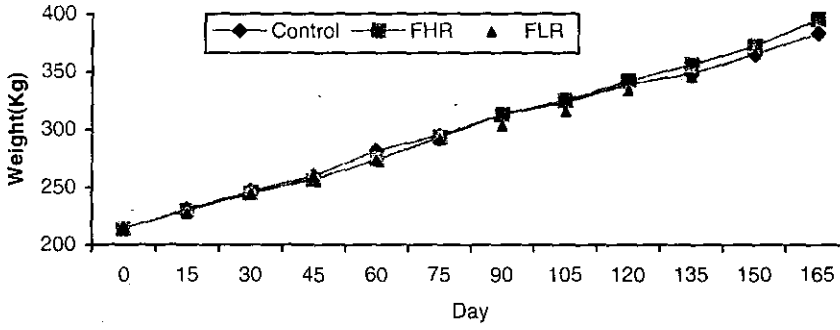

Figure 1. Effect of calcium soaps in low or high roughage rations on diurnal change in body weight of bulls during 165 days fed

Data in Table 3 showed no significant differences in average slaughter weight, carcass weight, dressing percentage, eye muscle area and fat thickness over eye muscle. Although, greater area was recorded for eye muscle of bulls fed FLR diets. Gilbert *et al.* (2003) found that fat thickness, longissimus muscle area, hot carcass weight and dressing percentage tended to be higher for carcass from protected fat fed steers than for carcasses from corn-fed steers but in contrary to our results, Zinn and Plascencia (1996) found that adding fat to low forage diet ($P<0.01$) decreased longissimus muscle area and retail yield, whereas with the high-forage diet, the addition of fat increased longissimus muscle area and did not affect ($P<0.10$) retail yield.

Table 3. Effect of calcium soaps in low or high roughage rations on carcass weight and dressing percentage

Item	Control	FHR ration	FLR ration	SE
No. of animals	4	4	4	
Slaughter body weight (SW), Kg	419	437	434	8
Carcass weight(CW), Kg	246	252	254	6
Dressing percentage	58.71	57.67	58.52	1.19
Eye muscle area (cm^2)	62.94	63.69	72.87	4.18
Fat thickness (mm)	2.75	3.00	2.87	0.20

No significant effect of dietary treatments on external offals (legs, head and hide) weights and its percentage of slaughter weight but there was a tendency for its percentage of body weight to be decreased for calcium soap supplemented groups (Table 4). Fat supplement specially with high roughage level increased (P>0.05) internal offal weight and its percentage of body weight. El-Bedawy *et al.* (1996) found no significant effect of fat supplement on external and internal offals of Baladi bulls.

Table 4. Effect of calcium soaps in low or high roughage rations on weights and percentages of external and internal offals

Item	Control	FHR ration	FLR ration	SE
External offals[1] (Kg)	54.14	56.20	53.62	1.79
% of body weight	12.92	12.86	12.35	0.56
Internal offals[2] (Kg)	12.37	14.54	13.25	0.60
% of body weight	3.04	3.32	3.05	0.10

1 (leg, hide and head)

2 (Liver, kidney, heart, spleen, lung and tests)

Data in Table 5 showed no significant effect on weight of tissue and content of the digestive tract. However, feeding FHR rations caused a slight increase in tissue weights and percentage by about 8%. Ruminal stomach content as well as the content of the whole digestive tract were higher for FLR groups (Table 5). Badr (1997) found a slight increase in the content of stomach and whole digestive tract of fattening bulls fed finishing rations supplemented with calcium soaps.

Abdominal, Intermuscular and intramuscular fats as well as total body fat were higher for group fed FHR rations, however, these differences were not statistically proven (Table 6). The higher intramuscular fat is an indication for marbling. Zinn and Plascencia (1996) found that fat supplement (P<0.10) marbling score. However, Gilbert *et al.* (2003) Found that marbling score and percentage of kidney, pelvic and heart fat was higher (P<0.01) for carcasses of steers fed protected canola lipids than those from corn fed steers. Zinn and Plascencia (1996) concluded that differences in carcass fat were small and not affected dietary fat or forage levels (P>0.10) and it seems unlikely that these differences will account for much of the divergence in estimated NE values for supplemental fat with low-forage vs high-forage diet. In our study, because of the large individual variations among bulls within group as

indicated from the great values of the standard errors, fat deposition is suggested to be affected by factors other than feeding regimen.

Table 5. Effect of calcium soaps in low or high roughage rations on weights of tissue and contents of digestive tract

Item	Weight, Kg				% of body weight			
	Control	FHR ration	FLR ration	SE	Control	FHR ration	FLR ration	SE
Ruminant stomach								
Content	18.22	22.40	29.49	4.45	4.35	5.13	6.79	1.00
Tissue	10.33	11.67	10.98	0.83	2.46	2.67	2.53	0.18
Intestine								
Content	7.45	8.52	7.55	0.88	1.78	1.95	1.74	0.21
Tissue	8.05	9.10	8.42	0.87	1.92	2.08	1.94	0.22
Whole digestive tract								
Content	25.67	30.92	37.04	5.13	6.13	7.08	8.53	1.15
Tissue	18.38	20.77	19.40	1.26	4.39	4.75	4.47	0.30

Table 6. Effect of calcium soaps in low or high roughage rations on body fat

Item	Control	FHR ration	FLR ration	SE
Kidney fat, Kg	9.43	9.92	8.06	0.96
% BW	2.25	2.27	1.86	0.20
Heart fat, Kg	1.87	2.07	2.41	0.21
% BW	0.45	0.48	0.55	0.05
Abdominal fat[1], Kg	18.75	22.00	19.60	1.97
% BW	4.47	5.03	4.53	0.44
Intermuscular fat[2], Kg	50.15	56.56	52.83	6.09
% BW	11.97	12.94	12.17	1.34
Intramuscular fat[2], Kg	4.63	4.97	4.08	0.94
% BW	1.11	1.14	0.94	0.21
Total body fat, Kg	84.82	95.53	87.06	8.10
% BW	20.24	21.86	20.06	1.72

[1] Abdominal fat = ruminal fat + intestinal fat + pelvic fat
[2] Intermuscular fat = Knife separable fat
[3] Intramuscular fat = boneless meat (Kg) x Ether extract content of muscle/100.

Feeding fat have not significantly altered the proportion of fore: hind quarters or meat: bone ratio. Feeding FHR tended to decrease meat: bone ratio but boneless meat as a percentage of carcass weight tended to be higher by feeding FLR rations (Table 7). Plascencia *et al.* (1999) found that the effect of feeding fat on carcass cuts was small ($P<0.10$). Retail cuts from round, lion, rib and chuck as a percentage of carcass weight tended to be decreased by fat supplement.

Table 7. Effect of calcium soaps in low or high roughage rations on weight and percentage of fore and hind quarter, boneless meat and meat: bone ratio

Item	Control	FHR ration	FLR ration	SE
Fore quarters, Kg	123	126	128	3
% of carcass	50.08	50.14	50.35	0.35
Hind quarters, Kg	123	126	126	3
% of carcass	49.92	49.86	49.65	0.35
Boneless meat, Kg	203	205	214	4
% of carcass	82.67	81.42	84.30	1.06
Meat: bone ratio	5.64	4.90	5.42	0.72

Physical composition of the 9,10 and 11^{th} ribs showed no significant differences among the experimental groups (Table 8). However, higher fat and bone but lower lean percentages were recorded for FHR group. Bendary *et al.* (1994) found DM and EE contents of eye muscle from buffalo calves tended to increase by fat supplement.

Table 8. Effect of calcium soaps in low or high roughage rations on physical composition of the best ribs and chemical composition and physical characteristics of the *longissimus dorsi* muscle

Item	Control	FHR ration	FLR ration	SE
Physical composition of the 9,10 and 11^{th} ribs				
Lean	66.98	63.83	66.59	2.36
Fat	20.27	22.39	20.82	2.27
Bone	12.75	13.78	12.59	1.36
Chemical composition,%				
Dry matter	26.74	28.50	28.16	1.42
Dry matter composition,%				
Protein	22.92	24.60	24.69	1.23
Fat	2.82	2.92	2.46	0.56
Ash	1.00	0.98	1.01	0.18
Physical characteristics				
pH	5.52	5.29	5.78	0.18
Cooking loss %	42.23	43.36	40.29	3.44
Expressible fluid, %	28.80	26.41	34.30	2.99
Fiber diameter, µm	33.52	32.97	33.91	2.64

Table 8 also showed feeding fat either in high or low roughage diet did not affect ($P>0.05$) chemical composition or physical characteristics of eye muscle. Muscle from bulls fed fat supplemented rations tended to contain higher percentages of dry matter and protein. Muscle from steers fed FLR ration showed the lowest fat content and cooking loss percentage but higher pH, expressible fluid and fiber diameter. In previous study El-Bedawy *et al.* (1996) found that chemical and physical characteristics of eye muscle from fattening bulls are less affected by calcium soaps.

Implications :

Supplementation with protected fat allowed to decrease the percentage of yellow corn and permit to use more roughages in rations of growing-finishing beef cattle without adverse effects on growth performance, carcass characteristics and meat quality. Furthermore, using higher percentage of roughages in finishing diets could eliminate the probable metabolic disorders that normally occur by feeding high grain in finishing diets.

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الدهن المحمى فى العلائق المنخفضة أو المرتفعة المادة الخشنة ٢- التأثير على النمـــو وصفات الذبيحة و جودة اللحم فى عجول التسمين البلدية

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استخدم ١٨ عجلا بلديا فى تجربة نمو لمدة ١٦٥ يوما لدراسة تأثير إضافة ٥% من الدهن المحمى الـى عليقتين تحتوى إحداهما على ١٨% دريس برسيم كمادة خشنة و الأخرى على ٢٧% بالإضافة الى عليقـه الكنترول التى لا تحتوى على دهن مضاف.

فى نهاية التجربة اختير ١٢ عجلا، أثقل أربعة عجول فى كل مجموعة للذبح و صومت لمدة ١٢ سـاعة قبل الذبح. و بلغ متوسط الأوزان عند الذبح ٤١٩، ٤٣٧ و ٤٣٤ كجم لمجموعـة الكنـترول (المجموعـة الأولى) والمجموعة المغذاة على دهن فى عليقة عالية المادة الخشنة (المجموعة الثانية) و المجموعة المغـذاة على دهن فى عليقه منخفضة المادة الخشنة (المجموعة الثالثة) و قدرت صفات الذبيحة ومقاييس جودة اللحم.

اكتسبت العجول فى المجموعة الثانية ١٢ كجم أكثر بنسبة زيادة قدرها ٧% أكـثر مـن المجموعتيـن الأولىّ والثالثة وتحسنت كفاءة تحويل المادة الجافة و مجموع المركبات الغذائية المهضومـة بدرجـة غـير معنوية، بينما تحسنت كفاءة تحويل البروتين معنويا فى المجموعة الثانية.

و لم تتأثر نسبة التصافي بإضافة الدهن بينما زادت مساحة العضلة العينية و سمك طبقة الدهـن عليـها بإضافة الدهن المحمى. و لم يتأثر وزن الأحشاء الخارجية ونسبتها من وزن الجسم بالمعاملات الغذائية ولكن أظهرت اتجاها للنقص فى المجموعات المغذاة على الدهن المحمى بينما أدت إضافة الدهن و خاصـة فـى العليقه مرتفعة المادة الخشنة الى زيادة غير معنوية فى وزن الأحشاء الداخلية ونسبتها من وزن الجسم.

وأظهرت النتائج أيضا عدم تأثر وزن نسيج أو محتويات القناة الهضمية بالمعاملات الغذائية الا أن تغذية العليقة المحتوية على الدهن و العالية فى المادة الخشنة الى زيادة طفيفة فى وزن أنسـجة القنـاة الهضميـة ونسبتها من وزن الجسم على العكس من المجموعة الثالثة التى أظهرت زيادة فى وزن المحتويات.

وأظهرت المجموعة الثانية ارتفاعا فى نسبة دهن العضلات والدهن داخل العضلات ودهن الجسم الكلى. وبتشفيه الضلوع التاسع و العاشر و الحادي عشر لم يكن هناك فروقا معنوية فى نسبة اللحم والدهن و العظم الا أن المجموعة الثانية كانت أعلى فى نسبة الدهن و العظم و اقل فى البروتين عن المجموعتين الأخريين. وبتحليل العضلة العينية وجد أن نسبة المادة الجافة و و البروتين الخام أعلى فى المجموعات المغـذاة علـى الدهن المحمى. ولم تظهر النتائج اختلافا فى درجة الحموضة و الفقد بالطبخ أو بالضغط أو قطر الليفة فـى العضلة باختلاف المعاملات الغذائية.

و يتضح من النتائج أن إضافة الدهن المحمى مكنت من تقليل نسبة الذرة الصفراء وسـمحت باسـتخدام نسبة أعلى من الدريس كمادة خشنة فى عليقة النمو و التهيئة دون تأثير سلبى على النمو وصفـات الذبيحـة وجودة اللحم. بالاضافة الى ان استخدام نسبة اعلى من المادة الخشنة فى علائق التهيئة قد تقلل من مشـاكل التمثيل الغذائى المحتملة من التغذية على العلائق العالية فى نسبة الحبوب.