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EFFECT OF FEEDING CALCIUM SALTS OF FATTY ACID AS A NON-TRADITIONAL ENERGY SOURCE ON PRODUCTIVE PERFORMANCE OF LACTATING BUFFALO

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ABSTRACT

Fifteen lactating buffalo at early lactation period were distributed randomly on three-tested groups (5 animals/group). Three concentrate mixtures were formulated, first one had no calcium salts of fatty acids (Ca-SFA) and served to be the control while calcium salts of fatty acids (Ca-SFA) was added to the second and the third mixture at level of 2 and 4% of total dry matter intake replacing corn grain. Rice straw was fed to the animals to cover the roughage part of the rations. The obtained data of this study revealed that, no significant differences were observed among control group compared with groups fed 2% or 4% Ca-SFA in the apparent digestibility of DM, OM, CP, CF and NFE. Groups fed Ca-SFA were ($P<0.05$) higher in AEE digestibility than the control. No significant differences were observed among Groups fed 2% or 4% Ca-SFA ($P<0.05$) in average daily milk production, fat%, protein%, lactose%, TS and SNF% of the milk compared with control fed group. Feeding Ca-SFA increased ($P<0.05$) serum total lipids (TL), cholesterol (Chol.) and trigylcerides (TG). Feeding dairy buffalo on ration contained Ca-SFA showed reduction in the cost of producing 1 kg milk with 17.3% and 15.5% respectively. From the above obtained results of this current study it can be concluded that calcium salt of fatty acids made from the wastes of refining sunflower oil and palm oil can be used as cheep energy sources supplement or partially substitution of corn grain in ration of lactating buffalo up to 4% of the total daily dry matter intake without any adverse effects on the performance of the animals.

Keywords: Calcium salts of fatty acids; Lactating buffalo; Digestibility; Milk production; Serum)

INTRODUCTION

Added fat have been used successfully for a number of years in ruminant rations. Fat presently being studied and used in lactating animal rations include tallow (animal fat), blend of animal and vegetable oil and recently protected or rumen by-pass fat. Conventional diets of lactating animal (without added fat or fat rich feed stuffs) generally contain less than 3 % ether extract. Since fat is a concentrated source of energy, *NRC (1978)* lists fats and oils as having energy value of 182% TDN. Dairy cows in early lactation rely heavily upon body fat stores to supply energy and precursors for milk synthesis (*Davis, 1994*). *Harrison et al*, (1995) reported that supplemental fat increased NE_L intake, percentage of milk fat, milk fat production and rate of recovery of body weight and body condition. Addition of protected fat to dairy animal rations increased milk yield (*Palmquist, 1988; Wu et al, 1993; Canale et al, 1990; Schingoethe and Casper, 1991; Mabjeesh et al 2000; and Abd-El-Gawad 2003*). Polyunsaturated fatty acids have a more negative effect on the metabolism of cellulolytic bacteria than do saturated fatty acids and thus decrease energy value of the non-lipid fraction of the diet (*Ferlay et al, 1993*). Conversely polyunsaturated FA are thought to have a higher intestinal digestibility than saturated FA (*Coppock and Wilks, 1991*). One possibility to increase their energy value is to protect the lipids against bacterial bio-hydrogenation. Development of ruminally inert fat, such as Ca salts of palm fatty acids has potentially overcome some negative effects of normal fats, such as free oils and oils with fatty acids of medium chain length or unsaturated chain on ruminal fermentation (*Grummer, 1988; Jerred et al, 1990; Schauff and Clark, 1989 and Doreau et al, 1993)*. An important consideration for successful and economical feeding of dietary fat is to maximize ration fiber digestion and thus forage intake. A high roughage diet stabilizes rumen fermentation and helps to normalize rumen function when dietary fat is fed (*Canale et al*, 1990). Soap stock supplementation (2.5% or 5% of DM) resulted in a trend toward decreased digestibility of CP and CF in beef cattle (*Perry and Weatherly, 1976; Jenkins and Palmquist, 1984; Chouinard et al, 2001*). While combination of soy lecithin and soap stock (4:1 wt/wt, DM basis) combined with soybean hulls improved milk yield of dairy cows by 14%, improved milk protein yield by 11% and efficiency of 4% FCM yield compared with control not given soybean lipid (*Shain et al, 1993). Exjalbert et al*, (1997) reported that total digestibility of DM, CF, fat and ruminal fermentation were not significantly altered by giving Ca-soap of unsaturated FA to dairy cows as well as milk protein (*Chan et al, 1994). El-Bedawy et al (1996) and Abo-Donia et al (2000)* reported that buffalo calves showed positive response to high fat rations in terms of feed utilization and growth.

This study was conducted to evaluate the production responses of dairy buffalo to feeding rations containing different levels of calcium soap of fatty acids from soap stock.

MATERIALS AND METHODS

This study was conducted at animal production research station at Seds, Beni-Souif governorate. Soap stock produced from refining sunflower oil and palm oil was used in this study at a ratio of (1:1 W/ W). This blind was developed to calcium salts of fatty acids (CA-SFA) with cooperation with Cairo Oil & Soap Company at El-Badrashein and Ghamrah according to (Omar 1999). The obtained product was dried under shade at room temperature then crushed through hammer mill into small particles with a diameter of 3 mm before mixing with the concentrate. Three concentrate mixtures were formulated, the first one had no fat and were representing the control group while calcium salts of fatty acids (Ca-FA) were added to the second and the third mixture at level of 2 and 4% of total dry matter intake replacing supplemented corn grain. Rice straw was fed to the animals to cover the roughage part of the rations. Nutrient requirements were calculated according to *Ghoneim* (1966). Fifteen lactating buffaloes at early lactation period were used in this study. The animals were distributed randomly on the three-tested groups (5 animals/group). Animals were fed on the experimental rations (Table 1) for 15 days prior the actual starting date of the experiment as an acclimatization period followed by 3 months of experimentation. Concentrate feed was offered to the animals individually 2 times a day before the first milking at 5 am and the second milking at 6 pm, while rice straw was offered 3 times a day after milking and in the mid of the day. Water was offered 3 times a day in the morning, in the after noon and in early evening. Animals were hand milked twice a day at 5 am and 6 pm and individual morning and evening milk yield were recorded daily. Every two weeks, composite milk samples were taken from composted morning and evening samples and was stored at –20 °C for analysis. A digestibility trial was carried out at the end of the experimental period. Fecal samples were collected from the rectum two times per day from 3 animals representing each group for 10 days to determine the digestibility of the nutrients by acid insoluble ash (AIA) method according to *Van Keulen and Young* (1977). Blood samples were drawn from jugular vein into heparinizd tubes 4 hours after the morning feeding 4 times at the beginning and after 1st, 2nd and 3rd month of experimentation. Chemical analysis of feed (Table 1) and feces were determined according to A.O.A.C (1984). Acid ether extract (AEE) was determined according to *Abo-Donia et al* (2003). Plasma total lipid (TL), cholesterol (Chol), Triglycerids (TG) were determined by using kits (Sentinel Ch.). Milk samples were analyzed for percentage of fat, protein, lactose, total solids (TS) and ash by milk scan 133 BN Foss Electric, Denmark. Solids not fat (SNF) content was calculated by the difference between total solid (TS) and fat content. The experimental data were statistically analyzed according to (SPSS 1997). Significant differences among treatments mean were detected using multiple range test (*Duncan*, 1955).

Table (1): Ration formulation and chemical composition of feed ingredients and experimental rations

Items	Treatments		
	T1 Control	T2 (2% Ca-FA)	T3 (4% Ca-FA)
CFM%	54.83	55.75	56.71
Corn%	7.27	3.70	0.00
Rice straw%	37.90	38.54	39.20
CaFA%	------	2.01	4.09
Chemical analyses			
DM	89.83	89.02	90.21
OM	88.68	88.20	87.69
CP	12.16	12.03	11.88
CF	25.18	25.51	25.84
AEE	3.08	4.61	6.20
NFE	48.26	46.05	43.77
Ash	11.32	11.80	12.31

CFM: mixture of corn, soybean meal, cotton seed cake wheat bran, salt, lime stone and mineral mixture.

RESULTS AND DISCUSSION

Body weight and dry matter intake

Average body weight at the beginning and at the end of experimental period as well as DM intake are summarized in Table (2). Group fed control ration was some what higher in average body weight at the beginning and at the end of experimental period compared with groups fed 2% or 4% calcium salts of fatty acids (protected fat). The same trend was realized among groups fed protected fat since group fed 2% calcium salts of fatty acids (Cs-FA) was higher than group fed on 4%. These differences in ABW at the beginning of experimental period and continued up to the end is attributed to the non-homogeneity of the weight among the individuals in the lactating buffalo herd at the research station at that particular time of experimentation. Even though the control group were some what higher in final BW compared with Ca-FA groups, the losses in weight along the experimental period were found to be 2.55%, 1.69% and 0.57% for the control, group fed 2% or 4% Ca-FA respectively. This mean that the rate of body weight recovery at the experimental period was in favor of the groups fed 2% or 4% Ca-FA ration compared with the control group. This improvement of the rate of body weight recovery as a result of feeding dairy buffalo on rations contained Ca-FA could be attributed to the by-pass digestibility mechanism of the Ca-FA to the rumen and be highly utilized later in the abomasums. This may enabled the groups fed on rations contained Ca-FA to utilize the energy of rations and passes the negative energy balance stage at early lactation phase much better than the control did (*Palmqiust, 1988; Canale et al, 1990; Wu et al, 1993; Harris, 1993 and Davis, 1994*).

Table (2): Average daily feed intake, body weight and economic efficiency.

Items	Treatments		
	T1	T2	T3
	Control	(2% Ca-FA)	(4% Ca-FA)
Av. Int. L.B.W/kg	550	532	522
Av. Fin. L.B.W./kg	536	523	519
CFM/ kg	6.65	6.65	6.65
Yellow corn /kg	0.88	0.44	0.00
Ca-SFA /kg	0.00	0.24	0.48
Rice straw /kg	4.59	4.59	4.59
Total feed/h/d kg	12.12	11.92	11.72
Total DMI kg/kg LBW	0.022	0.023	0.023
Total DMI kg/kg $W^{0.75}$	0.108	0.108	0.108
Economical evaluation			
Daily feeding cost LE/h	7.15	6.63	6.90
Feed cost, LE/ Kg milk	1.10	0.91	0.93

The highest average DMI/h/d, total DMI kg/kg LBW and total DMI kg/ kg $W^{0.75}$ were recorded by the control group compared with groups fed 4%

calcium salts of fatty acids. These differences in the amount of DMI among three-tested groups may be attributed to the quantitative substitution of maize against Ca-FA .These results are in agreement with findings obtained by *Wu et al, (1993); Grummer (1988); Smith et al (1978); Wrenn et al (1978); Schingoethe and Casper, (1991) and Canale et a l(1990)*.

Nutrient digestibility

As summarized in Table (3), no significant differences were observed among control group and groups fed 2% and 4% protected fat in the apparent digestibility of DM, OM, CP, CF and NFE. While groups fed 2% or 4% Ca-salt of fatty acids achieved ($P<0.05$) higher AEE digestibility compared with control group.

Table (3): Digestibility coefficients of tested rations

Items	Treatments T1	T2	T3	
	Control	(2% Ca-FA)	(4% Ca-FA)	± SE
DM	65.15	68.59	68.90	0.82
OM	71.80	71.96	72.46	0.59
CP	64.88	64.72	64.71	0.28
CF	62.51	62.49	62.31	0.64
AEE	79.02[b]	90.47[a]	92.12[a]	2.08
NFE	71.71	70.47	70.76	0.56

a,b,c Means bearing the same letter did not differ significantly (P<0.05)

The high digestibility of AEE of the groups fed 2% and 4% Ca-SFA than the control could be attributed to the high digestibility of fat supplementation (*Palmquist,1984).* The ruminally inert nature of the fat supplements and relatively low percentage (2% 0r 4%) of fat addition to the rations might have been responsible for the lack of grater differences in nutrients digestibility *(Wu et al, 1993; Grummer, 1988 and Jerred and Carroll et al 1990). Exjalbert et* al, (1997) reported that total digestibility of DM, CF, crude fat and rumenal fermentation were not significantly altered by giving Ca-soap of unsaturated FA to dairy cows as well as milk protein. A significant difference ($P<0.05$) was only found among tested groups in AEE digestibility (*Schingoethe and Casper*, 1991). There was a trend for increased apparent digestibility of fat with Ca FA supplementation. Calcium salts of fatty acids (0.58 to 0.68 kg/cow /d) have been demonstrated not to affect ruminal disappearance of DM or NDF *(Grummer 1988; Jenkins and Palmquist 1984; Schauff and Clark 1989*) or total tract digestibility of DM, protein, NDF or ADF *(Grummer 1988; Jenkins and Palmquist 1984*). Groups fed 2% or 4% protected fat were ($P<0.05$) higher in AEE digestibility compared with control fed group. The improved digestibility of total lipids suggest that added fat is perhaps more digestible than the lipid fraction of unsupplemented diet. *Grummer* (1988) hypothesized that supplemental fat dilutes endogenous lipid secretion, resulting in a more accurate estimate of true lipid digestibility. Wu et al (1993) reported that digestibility of DM, CP, starch; ADF and NDF were not affected by over all fat supplementation. Feeding ruminants on unprotected fat has an inhibitory effect on fiber digestion (*Chaulupa et al* 1986). The inhibitory effect of lipids on fiber digestibility is reduced when rumen by-pass fat was used as happened in this present study (*Canale et al* 1990).

Milk production and its chemical composition

Summarized data in Table 4 revealed that no significant difference were found among Groups fed 2% or 4% protected fat and the control group in average daily milk production, fat%, protein%, lactose%, TS and TSNF. However groups fed either 2% or 4% protected fat had better values of the all above mentioned milk traits compared with control group. Similar results were obtained by *Chalupa*, (1991); *Canale et al* (1990); *Schingoethe and Casper* (1991). *Wu et al* (1993) found an increase in milk yield with 2.1 kg/day as a result of supplementing cow rations with fat. As summarized by *Palmquist* (1984), supplemental fat generally increases milk yield.

Fat supplementation to the diets of dairy cows at early lactation increase the concentration of plasma long chain fatty acids supply to mammary glands which cause an increase in the syntheses of milk fat (*Grummer and Carroll, 1991; Coppock and Wilks, 1991; Vasquez-Anon et al, 1997; EL-Fouly et al, 2001). Andrew et al, (1990*) reported that the increase in the acetate and fatty acids digestibility as a result of feeding dairy cows on rations containing protected fat in early lactation may work for increasing milk fat percentage. Furthermore, long chain fatty acids in the Ca-salt of fatty acids can be transformed directly to milk fat *(Palmquist, 1987*). *Canale et al* (1990) reported that addition of CaFA did not affect milk fat percentage but lowered protein percentage. *Exjalbert et al*, (1997) reported that giving Ca-salt of rapeseed oil diet, higher in polyunsaturated fatty acids than the Ca-salt of palm oil and control diet, resulted in the absorption of a relatively high proportion of *trans*-18 :1*n*-7. Mammary uptake of this FA is efficient (*Thomson & Christie 1991*). So that this FA represented > 5g/kg total milk FA. Larger values have been observed with diets containing fish oil (*Wonsil et al 1994*)

Table (4): Milk production and its chemical composition

Items	Treatments T1 Control	T2 (2% Ca-FA)	T3 (4% Ca-FA)	± SE
Milk production kg/h/d	6.53	7.29	7.45	0.22
Fat %	6.45	6.48	6.58	0.02
Protein %	3.97	4.09	4.20	0.13
Lactose %	4.47	4.94	4.50	0.19
SNF %	9.22	9.79	9.44	0.14
TS %	15.67	16.27	16.02	0.55

a,b,c Means bearing the same letter did not differ significantly (P<0.05)

Blood serum lipid concentration

Feeding Ca-FA as shown in Table (5) increased (P<0.05) serum total lipids (TL), cholesterol (Chol) and trigylcerides (TG) than control. The increase of total lipids associated with feeding fat supplemented rations might be due the depression in lipogenic enzyme activities by liver and adipose tissues (*Storry, 1981*) and feeding long chain fatty acids induced a shift in the balance from active protomeric to inactive polymeric forms of acetyl-CoA carboxylase in bovine adipose tissues (*Bouman and Davis, 1975*). Hypercholerolemia was reported as a standard response to supplementary lipids (*Boila et al, 1993); Drackley and Elliot, 1993*). The increase in the serum cholesterol might be due to the increase in its intestinal biosynthesis (*Nestel et al,* (1978) or the increase in lipoprotein to meet the enhanced metabolic needs such as transport and absorption of a large load of circulating total lipids and fatty acids (*Bitman et al, 1973 and Sharma et al, 1978*). The enhanced total lipid level appeared to be due to, at least in part, to increases in cholesterol and phospholipids but not in triglycerides (*Sklan et al 1989*). *El-Bedawy et al* (1994) reported that blood serum total lipids, cholesterol and triglycerides of dairy cows increased by feeding fat supplemented rations especially sunflower oil seeds.

Table (5): Blood parameters

	Treatments			
Items	T1	T2	T3	
	Control	(2% Ca-FA)	(4% Ca-FA)	O.M/period
Cholesterol, Mg/dl				
Zero	30.73 ± 9.3	62.60 ± 9.3	68.4 0± 9.3	53.92 ± 5.4[e]
1	50.36 ± 9.3	83.96 ± 9.3	74.63 ± 9.3	69.65 ±5.4[de]
2	50.42 ± 9.3	60.80 ± 9.3	80.31 ± 9.3	63.86 ± 5.4[e]
3	66.87 ± 9.3	84.06 ± 9.3	90.94 ± 9.3	80.62 ± 5.4[d]
O.M/Treat.	49.60 ± 4.7[b]	72.78 ± 4.7[a]	78.58 ± 4.7[a]	
Total lipid, Mg/dl				
Zero	3.20 ± 0.42	4.7 ± 0.42	3.60 ± 0.42	3.84 ± 0.24
1	3.63 ± 0.42	3.8 ± 0.42	4.26 ± 0.42	3.90 ± 0.24
2	4.05 ± 0.42	3.13 ± 0.42	4.82 ± 0.42	4.00 ± 0.24
3	3.71 ± 0.42	4.8 ± 0.42	3.71 ± 0.42	4.36 ± 0.24
O.M/Treat.	3.65 ± 0.21[b]	4.10 ± 0.21[a]	4.32 ± 0.21[a]	
Tri-glycerids, Mg/dl				
Zero	07.38-± 5.65	20.61 ± 5.65	17.85 ± 5.65	15.21 ± 3.26
1	10.59 ± 5.65	30.46 ± 5.65	19.60 ± 5.65	20.21 ± 3.26
2	13.44 ± 5.65	15.8 ± 5.65	21.95 ± 5.65	17.10 ± 3.26
3	16.00 ± 5.65	23.39 ± 5.65	30.36 ± 5.65	23.25 ± 3.26
O.M/Treat	11.85 ± 2.83[b]	22.56 ± 2.83[a]	22.44 ± 2.83[a]	

a,b,c Means bearing the same letter did not differ significantly (P<0.05)
± = Stander error (SE)
O.M= Over all mean

Economic evaluation

As shown in Table 2, cost of producing 1 kg milk/ day was found to be 1.1; 0.91 and 0.93 LE for the control group; group fed ration contained 2% protected fat and group fed ration contained 4% protected fat respectively. It is clearly to notice that feeding dairy buffalo on ration contained protected fat at level of 2% and 4% achieved reduction in the cost of producing 1 kg milk with 17.3% and 15.5% respectively.

CONCLUSION

From the above obtained results of this study, it can be concluded that calcium salt of fatty acids made from the wastes of refining sunflower oil and palm oil can be used as cheep energy sources supplement or substitute for a part of corn grain in the ration of lactating buffalo up 4% of the total daily dry matter intake without any adverse effects on the performance of the animals.

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تأثير التغذية على الاحماض الدهنية المحمية باملاح الكالسيوم كمصدر طاقة غير تقليدي على الاداء الانتاجى للجاموس الحلاب

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اجري هذا البحث بغرض دراسة تاثير استخدام خليط من الزيوت المتخلفه عن تكرير زيت عباد الشمس وزيت النخيل فى صورة دهن محمى كمصدر طاقة غير تقليدى ورخيص على انتاج اللبن ومعدل استعادة الجاموس الحلاب لوزن الجسم بعد الولادة مباشرة حيث تكون واقعة تحت تاثير ميزان الطاقة السالب فى هذه الفترة. اجريت هذه الدراسة على عدد ١٥ جاموسة حلابة بعد الولادة مباشرة وفى مرحلة الثلاثة شهور الاولى للانتاج وتم توزيعها عشوائيا على ثلاث مجموعات بكل مجموعة ٥ حيوانات الاولى تمثل مجموعة المقارنة اما الثانية والثالثة فكانت تمثل المجموعات المغذاه على الدهن المحمى . تم تكوين ثلاث مخاليط من المركزات الاول منها لايحتوى على الدهن اما الثانى والثالث فقد اضيف اليهما الدهن المحمى بمعدل فى حدود ٢ او ٤% من اجمالى المادة الجافة الماكولة يوميا بحيث تحل محل كمية الذرة الاضافية المقدمة للحيوانات. تم تغذية المجموعات الثلاث على قش الارز كمادة علف خشنة. وقد اوضحت نتائج هذه الدراسة انه لم توجد فروقا معنوية بين المعاملات الثلاث فى معامل الهضم الظاهرى لكل من المادة الجافة، المادة العضوية، البروتين الخام والالياف الخام والمستخلص الخالى من الازوت الا ان المجموعتان اللتان تغذيتا على الدهن المحمى كانت معنويا اعلى من مجموعة المقارنة فى معامل هضم الدهن الخام. تلاحظ ان متوسط انتاج اللبن اليومى ونسبة دهن وبروتين وسكر اللاكتوز والمواد الصلبة الكلية والمواد غير الدهنية للبن كانت أعلى فى المجموعات المغذاه على الدهن المحمى عن مجموعة المقارنة بالرغم انه لم توجد فروقا معنوية. كانت قيم تركيز الدهن الكلى فى بلازما الدم ، الكوليستيرول والجلسيريدات الثلاثية اعلى معنويا بالمجموعتين اللتين تغذيتا على الدهن المحمى عن مجموعة المقارنة. حققت المجموعتان اللتان تغذيتا على الدهن بنسب ٢ او ٤% انخفاضا فى تكلفة انتاج كيلو اللبن قدره ١٧,٣% و ١٥,٥% على التوالى مقارنة بالكنترول. ويمكن ان نخلص من هذه الدراسة بان استخدام الدهن المحمى المصنع من مخلفات تكرير الزيوت بنسب تصل الى٤% من المادة الجافة المأكولة للحيوان يوميا ليس له تاثيرات ضارة على الاداء الانتاجى للجاموس الحلاب.