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# IMPACT OF USING SODIUM OR CALCIUM SALTS OF FATTY ACIDS AS SOURCES OF ENERGY IN BUFFALO RATIONS DURING LATE PREGNANCY.

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## SUMMARY

Thirty pregnant buffaloes expected to calve within 60-75 days were divided into three balanced groups (ten animals each) and lasted to parturition. Animal groups were randomly assigned to three tested rations. The first group received control ration consisted of concentrate containing (75% concentrate feed mixture with 25% yellow corn) plus berseem hay and rice straw. In the second and third rations, yellow corn was replaced with either Na-SFA or Ca-SFA. Content of AEE in Ca-SFA was lower than that of Na-SFA, while TFA's and ash in Ca-SFA was higher compared with Na-SFA. Chemical compositions of different concentrate mixtures and tested rations were similar except AEE was higher in that contained either Na-SFA or Ca-SFA.

Incubation of teased rations in the rumen for 8, 16, 32, 48, 64 and 72 hrs showed reduction in DM, OM, CP, NDF and ADF disappearances and fitted values with ration containing Na-SFA such degradable fraction (b), ED and PD. Undegradable values increased with adding Na-SFA compared to adding Ca-SFA or control diet.

Digestion coefficient of DM, OM, CP, energy, NDF, ADF and cellulose were significantly decreased with feeding ration containing Na-SFA compared to that containing Ca-SFA, while no significant differences were found between ration containing Ca-SFA and control one. Higher ($p<0.05$) digestibility of lipids was associated with fat supplementation in Na-SFA and Ca-SFA rations. Nutritive values as TDN and DCP were significantly ($P<0.05$) decreased with the ration contained Na-SFA compared to Ca-SFA. Feed intake was not affected with feed rations containing Na-SFA or Ca-SFA. Body weight during the experimental period was significantly increased with feeding ration containing fat than that of the control, but animals fed the ration containing Ca-SFA recorded highest values ($P<0.05$) than that fed ration containing Na-SFA. Overall means of pH value, propionic acid and FFA's in the rumen were ($P<0.05$) significantly higher with feeding ration containing Na-SFA compared to that containing Ca-SFA or control, while, significant decreases of TVFA's, acetic, Ac/Pr and $NH_3$-N. was detected with feeding Na-SFA compared to the other rations. Butyric acid was not affected with adding fat compared to control one. Adding Na-SFA in the ration decreased total protein concentration in blood of late pregnant buffalo compared to Ca-SFA or control. Concentration of albumin, globulin and their ratio were not affected with feeding rations containing either Na-SFA or Ca-SFA. Total lipids, triglyceride and

free fatty acids were significantly (P<0.05) increased with feeding ration containing fat compare to control. Glucose concentration was significantly (P<0.05) decreased with feeding ration containing Na-SFA compared to that containing Ca-SFA or control.

It could be concluded that Ca-SFA produced from Na-SFA could be using as a source of energy in the ration of buffaloes especially during the late period of pregnancy. May be higher content of Ca-SFA in unsaturated fatty acids improve their fertility.

***Keywords:*** *soapstock (Na-SFA), calcium salts of fatty acids (Ca-SFA), late pregnant buffalo, in-situ, rumen fermentation and digestibility.*

## INTRODUCTION

Feeding diets supplemented with fat has been suggested as a dietary strategy to decrease liver TG near the time calving. This strategy assumes that energy status of animal will improved as consequent of reducing fat mobilization from adipose (Bertics and Grummer, 1999). Mahouachi *et al.* (2004) pointed out that diets based on bulky feeding resources are unsuitable for pregnant animals if they are not supplemented with a high proportion of concentrates in their diets. It is expected that added fat is generally favorable especially for late pregnant buffalo to fetal development, mammary adipose tissue and subsequent milk yield. Soapstock is a by-product whish is available as potential dietary fat sources (Shain *et al.*, 1993). A significant amount of soapstock is produced from seeds oil refining processes, and these by-products are potentially harmful to the environment. Fatty acids linked with sodium are the major component of soapstock (Na-SFA) and represent approximately 40-60% of the Na-SFA composition on a wet basis Khattab *et al.*, (2001). Adding of either 2.5 or 5% dietary soapstock (DM basis) tended to decrease ruminal digestibilities of CP and crude fiber when fed to beef cattle (Perry and Weatherly, 1976). Soap-stock as fatty acids has a higher inhibitory effect on ruminal microbes than the triglycerides form (Wu *et al.*, 1993).

The aim of this research was to study the impact of adding both Na-SFA or Ca-SFA as energy sources instead of corn grains in rations buffalo on rumen activity and performance of buffaloes in late pregnancy.

## MATERIALS SND MEATHODS

Feeding trials were applied in Seds experimental station in Bani-souif governorate, *In-situ* study was conducted at the experimental animal house and laboratory of By-product Utilization Department belonging to Animal Production Research Institute.

***Tested ingredients:***

Soapstock (sodium salts of fatty acids, Na-SFA) is the waste generated in the mill during refining of crude oil when sodium hydroxide reacts with the free fatty acids in the oil. Palm oil soap-stock (PL-SS) and sunflower oil soap-stock (SF-SS) produced in soap & oil, manufacture (Cairo oil & soap Co.) was allowed to air drying, and lumps were then broken in a hammer mill after that mixed with (1:1 on DM basis) before being mix with

other concentrate ingredients (in granulose form 3mm diameter) or convert to calcium salts of fatty acids (Ca- SFA) according to El-Bedawy *et al.* (2005).

***In Situ Procedures:***

In-situ trials were conducted according to Mehrez and Ørskov (1977) to study impact of replacement Na-SFA or Ca-SFA instead of corn (on energy basis) on rapidly degradable fraction of DM, OM, CP, neutral detergent fiber (NDF) and acid detergent fiber (ADF) in the rumen for rations using in the feeding trials. Six male sheep equipped with a permanent rumen cannula (50mm inner diameter) were used for the in-situ trials and fed berseem hay to cover maintenance requirements. Nylon cloth (100% polyester) with a mean pore size of 120 µm was used for construction of in-situ bags (8 x 10cm) with nylon threads. Double dry weighed bags containing approximately 4 gm of dried tested rations were incubated for 8, 16, 32, 48, 64 and 72 hrs to determine DM and OM. Another 4 gm were incubated for protein degradability and another 4 gm for NDF and ADF at the same times. After removing the bags from the rumen they were washed gently with flowing strain of tap water until the reuse fluid was clear. Washing losses were estimated by soaking two bags per sample in McDougal's artificial saliva (McDougal, 1949) at (39°C) for 10 min. followed by washing and drying as before. Dry matter, OM and N were estimated according to the methods of A.O.A.C (1990). Both NDF and ADF were determined as described by (Goering and Van Soest, 1970). The data were fitted to the model of McDonald (1981)

$$Y = a + b\,(1-e^{-c\,(t-tl)})$$

Where:

Y = degradability at time (t), a = the zero time intercept, b = potentially degradable fraction, c = rate of degradation of b and tl = lag time.

Degradation of water insoluble fraction (**B**) = (a + b) - WL, where WL is washing loss and Undegradable components (**UND**) $=100 - B$, according to McDonald (1981). Effective degradability (**ED**) = a + (b c)/(c + k), and potential degradability (**PD**) = (a + b), were calculated according to Ørskov (1985).

***Feeding trials:***

Thirty pregnant buffalo expected to calve with 60-75 days were divided to three balanced groups and lasted until parturition. Each group was penned in ventilated sheds. Three concentrate portion of the diets were formulated and pelleted in a feed mill, the 1st one contained 75% concentrate feed mixture (CFM) with 25% yellow corn. In the 2nd and 3rd concentrate portions either Na-SFA or Ca-SFA replaced 100% of corn energy, respectively. Concentrate feed mixture (CFM) consisted of 29% cottonseed meal, 26% yellow corn, 35% wheat bran, 6% molasses, 3% limestone and 1% common salt. The diets were formulated and adjusted biweekly according to changes in body weight by adding berseem hay and rice straw to cover animal requirements according to NRC (1988).

Animals were group fed and adapted to their experimental rations for 7 days before starting the feeding trial. Chemical composition of ingredients and the experimental rations are presented in Tables 1 and 2. All the female buffaloes were weighed, before feeding and watering, immediately at the beginning of the experiment and then at fortnightly intervals to 24 hours post-partum to find out the body weight (BW) changes during the study. Body weight (BW) of both dams and calves were recorded within 24 hours of calving. The dams were weighed after expulsion of placenta.

Digestion trials were carried out at the end of the experimental period using three replicates applying the acid insoluble ash (AIA) technique suggested by Van Keulen and Young (1977). Chemical composition of feeds and feces was determined according to A.O.A.C. (1990). Acidified ether extract (AEE) was determined by modified method as was described by (Abo-Donia *et al.*, 2003). Total fatty acids (TFA's) in Na-SFA and Ca-SFA were determined according to A.O.C.S. (2000) while in feed and feces as described by Sukhija and Palmquist (1988). Fiber fractions (NDF, ADF and ADL) were determined according to Goring and Van Soest (1970). Hemi-cellulose and cellulose were calculated as the differences between NDF and ADF, ADL orderly. Calorific values for feeds and feces were determined by using Gollen Kump ballistic bomb calorimeter, catalogue No CCBB: 33-0101).

Blood plasma samples were withdrawn individually from three buffalo at the end of the feeding period after 4hr post feeding. Total protein, albumin, glucose, total lipids (TL) and triacylglycerols (TG) were determined calorimetrically using commercial kits (Bio Merieux 69280 Marcy-1, Etoile/France). Globulin was obtained by subtracting the albumin value from the total protein concentration. A/G ratio was measured by dividing albumin value on its corresponding globulin value. Total fatty acids (long-chain) in blood serum were determined according to Itaya and Ui (1965).

At the end of the feeding trials, cannulated rams were fed the tested rations (3 for each group) two weeks as an adaptation period, then samples of rumen fluids were withdrawn individually before feeding then after 4 and 8hrs post feeding. Ruminal pH was immediately determined by the HANNA-PH meter, model [HI8424]. Total VFA's concentration was determined as mentioned by Eadie *et al.* (1967), and VFA's fraction's (C2, C3 and C4) were analyzed according to Erwin *et al.* (1961). Free fatty acids (long-chain) in rumen liquor were determined by applying the method of Itaya and Ui (1965). Ammonia concentration in ruminal fluid was determined according to Conway method (1978).

Results obtained were subjected to analysis of variance according to SAS (2000), and treatment means were ranked using Duncan's multiple range test (Duncan, 1955).

## RESULTS AND DISCUSSION

Data in Table (1) show that, content of AEE in Ca-SFA was lower than that in Na-SFA, while the reverse was for TFA's and ash in Ca-SFA. Lower content of AEE in Ca-SFA was due to higher ash content, while lower content of TFA's in Na-SFA was due to higher content of other lipids such pigments, wax ...etc, which are concentrated in Na-SFA during refining oils. Lower content of other lipids in Ca-SFA 1.27 vs. 12.05% for Na-SFA may be attributed to loss of large amounts during converting Na-SFA to Ca-SFA. The AEE was higher with added either Na-SFA or Ca-SFA to CFM and this was reflected on chemical composition of tested rations (Tables 1&2). Higher ash content in the third concentrate (Con3) and ration content Ca-SFA as shown in Tables 1&2 was related to higher ash content in Ca-SFA (18.61%). Content of NDF and ADF for CFM and tested ration lowered with added either Na-SFA or Ca-SFA.

**Table (1): Formulation, chemical composition and cell wall constituents of concentrate, Na-SFA, Ca-SFA, concentrate feed mixture and yellow corn (% on DM basis).**

| Item | Con1 | Con2 | Con3 | Na-SFA | Ca-SFA | CFM | YC |
|---|---|---|---|---|---|---|---|
| ***Content of rations (%)*** | | | | | | | |
| CFM | 75.00 | 83.25 | 85.15 | ---- | ---- | ---- | ---- |
| YC | 25.00 | ---- | ---- | ---- | ---- | ---- | ---- |
| Na-SFA | ---- | 16.75 | ---- | ---- | ---- | ---- | ---- |
| Ca-SFA | ---- | ---- | 14.85 | ---- | ---- | ---- | ---- |
| ***Chemical composition (% on DM basis)*** | | | | | | | |
| DM | 90.63 | 85.64 | 91.14 | 61.73 | 94.78 | 90.50 | 91.00 |
| OM | 92.40 | 90.68 | 88.98 | 92.60 | 81.39 | 90.30 | 98.70 |
| CP | 15.46 | 14.73 | 15.05 | 0.00 | 0.00 | 17.68 | 8.79 |
| AEE | 3.51 | 16.25 | 14.35 | 81.00 | 78.22 | 3.21 | 4.41 |
| TFA's | 2.83 | 13.62 | 13.55 | 68.95 | 76.96 | 2.49 | 3.85 |
| OL | 0.68 | 2.62 | 0.80 | 12.05 | 1.27 | 0.72 | 0.56 |
| Ash | 7.60 | 9.32 | 11.02 | 7.40 | 18.61 | 9.70 | 1.30 |
| ***Cell wall constituents (%)*** | | | | | | | |
| NDF | 17.26 | 16.38 | 16.75 | 0.00 | 0.00 | 19.67 | 10.02 |
| ADF | 12.95 | 12.12 | 12.39 | 0.00 | 0.00 | 14.55 | 8.13 |
| Cellulose | 11.68 | 10.87 | 11.11 | 0.00 | 0.00 | 13.05 | 7.56 |
| H- Cell | 4.31 | 4.26 | 4.36 | 0.00 | 0.00 | 5.12 | 1.89 |
| GE (Mcal) | 4.131 | 4.467 | 4.542 | 6.562 | 7.402 | 4.043 | 4.396 |

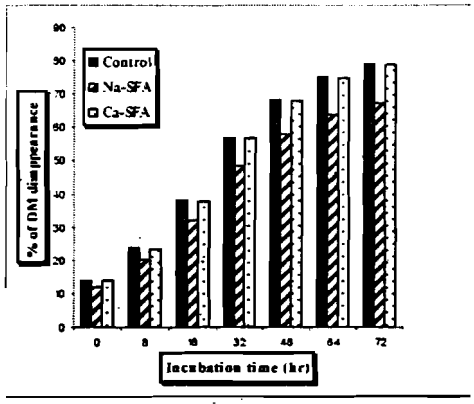
Con1= concentrate without fat, Con2 = concentrate containing Na-SFA and Con3 = concentrate containing Ca-SFA.
Soap Stock and Ca-SFA contained 70.38 and 76.96 % fatty acids, respectively.
TFA's= Total fatty acids, OL= Other lipids and H- Cell = Hemi Cellulose

Data of DM, OM, CP, NDF and ADF disappearances (Fig. 1) and fitted values (Table 3) at different incubations times in the rumen for rations contained Na-SFA were significantly ($P<0.05$) lower than the corresponding values for Ca-SFA or control. However no significant ($P<0.05$) differences were found between Ca-SFA and the control. Reduction of DM, OM, CP, NDF and ADF breakdown in the rumen with added Na-SFA may be due to redistribution of the microbial population through liberation of fatty acids from Na-SFA in the rumen which are toxic to microorganism. This explanation is supported by the findings of Roberts and McKirdy (1965). As a result of foaming and physical coating of the fiber with added Na-SFA has been proposed as a possible theory for the sometimes observed depressed DM, OM, CP, NDF and ADF disappearances (Devendra and Lewis, 1974).

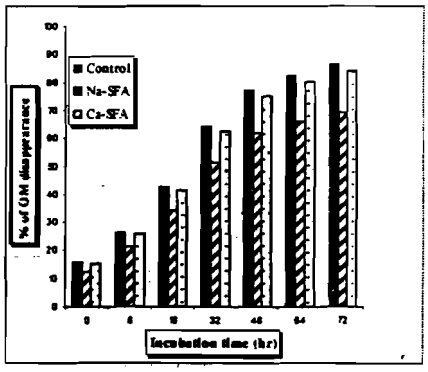
**Table (2): Formulation and chemical composition of different rations and roughages on DM basis.**

| Item | Control | Na-SFA | Ca-SFA | BH | RS |
|---|---|---|---|---|---|
| ***Content of ingredients (%)*** | | | | | |
| Con1 | 42.86 | ---- | ---- | ---- | ---- |
| Con2 | ---- | 42.86 | ---- | ---- | ---- |
| Con3 | ---- | ---- | 42.86 | ---- | ---- |
| BH | 14.29 | 14.29 | 14.29 | ---- | ---- |
| RS | 42.86 | 42.86 | 42.86 | ---- | ---- |
| ***Chemical composition (%)*** | | | | | |
| DM | 89.98 | 87.85 | 90.20 | 88.00 | 90.00 |
| OM | 87.67 | 86.93 | 86.20 | 86.00 | 83.50 |
| CP | 10.09 | 9.77 | 9.91 | 13.70 | 3.51 |
| AEE | 2.32 | 7.78 | 6.96 | 1.80 | 1.30 |
| TFA | 1.63 | 6.26 | 6.22 | 1.01 | 0.63 |
| OL | 0.69 | 1.52 | 0.74 | 0.79 | 0.67 |
| Ash | 12.33 | 13.07 | 13.80 | 14.00 | 16.50 |
| ***Cell wall constituents (%)*** | | | | | |
| NDF | 44.04 | 43.67 | 43.82 | 51.24 | 68.43 |
| ADF | 34.55 | 34.20 | 34.32 | 39.87 | 54.39 |
| Cellulose | 30.96 | 30.62 | 30.72 | 36.75 | 48.32 |
| Hemi-cellulose | 9.49 | 9.47 | 9.51 | 11.37 | 14.04 |
| GE (Mcal) | 3.884 | 4.028 | 4.060 | 3.856 | 3.647 |

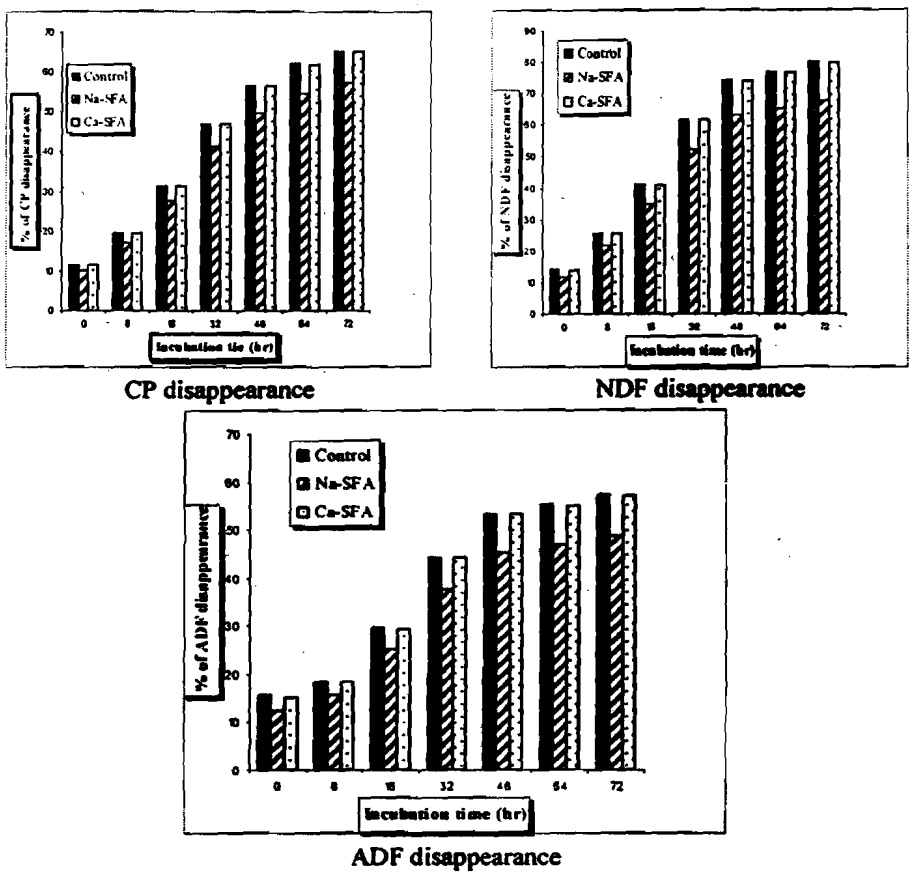
Con1= concentrate without fat, Con2 = concentrate containing Na-SFA and Con3 = concentrate containing Ca-SFA
RS = Rice straw. BH= Berseem hay




DM disappearance




OM disappearance




CP disappearance NDF disappearance

ADF disappearance

**Fig. (1): Dry matter, OM, CP, NDF and ADF disappearance for tested experimental rations at different times.**

The rapidly degradable fraction (a) of DM, OM, CP, NDF and ADF was similar with Ca-SFA and control ration, while was significantly ($P<0.05$) reduced with ration containing Na-SFA (Table 4). The slowly degradable fraction (b) was taken the same trends. These results might be due to Na-SFA have a higher inhibitory effect on ruminal microbes than the triglycerides form, as suggested by Wu, *et. al.* (1993). Perry and Weatherly (1976) reported that either 2.5 or 5% dietary soapstock (DM basis) tended to decrease ruminal digestibilities of crude protein (CP) and crude fiber (CF) when fed to beef cattle. The degradation rates (c) of DM, OM, CP, NDF and ADF were not affected by adding Na-SFA or Ca-SFA. Effective degradability (ED) and potential degradability (PD) of DM, OM, CP, NDF and ADF were lowered with adding Na-SFA than with Ca-SFA rations. Undegradable DM, OM, CP, NDF and ADF were similar among tested rations where higher significantly ($P<0.05$) with ration containing Na-SFA compared to ration containing Ca-SFA or control one, while no significant ($P>0.05$) differences were found between control and Ca-SFA. This study indicates that ruminal degradability of DM, OM, CP, NDF and ADF of Na-SFA ration were less compared to Ca-SFA ration. Data in Table

7 and illustrated in Fig. 1 and 2 confirm these results, where data illustrated in Fig. 1 show increased FFA's in the rumen with feeding a diet containing Na-SFA which in turn led to decrease concentration of $NH_3$-N. This result reflects the impact of added Na-SFA on protein degradability in the rumen. At the same time, data illustrated in Fig. 2 reflect the impact of feeding Na-SFA on fiber degradability through concentration of TVFA's resulting from the break down of fiber in the rumen. Eastridge (2002) reported that, both chemical and physical forms of fat sources can affect digestive aspects and reduce fiber digestibility in the rumen by inhibitory effects on cellulolytic microorganisms.

**Table (3): Mean values of fitted DM, OM, CP, NDF and ADF% disappearance for tested experimental rations at different intervals.**

| Item | 8hrs | 16hrs | 32hrs | 48hrs | 64hrs | 72hrs |
|---|---|---|---|---|---|---|
| ***Dry matter (%)*** | | | | | | |
| Control | 23.97$^a$ | 37.73$^a$ | 56.93$^a$ | 68.73$^a$ | 75.93$^a$ | 78.43$^a$ |
| Na-SFA | 20.37$^b$ | 32.07$^b$ | 48.37$^b$ | 58.40$^b$ | 64.53$^b$ | 66.63$^b$ |
| Ca-SFA | 23.90$^a$ | 37.60$^a$ | 56.73$^a$ | 68.47$^a$ | 75.67$^a$ | 78.17$^a$ |
| ±SE | ±0.76 | ±1.20 | ±1.82 | ±2.20 | ±2.43 | ±2.52 |
| ***Organic matter (%)*** | | | | | | |
| Control | 26.77$^a$ | 42.90$^a$ | 64.37$^a$ | 76.63$^a$ | 83.67$^a$ | 85.97$^a$ |
| Na-SFA | 21.47$^b$ | 34.40$^b$ | 51.60$^b$ | 61.43$^b$ | 67.07$^b$ | 68.93$^b$ |
| Ca-SFA | 26.00$^a$ | 41.70$^a$ | 62.60$^a$ | 74.50$^a$ | 81.37$^a$ | 83.57$^a$ |
| ±SE | ±0.44 | 0.71± | ±1.04 | ±1.26 | ±1.35 | ±1.40 |
| ***Crude protein (%)*** | | | | | | |
| Control | 19.77$^a$ | 31.07$^a$ | 46.87$^a$ | 56.60$^a$ | 62.53$^a$ | 64.57$^a$ |
| Na-SFA | 17.40$^b$ | 27.40$^b$ | 41.37$^b$ | 49.87$^b$ | 55.13$^b$ | 56.97$^b$ |
| Ca-SFA | 19.73$^a$ | 31.00$^a$ | 46.83$^a$ | 56.53$^a$ | 62.50$^a$ | 64.50$^a$ |
| ±SE | ±0.31 | ±0.49 | ±0.74 | ±0.90 | ±0.99 | ±1.04 |
| ***NDF (%)*** | | | | | | |
| Control | 25.40$^a$ | 41.83$^a$ | 62.10$^a$ | 72.63$^a$ | 78.07$^a$ | 79.67$^a$ |
| Na-SFA | 21.57$^b$ | 35.53$^b$ | 52.80$^b$ | 61.70$^b$ | 6630$^b$ | 67.70$^b$ |
| Ca-SFA | 25.30$^a$ | 41.70$^a$ | 61.87$^a$ | 72.37$^a$ | 77.77$^a$ | 79.40$^a$ |
| ±SE | ±0.81 | ±1.33 | ±1.97 | ±2.32 | ±2.49 | ±2.53 |
| ***ADF (%)*** | | | | | | |
| Control | 18.30$^a$ | 30.13$^a$ | 44.70$^a$ | 52.27$^a$ | 56.17$^a$ | 57.37$^a$ |
| Na-SFA | 15.53$^b$ | 25.57$^b$ | 38.00$^b$ | 44.40$^b$ | 47.73$^b$ | 48.73$^b$ |
| Ca-SFA | 18.20$^a$ | 30.00$^a$ | 44.57$^a$ | 52.07$^a$ | 56.00$^a$ | 57.17$^a$ |
| ±SE | ±0.57 | ±0.97 | ±1.44 | ±1.67 | ±1.79 | ±1.84 |

a and b Means in the same column for each category with different superscripts are significantly different (P<0.05).

**Table (4): Ruminal degradation kinetics (%) of tested rations defined by equation terms for feeds incubated *in sacco*.**

| Item | WL (%) | a (%) | b (%) | c (%/h) | PD (%) | ED (3%h-1) | B (%) | UND (%) |
|---|---|---|---|---|---|---|---|---|
| ***Dry matter (%)*** | | | | | | | | |
| Control | 13.96[a] | 6.43[a] | 81.00[a] | 0.031 | 87.43[a] | 47.27[a] | 73.47[a] | 26.53[b] |
| Na-SFA | 11.90[b] | 5.47[b] | 68.83[b] | 0.031 | 74.30[b] | 40.17[b] | 62.40[b] | 37.60[a] |
| Ca-SFA | 13.97[a] | 6.40[a] | 80.70[a] | 0.031 | 87.17[a] | 47.13[a] | 73.20[a] | 26.80[b] |
| ±SE | ±0.45 | ±0.22 | ±2.58 | ±0.00 | ±2.80 | ±1.51 | ±2.36 | ±2.36 |
| ***Organic matter (%)*** | | | | | | | | |
| Control | 15.74[a] | 5.43[a] | 87.67[a] | 0.035 | 93.07[a] | 52.53[a] | 77.33[a] | 22.67[b] |
| Na-SFA | 12.63[b] | 4.37[b] | 70.27[b] | 0.035 | 74.63[b] | 42.13[b] | 62.00[b] | 38.00[a] |
| Ca-SFA | 15.30[a] | 5.30[a] | 85.20[a] | 0.035 | 90.50[a] | 51.07[a] | 75.20[a] | 24.80[b] |
| ±SE | ±0.25 | ±0.10 | ±1.42 | ±0.00 | ±1.53 | ±0.87 | ±1.26 | ±1.26 |
| ***Crude protein (%)*** | | | | | | | | |
| Control | 11.50[a] | 5.30[a] | 66.70[a] | 0.031 | 72.00[a] | 38.90[a] | 60.50[a] | 39.50[b] |
| Na-SFA | 10.17[b] | 4.67[b] | 58.80[b] | 0.031 | 63.50[b] | 34.33[b] | 53.33[b] | 46.67[a] |
| Ca-SFA | 11.50[a] | 5.27[a] | 66.60[a] | 0.031 | 71.90[a] | 38.90[a] | 60.40[a] | 39.60[b] |
| ±SE | ±0.18 | ±0.09 | ±1.06 | ±0.00 | ±1.15 | ±0.62 | ±0.96 | ±0.96 |
| ***NDF (%)*** | | | | | | | | |
| Control | 13.96[a] | 2.60[a] | 81.30[a] | 0.041 | 83.83[a] | 49.63[a] | 69.87[a] | 30.13[b] |
| Na-SFA | 11.93[b] | 2.20[b] | 69.07[b] | 0.041 | 71.30[b] | 42.17[b] | 59.37[b] | 40.63[a] |
| Ca-SFA | 13.94[a] | 2.60 | 81.00[a] | 0.041 | 83.57[a] | 49.43[a] | 69.63[a] | 30.37[b] |
| ±SE | ±0.45 | ±0.09 | ±2.59 | ±0.00 | ±2.68 | ±1.58 | ±2.23 | ±2.23 |
| ***ADF (%)*** | | | | | | | | |
| Control | 15.77[a] | 1.87[a] | 58.53[a] | 0.041 | 60.40[a] | 35.70[a] | 44.63[a] | 55.37[b] |
| Na-SFA | 12.60[b] | 1.57[b] | 49.73[b] | 0.041 | 51.30[b] | 30.33[b] | 38.70[b] | 61.30[a] |
| Ca-SFA | 15.33[a] | 1.87[a] | 58.33[a] | 0.041 | 60.20[a] | 35.60[a] | 44.87[a] | 55.13[b] |
| ±SE | ±0.25 | ±0.07 | ±1.86 | ±0.00 | ±1.93 | ±1.16 | ±1.82 | ±1.82 |

a and b Means in the same column for each category with different superscripts are significantly different (P<0.05).

**a** = the zero time intercept, **b** = potentially degradable fraction, **c** = rate of degradation of b, **B**= Degradation of water insoluble fraction, **UND**= Undegradable components, **ED**= Effective degradability and **PD**= potential degradability

**Table (5): Nutrient digestibility, cell Wall constituent and nutritive value for tested rations.**

| Item | Control | Na-SFA | Ca-SFA | ±SE |
|---|---|---|---|---|
| ***Nutrient digestibility, (%)*** | | | | |
| DM | 69.64[a] | 64.89[b] | 68.92[a] | ±0.73 |
| OM | 72.11[a] | 67.67[b] | 70.92[a] | ±0.86 |
| CP | 61.25[a] | 56.83[b] | 60.90[a] | ±0.71 |
| AEE | 69.26[b] | 75.21[a] | 77.39[a] | ±1.92 |
| Energy | 68.66[a] | 64.67[b] | 67.33[a] | ±0.74 |
| ***Cell Wall constituent (%)*** | | | | |
| NDF | 68.62[a] | 62.26[b] | 67.96[a] | ±1.35 |
| ADF | 65.45[a] | 60.46[b] | 64.92[a] | ±1.10 |
| Cellulose | 71.71[a] | 66.30[b] | 71.20[a] | ±1.21 |
| Hemicellulose | 79.76[a] | 68.56[b] | 78.61[ab] | ±3.03 |
| ***Nutritive value, (%)*** | | | | |
| TDN | 67.97[a] | 64.03[b] | 66.66[a] | ±0.74 |
| DCP | 7.27[a] | 6.54[b] | 7.09[a] | ±0.08 |

a and b Means in the same row with different superscripts are significantly different (P<0.05).

Data in Table (5) show digestion coefficients of DM, OM, CP and energy which were significantly lowered with feeding ration containing Na-SFA compared to that containing Ca-SFA, while no significant differences were found between ration containing Ca-SFA and control one. These results are an good agreement with those obtained from the in-situ study, where DM, OM and CP disappearances were significantly ($P<0.05$) decreased with added Na-SFA compared to Ca-SFA. In contrary, undegradable DM, OM and CP were significantly higher as shown in Table 4. Palmquist (1994) and Kattab *et al.* (2001) reported that, added fat decreased DMD. They also, stated that, effect of added fat on digestibility depended on type of fat and the circumstances of the experiment where several investigators did not reveal significant influence of supplemented fat on DMD. Jenkins (1994) suggested that when fat supplementation decreased protein digestibility in the whole tract, the less nitrogen absorbed across the rumen as ammonia, which is not utilized by body tissues for production. The reduction in CPD is attributed to depression of degradation in the rumen (Boggs *et al.*, 1987).

Feeding ration containing Na-SFA or Ca-SFA significantly ($P<0.05$) increased digestion coefficient of AEE. The higher ($p<0.05$) digestibility of lipids associated with fat supplementation in Na-SFA and Ca-SFA rations might be related to the higher digestibility of the supplemented fat (Devendra and Lewis, 1974 and El-Bedawy *et al.*, 2005). The 18 carbon unsaturated fatty acids (e.g., linolenic and linoleic acids) are more digestible in the small intestine than the 18 carbon saturated fatty acids (e.g., stearic acid) (Pantoja *et al.*, 1996). Palmquist (1994) reported that, calcium soap was solubilized as fatty acids, which increase the solubility of the acid-soap complex in the bile salt micelle system. Ruminant animals absorb fats with a high degree of efficiency: digestion or absorption coefficients of between 80% and 90% have been reported for a variety of fats, oils and fatty acids (Moore and Christie, 1984). This high efficiency was maintained even when the dietary intake of fatty acids was greatly increased.

Digestibilities of NDF, ADF and cellulose significantly ($P<0.05$) decreased for ration containing Na-SFA compared to Ca-SFA or control one, however no significant differences was found between ration containing Ca-SFA and control ones. El-Hag and Miller (1972) concluded that depression in fiber digestibility was due to inhibitory effect of LCFA on microbial growth. Growth of the celluloytic species *Butyrivibrio fibrisolvens, Ruminococcus albus* and *Ruminococcus flavefaciens* was inhibited by oleic acid in the presence of a soluble substrate (cellobiose) (Palmquist, 1988). The lack of impact of the addition of Ca-SFA on digestibility of fiber fractions could indicate that added fat was protected and did not affect the cellulotic activity in the rumen. These results are supported by the in-situ study, where disappearances of cell wall constituents were significantly ($P<0.05$) decreased with added Na-SFA compared to Ca-SFA, while undegradable cell wall constituents significantly ($P<0.05$) increased (see Fig.1 and Table 4). Data of rumen parameters (Table 7) showed significant decreases in TVFA's and acetate concentrations in the rumen.

Nutritive values as TDN and DCP were significantly ($P<0.05$) decreased with ration containing Na-SFA compared to Ca-SFA, while no significant differences was found between control group and that containing Ca-SFA. These results might be due to the effect of Na-SFA on rumen fermentation which affect fiber and protein digestibility. Jenkins (1993) reviewed that, if the ability of the microorganisms to ferment fiber is inhibited by fat, the fiber energy is lost in feces.

**Table (6): Feed intake and change in body weight for pregnant females fed tested rations.**

| Item | Control | Na-SFA | Ca-SFA | ±SE |
|---|---|---|---|---|
| ***Feed intake on basis DM (kg)*** | | | | |
| Concentrate, CFM | 3.00 | 3.00 | 3.00 | --- |
| Berseem hay, BH | 1.00 | 1.00 | 1.00 | --- |
| Raise straw, RS | 3.00 | 3.00 | 3.00 | --- |
| TDMI | 7.00 | 7.00 | 7.00 | --- |
| Concentrate/ roughages | 0.75 | 0.75 | 0.75 | --- |
| ***Change in body weight (kg)*** | | | | |
| BWBP | 565.40 | 567.70 | 566.10 | ±7.79 |
| BWPP | 522.80 | 523.30 | 518.70 | ±7.75 |
| Changing | 42.60$^{c}$ | 44.40$^{b}$ | 47.40$^{a}$ | ±0.41 |
| Av. BW | 544.10 | 545.50 | 542.40 | ±7.77 |
| Av. BW$^{0.75}$ | 122.70 | 112.90 | 112.40 | ±1.24 |
| Birth weight | 34.30$^{c}$ | 36.00$^{b}$ | 38.80$^{a}$ | ±0.38 |
| Duration (day) | 67.20$^{a}$ | 63.40$^{ab}$ | 61.80$^{b}$ | ±1.61 |

a, b and c Means in the same row with different superscripts are significantly different (P<0.05).
BWBP=body weight before parturition at beginning of experimental started BWPP= body weight postpartum

Concentrate: roughage ratio was fixed in tested rations to avoid its effect on feed intake and to study the effect rations containing Na-SFA or Ca-SFA on intake. No significant differences were found for body weight among tested groups the beginning or at the end of the experimental period (Table 6). Changing in body weight was significantly (P<0.05) increased with feeding a ration containing fat than the control one, but animals feed ration containing Ca-SFA recorded highest values (P<0.05) than those fed a ration containing Na-SFA. These results might be revealed that fat is generally favorable especially for late pregnant buffalo to fetal development especially Ca-SFA which was containing calcium for develop fetal skeleton. The special data of birth weight support this suggestion where shown the same trend. Usual changes in the live weight of dams during gestation are often assumed to be indicative of pre-natal fetus development (Amoah *et al.*, 1996). (Akingbade *et al.*, 2001) reported that during late pregnancy there is preferential nutrient utilization for foetal growth at the cost of mobilization of maternal body tissues, which results in weight loss of doe if the dietary supply of nutrients is inadequate (Al-Totanji and Lubbadeh, 2000). The pattern of foetal growth rate in dams during the experiment corroborate these observations and also indicate that last month of gestation is the period of most rapid foetal growth.

**Table (7): Basic pattern of rumen parameters for sheep fed the experimental rations.**

| Item | Time | Control | Na-SFA | Ca-SFA | ±SE | Overall mean |
|---|---|---|---|---|---|---|
| pH | 0 | $6.50^{a}$ | 6.97 | 6.57 | ±0.168 | 6.68 |
| | 4 | $5.84^{b}$ | 6.79 | 6.03 | ±0.207 | 6.22 |
| | 8 | $6.13^{Bab}$ | $6.82^{A}$ | $6.60^{A}$ | ±0.072 | 6.52 |
| **Overall mean** | | $6.16^{B}$ | $6.86^{A}$ | $6.40^{B}$ | ±0.112 | 0.136 |
| TVFA's (meq/dl) | 0 | $12.22^{A}$ | $8.99^{Bb}$ | $10.72^{Ab}$ | ±0.302 | $10.64^{b}$ |
| | 4 | $14.43^{A}$ | $11.06^{Ba}$ | $12.51^{ABa}$ | ±0.505 | $12.67^{a}$ |
| | 8 | 11.89 | $9.88^{ab}$ | $11.81^{ab}$ | ±0.384 | $11.19^{ab}$ |
| **Overall mean** | | $12.85^{A}$ | $9.98^{B}$ | $11.68^{A}$ | ±0.383 | 0.48 |
| Acetic (%) | 0 | $59.32^{A}$ | $52.51^{B}$ | $57.24^{ABb}$ | ±1.180 | 56.36 |
| | 4 | 62.05 | 53.84 | $62.11^{a}$ | ±2.320 | 59.33 |
| | 8 | $60.22^{A}$ | $51.40^{B}$ | $60.81^{Aa}$ | ±0.442 | 57.48 |
| **Overall mean** | | $60.53^{A}$ | $52.58^{B}$ | $60.05^{A}$ | ±0.923 | 1.523 |
| Propionic(%) | 0 | $25.05^{b}$ | 25.41 | $25.40^{b}$ | ±0.342 | 25.29 |
| | 4 | $25.95^{a}$ | 29.03 | $25.99^{a}$ | ±0.833 | 26.99 |
| | 8 | $25.95^{a}$ | 28.72 | $25.83^{ab}$ | ±0.587 | 26.83 |
| **Overall mean** | | $25.65^{B}$ | $27.72^{A}$ | $25.74^{B}$ | ±0.467 | 0.508 |
| Ac/Pr | 0 | 2.37 | 2.07 | $2.25^{b}$ | ±0.006 | 2.23 |
| | 4 | 2.39 | 1.87 | $2.39^{a}$ | ±0.117 | 2.22 |
| | 8 | $2.32^{A}$ | $1.79^{B}$ | $2.35^{Aa}$ | ±0.038 | 2.15 |
| **Overall mean** | | $2.36^{A}$ | $1.91^{B}$ | $2.33^{A}$ | ±0.038 | 0.086 |
| Butyric (%) | 0 | $10.63^{b}$ | $10.58^{b}$ | 10.94 | ±0.367 | $10.72^{b}$ |
| | 4 | $12.17^{a}$ | $13.79^{a}$ | 12.32 | ±0.538 | $12.76^{a}$ |
| | 8 | $11.16^{Bab}$ | $12.48^{Aab}$ | $12.28^{A}$ | ±0.180 | $11.97^{a}$ |
| **Overall mean** | | 11.32 | 12.28 | 11.85 | ±0.380 | 0.275 |
| $NH_3$-N (mg/dl) | 0 | $10.36^{b}$ | $9.26^{Bb}$ | $11.08^{Ab}$ | ±0.267 | $10.23^{b}$ |
| | 4 | $13.38^{a}$ | $10.67^{Ba}$ | $12.59^{Aa}$ | ±0.204 | $12.21^{a}$ |
| | 8 | $12.33^{a}$ | $9.55^{Bb}$ | $12.40^{Aa}$ | ±0.108 | $11.43^{ab}$ |
| **Overall mean** | | $12.02^{A}$ | $9.83^{B}$ | $12.02^{A}$ | ±0.334 | 0.404 |
| FFA's Umol/l | 0 | $2.41^{B}$ | $7.14^{A}$ | $3.13^{B}$ | ±0.313 | 4.23 |
| | 4 | $2.86^{B}$ | $7.34^{A}$ | $4.45^{B}$ | ±0.333 | 4.88 |
| | 8 | $2.54^{B}$ | $6.86^{A}$ | $3.51^{B}$ | ±0.247 | 4.30 |
| **Overall mean** | | $2.60^{C}$ | $7.11^{A}$ | $3.70^{B}$ | ±0.200 | 0.701 |

A, B and C Means in the same row with different superscripts are significantly different (P<0.05)
a, and b Means in the same column within each category with different superscripts are significantly different (P<0.05)

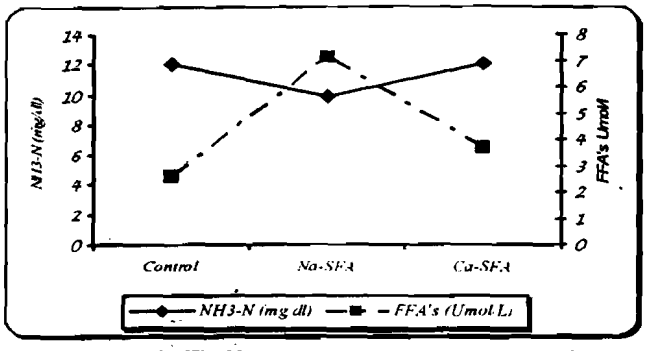



**Fig. 2. Relation between FFA's and $NH_3$-N in the rumen of sheep feed ration containing Na-SFA or Ca-SFA.**

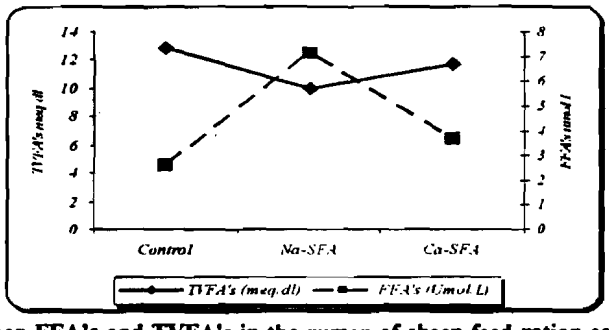



**Fig. 3. Relation between FFA's and TVFA's in the rumen of sheep feed ration containing Na-SFA or Ca-SFA.**

Data in Table (7) revealed that overall mean of pH values , propionic acid and FFA's in the rumen were significantly ($P<0.05$) increased while TVFA's, acetic, Ac/Pr and $NH_3$-N significantly decreased when ration containing Na-SFA was fed compared with that containing Ca-SFA or control one. Butyric acid was not affected with added fat compared to control one. Increase release of FFA's in the rumen when feeding Na-SFA decreased both $NH_3$-N and TVFA's as illustrated in Figs. 1 and 2. These figures refers to relation between increase FFA's with feed Na-SFA and decrease both protein and NDF degradability in the rumen as shown in Tables 3 and Fig. 1. Fatty acids, especially unsaturated fatty acids, are antimicrobial and interfere with normal function of the ruminal microbes (Palmquist, 1988). Devendra and Lewis (1974) reported that, rumen fermentation is negatively affected as fatty acids become more unsaturated and/or are released faster from feedstuffs. Effects of adding fat on the rumen fermentation depend on source and content of fiber in the ration (Jenkins, 1994), type and level of fat (Abo-Donia *et al.*, 2003).

**Table (8): Some blood parameters of buffalo fed rations containing Na-SFA or Ca-SFA at late pregnant period.**

| Item | Control | Na-SFA | Ca-SFA | ±SE |
|---|---|---|---|---|
| Total protein (g/dl) | 6.51[a] | 6.21[b] | 6.49[a] | ±0.06 |
| Albumin (g/dl) | 2.61 | 2.59 | 2.67 | ±0.05 |
| Globulin (g/dl) | 3.88 | 3.80 | 3.83 | ±0.04 |
| Albumin / Globulin | 0.69 | 0.69 | 0.71 | ±0.02 |
| Total lipids(g/dl) | 5.00[b] | 6.14[a] | 6.31[a] | ±0.15 |
| Triglyceride(mg/dl) | 66.60[b] | 72.97[a] | 75.43[a] | ±0.89 |
| FFA's (Umol/l) | 19.35[c] | 26.14[b] | 30.47[a] | ±044 |
| Glucose (mg/dl) | 58.74[a] | 52.74[b] | 52.55[b] | ±0.72 |

a, b and c and means in the same row with different superscripts are significantly different (P<0.05)

Results in Table (8) show clearly that, including Na-SFA in the ration decreased total protein concentration in blood of late pregnant buffalo compared to Ca-SFA or the control. This result is an agreement with data in Tables 3, 5 and 6, where protein degradability and digestibility decreased with ration containing Na-SFA compared to that containing Ca-SFA or control ones. Concentration of albumin, globulin and their ratio were not affected with feeding ration containing either Na-SFA or Ca-SFA. Effect of Na-SFA on protein concentration in the blood might be dependent on kind of fatty acids in Na-SFA (Aiad *et al.*, 2005). Concentration of total lipids, triglyceride and free fatty acids were significantly (P<0.05) increased with feeding a ration containing fat compare to control ones. No significant (P<0.05) difference was found between Na-SFA and Ca-SFA except FFA's which was significantly higher with Ca-SFA compared to Na-SFA. The higher blood lipids might be due to the inhibition in lipogenic enzyme activities by liver and adipose tissue of animals fed fat containing rations (Storry, 1981). These results are related to the high content of fatty acids in Na-SFA and Ca-SFA. The herein results are supported with those reported by Aiad *et al.* (2005). Palmquist and Conrad (1978) attributed the high blood plasma lipids of fat supplemented cows to the greater quantity of fatty acids absorbed from fat supplemented diets than the control ones. All serum parameters were within the normal range as reported by William (1997). Glucose concentration was significantly (P<0.05) decreased with feeding a ration containing Na-SFA compared with that containing Ca-SFA or control one.

## CONCLUSION

From the previous results it seems clear that feeding diets supplemented with fat has been found suitable for pregnant animals especially for late pregnant buffalo to fetal development, mammary adipose tissue and subsequent milk yield. Soapstock as Na-SFA an available by-product is considered a potential dietary fat source. Converting it to Ca-SFA is favorable to reduce its negative effect. It could be concluded that Ca-SFA produced from Na-SFA could be used as a source of energy in the ration of buffaloes especially during the late period of pregnancy.

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# تاثير استخدام الدهن الصوديومى او الكالسيومى كمصدر للطاقة فى علائق الجاموس فى الفترة الاخيرة من الحمل

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قسمت ثلاثون جاموسة عشار متوقع ولادتها فى فترة ٦٠ – ٧٥ يوما الى ثلاث مجموعات وزعت عشوائيا على ثلاث علائق الاولى غذيت على عليقة مشاهدة ( كنترول) تتكون من خليط مركز يتكون من ( علف مركز ٧٥٪ بالاضافة لـ ٢٥٪ ذرة صفراء) فى صورة مكعبات مع دريس البرسيم وقش الارز. المجموعة الثانية والثالثة غذيتا على نفس العليقة الشاهد مع استبدال الذرة الصفراء بالدهن الصوديومى او الكالسيومى على اساس الطاقة بالتوالى.

اوضح التحليل الكيماوى تشابه التركيب الكيماوى فى العلف المركز والعلائق المختلفة فيما عدا ارتفاع نسبة مستخلص الاثير مع اضافة الدهون.

من نتائج تحضين عينات تلك العلائق فى حيوانات مزودة بفستيولات على الكرش عند اوقات ٨، ١٦، ٣٢، ٤٨، ٦٤ و ٧٢ ساعة شوهد انخفاض فى نسبة اختفاء المادة الجافة والعضوية والبروتين الخام كذلك فى مستخلص الالياف الذائب فى المحلول المتعادل او الحامضى لعينات العليقة المحتوية على الدهن الصوديومى. كما وجد ايضا انخفاض فى قيم الجزء المتكسر (b) وكفاءة التكسر (ED) والمحتمل تكسره (PD) فى الكرش والناتج من معادلة الانحدار الاسى. بينما لوحظ ارتفاع فى قيم الجزء غير المتكسر بالكرش وذلك مقارنة بالعليقة الشاهد او التى تحتوى على الدهن الكالسيومى.

اظهرت نتائج الهضم انخفاض معاملات هضم المادة الجافة العضوية والبروتين الخام والطاقة المهضومة وكذا انخفاض كل من مستخلص الالياف الذائب فى المحلول المتعادل والمحلول الحامضى بينما لم تظهر النتائج اختلافات بين المعاملة الشاهد والتى بها دهن كالسيومى.

اشارت النتائج الى ارتفاع معاملات هضم مستخلص الاثير فى العلائق المحتوية على الدهن مقارنة بالعليقة الشاهد. كما اوضحت النتائج المتحصل عليها انخفاض قيم كل من المركبات الغذائية الكلية المهضومة والبروتين المهضوم للعلائق المحتوية على الدهن الصوديومى مقارنة بالعليقة الشاهد او تلك التى احتوت على الدهن الكالسيومى.

لم يتاثر الماكول من العلائق المحتوية على كلا من شكلى الدهون. كما اشارت النتائج الى زيادة معدل التغير فى الوزن للحيوانات المغذاه على علائق محتوية على دهون مقارنة بالعليقة الشاهد الا ان الحيوانات التى غذيت على الدهن الكالسيومى سجلت ارتفاعا اعلا من تلك التى غذيت على الدهن الصوديومى.

اوضحت نتائج قيم حموضة الكرش وتركيز البروبيونات والاحماض الدهنية الحرة طويلة السلسلة فى الكرش ارتفاعا واضحا مع تغذية العليقة المحتوية على الدهن الصوديومى فى حين انخفضت قيم الاحماض الدهنية الطيارة الكلية والخلات ونسبة الخلات للبروبيونات وكذا الامونيا مقارنة بالعليقة الشاهد او تلك التى احتوت على الدهن الكالسيومى.

ادى اضافة الدهن الصوديومى الى خفض البروتين الكلى فى بلازما الدم بينما لم يحدث تغير فى قيم الالبيومين والجلوبيولين او النسبة بينهما مقارنة بالعليقة الشاهد او التى تحتوى على الدهن الكالسيومى.

من نتائج هذه الدراسة يخلص القول الى ان التغذية على الدهون كمصدر للطاقة فى الفترة الاخيرة من الحمل لاناث الجاموس قد تكون مناسبة خاصة اذا كانت فى صورة دهن كالسيومى حيث انها قد تساعد على تطور الجنين وتحسين اداء الغدد اللبنية فى فترة الحليب بعد الولادة.