

EFFECT OF SUNFLOWER OIL SUPPLEMENTATION ON NUTRIENTS DIGESTIBILITY AND MILK FAT CONTENT OF CONJUGATED LINOLEIC ACID IN DAIRY CAMELS

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ABSTRACT: Three experiments were carried out to study the effect of sunflower oil (SFO) supplementation on nutrients digestibility (Exp.1), *in vitro* degradation kinetics of organic matter and fiber fractions (Exp. 2); and milk composition and fatty acids profile in milk fat of dairy camels (Exp.3). Chemical composition of the basal diet was 92.3%, 14.1%, 29.1%, 12.9% and 2.1%; of organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and ether extract (EE), respectively. The SFO was added at the level of 0, 2 and 4% of DM for basal diet. Experimental diets were basal diet (SF-0) and basal diet with 2% SFO (SF-2) and basal diet with 4% SFO (SF-4). In digestibility trial (Exp.1), dry matter intake (DMI) and digestibility of NDF, ADF and N were significantly decreased ($P < 0.05$) by diet SF-4, but not with SF-2. Adding SFO at the level of 4% of DM negatively affected the ruminally degradable fraction and degradation rate of OM, NDF and ADF. Milk yield was significantly decreased ($P < 0.05$) when dairy camels were fed SF-4, however, no significant differences were detected on DMI and milk composition for either SF-2 or SF-4 (Exp.3). The principal aim of this study was to study the effect of different levels of SFO on the concentration of *cis*-9, *trans*-11 C18:2 in milk of dairy camels. The provision of SF-2 and SF-4 to dairy camel had no significant effect on the concentrations of capric acid (C_{10:0}) and lauric acid (C_{12:0}) of milk fat. Myristic (C_{14:0}) and palmitic acid (C_{16:0}) contents of milk fat of animals fed added-oil diets (i.e., SF-2 and SF-4) were decreased ($P < 0.05$) compared with SF-0. The concentrations of total short and medium chain FA (i.e. C_{10:0} to C_{16:0}) were reduced by 38% and 48% with SF-2 and SF-4 than SF-0. A positive response was observed for *cis*-9, *trans*-11 conjugated linolenic acid (CLA) content in milk fat, which significantly increased ($P < 0.05$) by about 5 folds in animals fed SF-2 compared to SF-0. However, no significant difference was found between SF-0 and SF-4 in this respect. Total CLA isomers of milk fat were significantly ($P < 0.05$) higher in SF-2 than in other treatments, since the values were 0.94, 3.80 and 0.60 g/100 g fat for, SF-0, SF-2 and SF-4 respectively. Therefore, CLA content of dairy camels milk could be increased by the addition of SFO at the level of 2% of DM of the diet with no adherent effect on nutrients digestibility and daily milk production.

Key words: Dairy camel; Sunflower oil, CLA.

Introduction

Conjugated linoleic acid (CLA) represents a mixture of positional and geometric isomers of octadecadienoic acid with conjugated double bonds. The CLA are effective as anticarcinogenic, antidiabetic, and antilipogenic agents in the diet of laboratory animals (Pariza et al., 2001). Milk fat-derived *cis*-9, *trans*-11 C18:2 prevented growth of human mammary cancer cells more effectively than did synthetic *trans*-10, *cis*-12 C18:2 (O'Shea et al., 2000). Ruminant meat and milk are the predominant natural sources of the *cis*-9, *trans*-11 CLA, that accounts for nearly 90% of total CLA in milk fat from cows fed typical diets (Bauman et al., 1999). The *cis*-9, *trans*-11 CLA can be formed as a result of incomplete biohydrogenation of dietary fatty acids and by desaturase action on *trans*-11 C18:1 (another intermediate of biohydrogenation) in the rumen. It can also arise from isomerization via *cis*-12, *trans*-11 isomerase produced by rumen bacteria (Kepler and Tove, 1967). In the bovine mammary gland (Bauman et al., 1999) or human tissues (Pariza et al., 2001), *trans*-11 C18:1 can be a source for endogenous synthesis of *cis*-9, *trans*-11 CLA via Δ 9-desaturase. The substantial variation in content of CLA in milk fat between herds suggests that diet has a major influence. Kelly et al., (1998) demonstrated that dietary supplementation of vegetable oils high in linoleic acid gave the greatest response, and there is a clear dose-dependent increase in milk fat content of CLA. Cruz-Hernandez et al. (2007) found that the addition of sunflower oil (i.e. 1.5%, 3.0% and 4.5% DM) to the diet in the percent of 0.5% of fish oil had no significant effect on milk production, and there was linear decrease in all short- and medium chain saturated fatty acids and a linear increase in total *trans*- 18:1 and total CLA.

Camel's milk is much more nutritious than that of cows. It is lower in fat and lactose and higher in potassium and its content of vitamin C is higher than that of cow's milk (Mehaia 1995; Farah 1993). Therefore, this study aimed to evaluate the effect of supplementing camels' diets with sunflower oil (SFO, that rich in unsaturated fatty acids) (UFA), on nutrients digestibility and fatty acid profile of milk in order to increase its nutritive quality for consumers.

Materials and Methods

Experimental location and diets. This study was carried out at the Agricultural Research Station, Qassim University. Basal diet was formulated by Arabian Agriculture Services Company (ARASCO)-Riyadh, Saudi Arabia. Basal diet contained 92.3%, 14.1%, 29.1%, 12.9% and 2.1%; organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and ether extract

(EE), respectively. Sunflower oil (SFO) was acquired from the local supermarket; it was added at levels of 0, 2 and 4% of DM for ground basal diet. Experimental diets were basal diet (SF-0) and basal diet with 2% SFO (SF-2) and basal diet with 4% SFO (SF-4).

Metabolism trial (Experiment 1). Three intact camel-claves (*Camelus dromedaries*) with body weight of 225 ± 11.3 kg, (mean \pm SD) were used, diets and periods were randomly assigned for each animal in a 3 x 3 Latin square design. Each animal was kept in an individual metabolic cage having a tray for quantitative collection of feces and urine. The initial 21 days were used for adapting the animals, and the collection period of samples was carried out during the subsequent 7 days. During the collection period, daily feed intake and feces were recorded. Samples of feed and feces were collected every morning. One fifth of the weight of each daily feces voided by each animal was dried at 60°C for 48 h, then was ground to pass through a 1 mm sieve and was preserved for chemical analysis.

In vitro rumen degradation of OM, NDF and ADF (Experiment 2). By the end of the metabolism trial, animals were slaughtered to obtain rumen contents to carry out an *in vitro* experiment. Rumen content of each camel was squeezed through four layers of cheesecloth into pre-warmed flasks to separate the liquid from solid fractions. An automatic incubator (Daisy^{II} incubator; ANKOM Technology, NY, USA) with 4-glass bottles was used for the *in vitro* study. To begin the *in vitro* experiment, each glass was filled with 360 mL of rumen fluid and 1440 mL artificial saliva (Hungate 1966) and was kept in an incubator adjusted at 39 °C. Twenty-four bags were used for each treatment (pore size of 45 μ m, Swiss Nylon Monofilament, Luzern- Switzerland). Six bags were incubated in each glass, then one bag was removed at intervals of 3, 6, 12, 24, 48 or 72h. Diets (i.e. SF-0, SF-2 and SF-4) were incubated with rumen fluid obtained from the animal fed the same diet. After the incubation, bags and residues were washed by running tap water until the water became clear, then they were squeezed gently. After washing, the bag contents were dried in an oven at 60 °C for 48h and reweighed. Residuals of OM, NDF and ADF were determined in each bag. Degradability coefficients were calculated by fitting the data for OM, NDF and ADF disappearance to model of Ørskov and McDonald (1979). as following:

$$P = a + b(1 - e^{-ct}),$$

where P is the cumulative amounts of OM, NDF and ADF degraded at time t , a is the readily degraded fraction, b is the fraction potentially degraded in the rumen, c is a rate constant of degradation of b and t is the incubation time in hours. Outflow rate was assumed to be 0.03 per h (AFRC 1993).

Feed intake and milk yield measurements (Experiment 3). Twelve multiparous she-camels (90 \pm 30 days postpartum; mean \pm SD) were used to determine feed intake and milk yield as influenced by different levels of SFO supplementation. Each female was housed with its calve in an individual pen. The duration of milking trial was 8 wks. One day before the end of each week of lactation, calves were separated in the evening

from their mothers and the mothers were machine milked for the remaining milk after calve suckling. Calves were kept near to their dames to stimulate milk secretion at both milking times (i.e. 06:00 and 18:00 h). On the last day of each week (milking and sampling day), does were totally machine milked in the morning and in the evening and milk yield was recorded and sampled for each female. Samples (100 mL from each) were divided into 2 equal subsamples, then 2 subsamples of 50 mL each (with and without potassium dichromate preservative) were stored for further analysis. Milk samples, with preservative, were kept at 4°C for further analysis. Milk samples without preservative were kept frozen at -20°C for fatty acids determination. Also, on the last day of each week of lactation trial diets were offered at 105% of the previous day's intake. The amount of feed offered and orts were recorded and sampled, then composited weekly according to treatment. Pooled samples of feed offered and orts were dried at 60°C for 48 h to determine dry matter intake.

Laboratory analysis. Dry matter (DM), organic matter (OM) and ether extract (EE) and nitrogen (N) of feed and feces samples were determined according to AOAC (1990), while neutral detergent fiber (NDF), acid detergent fiber (ADF) were determined as described by Van Soest et al., (1991). Milk fat, N and Lactose contents of milk were determined using LactoStar (Funke-Gerber, Berlin-Germany).

Fatty acids analysis. Fat was extracted from 5 mL of milk using mixture of chloroform and methanol (2:1, v/v) as described by Folch et al., (1957). Fatty acids of milk fat were transmethylated using sodium methoxid. Fatty acids methyl ester (**FAME**) were separated on a Shimadzu 2010A gas chromatograph equipped with a FID detector, and a fused silica capillary column of 100 m \times 0.25 mm i.d.; 0.2 μ m phase film (SP 2380; Supelco, Inc., Bellefonte, PA). The split ratio in the injector port was 50:1 with a linear velocity of 25 cm/sec of He. Oven temperature was programmed to 60 °C for 5 min, then increased from 60°C to 170°C at 3 °C/min, held at 170 °C for 10 min, ramped to 230 °C at 5 °C/min. then hold for 20 min. Injector and detector temperatures were 250 °C. Fatty acids of milk fat were identified by comparison of their retention times with standard mixture of FAME (Cat.# O5632, Sigma-Germany & Cat.# 4-7123, Supelco, Bellefonte, PA-USA).

Statistical analysis. Data for metabolism trial were analyzed as a 3X3 Latin square design using StatView for Windows (SAS 1999) according to the following model

$$Y_{ijk} = \mu + T_i + P_j + A_k + e_{ijk}$$

where Y_{ijk} = observation, μ = overall mean, T_i = treatment ($i = 1, 2$ and 3), P_j = period ($j = 1, 2$ and 3), A_k = animal ($k = 1, 2$ and 3) and e_{ijk} = residual error. Results of feed intake, milk yield and composition and fatty acid content of milk fat, and results of the *in vitro* experiment were analyzed according to the following model

$$Y_{ij} = \mu + T_i + e_{ij}$$

where Y_{ij} = observation, μ = overall mean, T_i = treatment ($i = 1, 2$ and 3), and e_{ij} = residual error. Tests of significance were performed using Tukey and Kramer test.

Results

Experimental diets contained similar concentrations of CP and metabolizable energy (ME). The EE was increased in linear manner as a result of oil supplementation and the values were 2.1, 4.1 and 6.2% for SF-0, SF-2 and SF-4 respectively.

Table 1: Effect of different levels of sunflower oil on dry matter intake and nutrients digestibility in she-camel (Exp.1)

	Levels of sunflower			SEM ²
	SF-0 ¹	SF-2	SF-4	
Dry matter intake (kg)	4.9 ^a	4.7 ^{ab}	4.2 ^b	0.17
Digestibility coefficient (%)				
DM	81.1 ^a	76.7 ^a	70.3 ^b	1.62
NDF	64.6 ^{ab}	66.5 ^a	58.6 ^b	2.51
ADF	57.9 ^a	59.2 ^a	49.2 ^b	2.34
N	73.4 ^{ab}	77.5 ^a	70.9 ^b	1.76

¹Diet + 0% sunflower oil (SF-0), Diet + 2 % sunflower oil (SF-2), Diet + 4 % sunflower oil (SF-4).

²SEM = standard error of the means.

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

In the digestibility trial (Exp.1), the addition of sunflower oil to the basal diet decreased dry matter intake for SF-2 ($P > 0.05$) and SF-4 ($P < 0.05$) than SF-0, and the reduction was 5% and 15% compared to SF-0 (Table 1). A non-significant negative effect was noticed for FS-2 on digestibility coefficient of DM. As for NDF and ADF the digestibility coefficient were not affected ($P > 0.05$) by the treatment compared to SF-0. On the contrary, SFO supplementation at the level of 4% (i.e. SF-4) significantly ($P < 0.05$) reduced the digestibility of DM, NDF and ADF than SF-0. Digested N was decreased ($P < 0.05$) for SF-4 compared to SF-2, while no significant differences were found between FS-2 and neither SF-4 or SF-0 (Table 1).

Table 2: In vitro, degradation kinetics of organic matter (OM), neutral detergent fiber (NDF) and acid detergent fiber (ADF) of diets supplemented with different levels of sunflower oil (Exp.2)

	Levels of sunflower oil			SEM
	SF-0 ¹	SF-2	SF-4	
OM				
<i>a</i> ²	26.4	25.9	24.6	1.65
<i>b</i> ²	56.3 ^a	54.3 ^{ab}	49.3 ^b	1.48
<i>c</i> ²	0.108 ^{ab}	0.119 ^a	0.094 ^b	0.007
NDF				
<i>b</i>	55.1 ^a	54.3 ^{ab}	47.6 ^b	2.36
<i>c</i>	0.062	0.059	0.052	0.006
ADF				
<i>b</i>	43.3 ^a	41.9 ^a	32.1 ^b	1.98
<i>c</i>	0.041 ^a	0.039 ^a	0.031 ^b	0.002

¹Basal diet + 0% sunflower oil (SF-0), basal diet + 2 % sunflower oil (SF-2), basal diet + 4 % sunflower oil (SF-4).

² *a*, *b* and *c* are constants predicted by the exponential equation as proposed by Ørskov and McDonald (1979).

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

Degradation parameters of OM, NDF and ADF in tested diets were presented in Table 2. The rapidly degradable fraction (*a*) of OM was not affected by the SFO supplementation. Ruminally degraded fraction (*b*) was decreased ($P > 0.05$) for SF-2 and SF-4 ($P < 0.05$) compared with the basal diet. Degradation rate (*c*, % per h) of OM in SF-0 was increased ($P > 0.05$) by 10% compared to SF-0, however, addition of SFO at the level of 4% of DM significantly ($P < 0.05$) reduced the *c* fraction compared with control (Table 2). The *b* fraction

of NDF was numerically decreased for SF-2, however, it was significantly ($P < 0.05$) lower at the level of 4% SFO than SF-0 (Table 2). A non-significant inhibitory effect after addition of SFO was noticed for *b* fraction and *c* of ADF when the SF-2 was incubated, and that effect was significant in SF-4.

Results of milk composition as affected by different levels of oil supplementation are presented in Table 3. Milk fat content was found to increase by 7% in SF-2 compared to basal diet (Table 3).

Table 3: Means of dry matter intake and milk yield and composition of dairy camels fed diets supplemented with different levels of sunflower oil (Exp.3)

	Levels of sunflower oil			SEM ²
	SF-0 ¹	SF-2	SF-4	
Chemical composition of milk				
Fat, %	1.98	2.12	2.01	0.09
Fat yield (g/d)	210	239	216	10.5
Protein, %	2.52	2.66	2.70	0.08
Lactose, %	4.65	4.92	5.04	0.12

¹Diet + 0% sunflower oil (SF-0), Diet + 2 % sunflower oil (SF-2), Diet + 4 % sunflower oil (SF-4).

²SEM = standard error of the means.

Means in the same row with different letters in their superscripts differ significantly ($P < 0.05$).

Higher milk yield (data are not presented) and fat content for SF-2 than SF-0 and SF-4 led to a higher fat yield by about 14% in FS-2 than the control diet. Contents of milk protein and lactose remained unchanged for all SFO levels (Table 3). Fatty acid concentrations (g/100 g FA) of milk fat were presented in Table 4. The provision of FS-2 and SF-4 to dairy camel had no significant effect on the concentrations of capric acid (C_{10:0}) and lauric acid (C_{12:0}) of milk fat. Myristic (C_{14:0}) and palmitic acids (C_{16:0}) contents of milk fat for animals fed added-oil diets (i.e., SF-2 and SF-4) were decreased ($P < 0.05$) compared with SF-0 (Table 4). Total short and medium chains FA (i.e. C_{10:0} to C_{16:0}) were reduced by 38% and 48% with SF-2 and SF-4 when compared with SF-0. An increasing response was observed in the concentration of C_{18:0} for SF-2 ($P > 0.05$) and SF-4 ($P < 0.05$) vs SF-0. Oleic acid was significantly increased ($P < 0.05$) and was relatively higher in response to level of SFO supplementation. The C_{18:2} content in milk fat did not differ due to SFO supplementation (Table 4).

A positive response was observed for the *cis*-9, *trans*-11 conjugated linolenic acid (CLA) content in milk fat, which significantly increased ($P < 0.05$) by about 5 folds in fat for animals fed SF-2 compared to SF-0. However, no significant difference was found between SF-0 and SF-4. Similar response was found for *cis*-10, *trans*-12 CLA contents in milk fat of animals fed SF-2 and the increment was significantly higher than SF-0. Total CLA isomers of milk fat were significantly ($P < 0.05$) higher in FS-2 than other treatments, since the values were 0.94, 3.80 and 0.60 g/100 g fat for, SF-0, SF-2 and SF-4 respectively. The ratio between saturated fatty acids to unsaturated fatty acids (SFA/USFA) of milk fat was decreased, which reflect the significant reduction of SFA in fat as a result of added SFO to the diet. Meanwhile, the sum of USFA was increased significantly for SF-2 and SF-4 compared to SF-0, and the values were 40.3, 48.8 and 49.1 mg/ 100 g fatty acids of milk fat for SF-0, SF-2 and SF-4 respectively (Table 4).

Table 4: Fatty acid concentrations in milk fat of dairy camels fed diets supplemented with different levels of sunflower oil

	Levels of sunflower oil			
	SF-0 ¹	SF-2	SF-4	S.E.M. ³
Fatty acid (FA, g/100g) of total methyl esters				
Capric (10:0)	0.21	0.23	0.19	0.03
Lauric (12:0)	0.22	0.21	0.21	0.02
Myristic (14:0)	9.5 ^a	6.3 ^b	6.1 ^b	0.18
Palmitic (16:0)	16.5 ^a	9.7 ^b	7.2 ^c	0.53
Stearic (18:0)	33.3 ^b	34.8 ^{ab}	37.3 ^a	0.92
Oleic (18:1)	36.1 ^b	38.2 ^b	43.7 ^a	1.52
Linoleic (18:2)	2.3	2.85	3.3	0.51
CLA ^{18:2 cis-9, trans-11} ²	0.51 ^b	2.53 ^a	0.32 ^b	0.15
CLA ^{18:2 cis-10, trans-12}	0.43 ^b	1.27 ^a	0.28 ^b	0.10
Total CLA	0.94 ^b	3.80 ^a	0.60 ^b	0.20
Categories of fatty acids (g/ 100 g FA)				
Saturated FA (SFA)	59.7 ^a	51.2 ^b	51.0 ^b	1.41
Unsaturated FA (USFA)	40.3 ^b	48.8 ^a	49.1 ^a	1.44
SFA/USFA	1.48 ^a	1.05 ^b	1.03 ^b	0.08

¹Basal diet + 0% sunflower oil (SF-0), Basal diet + 2 % sunflower oil (SF-2), Basal diet + 4 % sunflower oil (SF-4).

²CLA = Conjugated linoleic acid

³ S.E.M. = standard error of the means.

^{a,b,c} Means in the same row with different letters in their superscripts differ significant ($P < 0.05$).

Discussion

Diets were formulated on the basis of chemical analysis of initial samples of ingredients; consequently, we anticipated that keeping the forage to concentrate ratio and energy the same between diets. However, NDF actually fed throughout the experiment for SF-2 and SF-4 were greater by about 1.3 and 3.6 units than SF-0, respectively.

Low digestibility of DM in the SF-2 and SF-4 (Table 1) could partially explain the linear reduction of DM intake that might be due to decreasing turnover of the digesta to post-ruminal tract. Sekine et al. (2003) reported that the capacity of the rumen to accommodate the bulky food is one of limiting factors for DM intake. In contrary to these results, several researchers found no adverse effects of supplemental fat on DM intake of ewes (Zhang et al., 2007), dairy cows fed canola seed (Khorasani et al., 1991), sunflower seed (Markus et al., 1996) or flaxseed (Mustafa et al., 2003). However, feeding supplemental fat in the form of oilseeds is expected to have less detrimental effects on DMI than if similar amount was added as free oil (Kennely, 1996).

The high NDF content in SF-4 (about 12% higher than SF-0) and high oil supplementation can attribute to low digestibility of NDF and ADF; and subsequently DM digestibility. This finding is confirmed by the results of degradation kinetics of OM, NDF and ADF (Table 2). Veira et al., (2001) found that the ruminal DM and NDF degradability of alfalfa hay were reduced by over 20% when soybean oil added at the level of 3% to the ration of dairy cows.

The reduction of OM ruminally degraded was associated with a marked depression in NDF and ADF degraded in the *in vitro* study (Exp.2) for SF-4 and the values were lower than SF-0 by 14% and 26%, respectively. Results of the current study are in agreement with those of Ikwuegbu and Sutton (1982), they reported that the inclusion of free oil in the diet of sheep reduced digestion of energy and OM in the rumen in a linear manner with increasing oil level added. Reduction of ruminally degradable *b* fraction

of OM, NDF and ADF with diet SF-4 could be due to the adversary effect of oil supplement on rumen fermentation and fiber digestion. Disruption of ruminal digestion by addition of fat to the diet has been documented (Palmquist and Jenkins 1980; Zinn 1989) and is more pronounced when polyunsaturated fatty acids (PUFA) are fed relative to saturated fatty acids (Ferlay et al., 1991).

As for the non-significant effect of SF-2 on the ruminal *b* fraction of OM, NDF and ADF; and total tract digestibility of nutrients, it could be due to low level of supplemental oil added and its effect on ruminal fermentation. These results are consistent with Dutta et al. (2008) who found that diet supplemented with low level of palm oil (2.5% of DM) had no effect on digestibility of DM, OM and crude fiber, while, increasing supplemental oil to the diet had reduced those parameters.

Apparent digestibility of nitrogen was not affected at the low level of supplemental SFO (SF-2), however it was 5.5% higher than the SF-0 (Table 1). Animals fed diet with 4% SFO showed a significant ($P < 0.05$) reduction in N digestibility. The lower digested N found in the current study could be due to the negative effect of fat on activities of rumen microorganisms, and subsequently the constant digestion rate of ruminal undegraded N in the small intestine would lead to increasing fecal N and reducing the total tract digestibility of N.

Supplementing camel diets with SFO had no significant effect on milk fat contents (%), while; SF-2 had higher fat content by about 8% and 14% compared to SF-0, SF-4 respectively. Fat supplementation in animal diets affects milk fat percentage and composition by different mechanisms. First, fat feeding may have negative effects on rumen fiber digestion, thus decreasing acetic and butyric acid production thus affecting the *de novo* fat synthesis in mammary gland (Griinari et al., 1998). Second, when fat is included in the ration the uptake and direct incorporation of long-chain fatty acids into triglycerides by mammary gland are increased (Palmquist and Jenkins, 1980). Therefore, milk fat content will respond to the balance between a fatty acid uptake and secretion by the mammary gland, resulting in a decrease in *de novo* synthesis.

Milk protein concentration in dairy camels was found not to be affected by the level of supplemental oil. Whitlock et al. (2003) showed no difference in protein concentration or yield when cows were fed either conventional corn (CC) or high oil corn (HOC). This is in contrast to Weiss and Wyatt (2000), who observed a decrease in milk protein concentration when cows were fed HOC silage compared with CC silage.

Overall, treatments have a negative effect in milk fatty acids having 16 or fewer carbons (Table 4). When supplemental fats are fed, the relative concentration of short-chain and medium-chain fatty acids decreased and that of long chain fatty acids increased because of *de novo* fatty acids synthesis and esterification in mammary tissue is reduced (Palmquist and Jenkins, 1980). It is interesting to notice that the concentration of C16:0 in milk fat for camels fed SF-0 was found to be 16.5 g/100 g fatty acids. However, palmitic acids comprised about 31.1g/ 100g fatty acids of milk fat for cows with the range of 25.5-46.1 g/ 100g fatty acids of milk fat (Murphy et al., 2008; Cruz-Hernandez et al.,

2007; AbuGhazaleh, 2008). Ney (1991) reported that the reduce of medium-chain fatty acids may represent an improvement in the profile of milk fat fatty acids as these fatty acids have been reported to constitute the hypercholesterolemic portion of milk fat.

Increases in the concentration of milk stearic acid with the added-oil diet (Table 4) can be attributed to the complete ruminal biohydrogenation of some mono- and polyunsaturated fatty acids supplied by the SFO in the diet.

The main objective of this study was to examine the effect of different levels of SFO supplementation to camel diets on milk *cis-9, trans-11* CLA. In the current study, the concentrations of *cis-9, trans-11* CLA and total CLA were increased by about 5 and 4 fold for dairy camels fed SF-2 compared with that fed the control diet respectively. Previous work has suggested that the biohydrogenation sequence of linoleic acid can lead to an increase in CLA levels in milk fat (McGuire et al., 1996). As for the effect of SFO on concentrations of *cis-9, trans-11* CLA and total CLA in milk fat of camels fed SF-4, it was lower ($P > 0.05$) than SF-0 and SF-2 ($P < 0.05$). This finding is in agreement with that of Gervais et al., (2005) who found a significant reduction in *cis-9, trans-11* CLA content of milk fat when dairy cows received gradual levels of a rumen-inert conjugated linoleic acid supplementation. Also, Onetti et al., (2001) reported a decline in *cis-9, trans-11* CLA content of milk fat when tallow was increased from 2% to 4% of DM as a supplemental fat.

The content of PUFA of milk fat of camels fed the basal diet was 40.3g/ 100g of fatty acids; this value was relatively similar to those of Najdi camel (45.3%) as reported by Sawaya et al., (1984) and that of Abu-Lehia (1989) that was 43.1% of total fatty acids in camels milk fat.

Implications

It can be concluded that adding SFO at 4% of DM would negatively affect nutrients digestibility. However, CLA content of camel milk would be increased by the addition of SFO at the level of 2% of DM with no adherent effects on nutrients digestibility and daily milk production.

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