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Effects of varying levels of protected fat on performance of Shami goats during early and mid lactation

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Abstract: This study was conducted to determine the responses of early lactating Shami goats to varying amounts of dietary supplementation of Ca salts of fatty acids. Shami goats (n = 75) in their first week of lactation were randomly assigned to 3 isonitrogenous dietary (TMR) treatments containing 0%, 3%, or 5% added Ca salt. The study took 60 days during which the following variables were measured: milk production and composition, body weight, feed intake, serum cholesterol and triglyceride, kids weaning weight, and milk fatty acids. Milk production and energy corrected milk were higher (P< 0.05) at 5% level. Percentages of milk composition were higher (P <0.05) at 3% with CP% not different from 5%. No differences were observed in yields of different milk components including casein, final body weights, feed intake, or weaning weights of kids. Intake of metabolizable energy was higher (P < 0.05) at 5% level of Ca salts. Differences in milk fatty acids were mainly restricted to unsaturated ones with no effect on the saturated fatty acids. Such results suggest that milk production and content of lactating Shami goat can be changed by a level of 5% of Ca salts.

Key words: Shami goat, Ca salts, lactation, fatty acid profile

Introduction

The world production of goat milk seems relatively minor compared to that of cows; however, goat milk today is considered to have certain nutritional advantages over cow milk. It differs from that of cow in respect to fatty acids (FA) content, particularly medium chain FA. Goat milk has been identified as an alternative for infants and adults who are either sensitive or allergic to cow milk (1). Furthermore, goat milk content and composition can be extensively modified by genetic and physiological factors as well as by nutritional factors, among which is dietary fat supplementation (2).

Dietary fat has been considerably used with dairy cows in order to include different sources at different levels. Findings of these studies demonstrate that fat supplementation to early lactating diets can increase energy density and increase milk production without necessitating an increased level of concentrate (3,4). Recently, fats have been added to ruminant diets with the intention of changing the fatty acid profile of milk to better suits human dietary concern (1,5,6). Also, fat supplementation could improve goat milk composition for better control of processing and satisfaction of consumers' demand (2,7).

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Rumen-protected fat or fat salts in the diets of lactating ruminants have been widely tested in many experiments. Feeding trials with dairy cows resulted in increased milk and 3.5% FCM but did not always influence milk yield of goats (8). Supplemental fat sources have increased milk yield and fat concentration as well as milk fatty acid composition of dairy goats (3,6,8).

Shami goats or Damascus goats are considered to be the most predominant and important breed in the Middle East countries. Although there has been research with added fat dietary fat for other dairy goats, there is a variety of commercial fat products presently available and utilized with different levels. Brown-Crowder et al. (3) reported that fat source has an impact besides the effect of fat level and stage of lactation. Therefore, the objective of this experiment was to determine the effects of dietary level of Ca salts of fatty acids on the performance of Shami goat in early and mid lactation.

Materials and methods

Seventy five multiparous Shami goats with body weight range between 47 and 58 kg and age range of 3-4 years were used. Goats were randomly assigned into 1 of 3 dietary treatments with 25 does each in a completely randomized design. Age, body weight, and parity were considered in randomization. Females were fed 1 of 3 total mixed rations (TMR) with 0%, 3%, or 5% of dry fat (Feedaren, The Modern Establishment for Fats and Glycerin Manufacture, Amman, Jordan). The experimental diets were formulated to be approximately isonitrogenous but not isocaloric. The percents of ingredients composition and chemical analysis of the experimental diets are presented in Table 1. Chemical composition and fatty acid profile of the Ca salt fat used are presented in Table 2. Goats were fed at a level of 1.5 kg (DM) per head per day and with free access to alfalfa hay. The amount of hay consumption was measured individually. Clean water was provided ad libitum throughout the trial period.

Table 1. Ingredient composition and chemical analysis of the experimental diets*.

	Diets		
Ingredients	**0% fat**	**3% fat**	**5% fat**
Barley	52.00	52.00	52.00
Soybean meal	18.00	18.00	18.00
Alfalfa hay	10.00	10.00	10.00
Straw	13.00	10.00	8.00
Wheat bran	5.00	5.00	5.00
Dry fat	0	3.00	5.00
Di-calcium phosphate	1.00	1.00	1.00
Salt	0.40	0.40	0.40
Limestone	0.50	0.50	0.50
Minerals and vitamins**	0.10	0.10	0.10
Chemical composition			
Dry matter (%)	94.29	94.39	94.30
Crude protein (%)	16.07	16.20	16.32
Ether extract (%)	1.25	3.35	4.45
Crude fiber (%)	14.38	14.81	14.23
NDF (%)	30.42	29.67	23.89
ADF (%)	13.09	12.25	12.22
Ash (%)	7.50	7.91	12.4
ME (MJ/kg)	10.21	10.99	11.50

* All results are expressed based on dry matter basis.

** Each 1 gram contains 1500 I.U. Vitamin A; 150 I.U. Vitamin D3; 2 mg Vitamin E 50%; 300 µg Vitamin B1; 300 µg Vitamin B2; 300 µg Vitamin B6; 300 µg Vitamin K3 50%; 218 µg, 435 µg, 15.5 µg, 138.5 µg 2.2 µg KI, 0.9 µg , 0.43 µg , reach 1 g CaCO3.

Table 2. Chemical and fatty acid composition of Ca salts used in the experiment.

Chemical Composition	%
Dry matter	96.7
Ether extract	89.8
Ca	9.2
Fatty acid	
C12:0	9.07
C14:0	5.32
C16:0	22.17
C18:0	3.32
C18:1	12.24
C18:2	21.90
C18:3	7.18
C20:1	8.04
C22:1	6.77
C24:0	4.00

Females were kept under the experimental protocol exactly after kidding up to 60 days post kidding. Animals were maintained at ambient temperature and natural day length in covered loose pens with adjacent open yards. Rations were mixed twice-weekly and daily and allowances were offered for all animals once at 0700. Diets were sampled upon mixing for chemical analysis and kept at 4 °C until analysis. Feed samples were ground by a Wiley mill through a 1-mm screen and analyzed for dry matter (DM), ash, crude protein (CP), crude fiber (CF), and ether extract (9). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed according to Van Soest et al. (10). All analyses were conducted in duplicates.

Milk production was measured once weekly in all females using double oxytocin injection and hand milking procedure. Does received 2 intravenous injections of 2 mL oxytocin each (Oxytocin, Alfasan, Worden, Holland) with 4 h intervals and milk production was evaluated using a graduated cylinder. Amount of milk obtained was adjusted for 24 h and weekly basis. Kids were left with their dams for the whole experimental duration and were not fed creep ration. Energy corrected milk (kg/day) was estimated as: 0.3246 * milk yield + (12.86 * fat yield) + (7.04 * protein yield). Milk energy value (Kcal/kg) was calculated according to Baldi et al. (8) as 203.8 + (8.36 * fat%) + (6.29 * CP%).

An individual milk sample was taken weekly for composition analysis from each dam and samples were analyzed for composition of crude protein (Kjeldahl), fat (Gerber), and TS (11). Protein values were determined by multiplying the nitrogen results by 6.38. Casein was determined according to the AOAC procedure (9). For milk FA analysis, fat was separated, transesterified into fatty acid methyl esters by methylation at room temperature with NaOH (2 M) in methanol, and analyzed by gas chromatography using a Shimadzu 2010 equipped with flame ionization detector. The GC conditions were as follows: a Supelcowaxs-10 fused silica capillary column (60 m × 0.75 mm i.d, phase thickness 1.0 mm; Supelco Inc., Bellefonte, PA, USA). The carrier gas was nitrogen. Initial oven temperature was programmed from 60 to 70 °C at 2 °C/min, and from 70 to 230 °C at 20 °C/min. Injector and detector temperatures were 250 °C and nitrogen flow rate was 1.2 mL/min (6).

On the day of milk sampling, blood samples were also taken individually from the jugular vein into EDTA tubes for cholesterol and triglycerides analysis. Blood samples were serum aspirated, and stored at -30 °C until assayed for cholesterol and triglycerides using a biochemical analyzer established procedures (8). Body weight of each dam was taken once at kidding and once at the end of the experiment, 60 days after kidding. Birth weight of kids and weaning weight on day 60 were also recorded.

Data were analyzed using the general linear model procedure of SAS (12). Least squares means analysis of variance was utilized to compare means (13). Effects of treatment and animal (replicate) on different variables were tested in a repeated measure design. Furthermore, initial body weights of dams and birth weights of kids were used as a covariate for correction during analysis.

Results

Milk production (kg/day) was highest ($P < 0.05$) in dams fed the 5% Ca salt supplemented diets (Table 3) with no effect of the 3% level. In the same manner, energy corrected milk was maximum for the 5% Ca

Table 3. Milk production and milk composition of Shami goat fed different level of Ca salt in their ration.

	0%	3%	5%	SE	P value
Milk production (Kg/day)	1.86[b]	2.01[b]	2.27[a]	0.19	0.02
Energy corrected milk (Kg/day)[1]	2.32[b]	3.05[ab]	3.25[a]	0.29	0.06
Fat					
%	6.44[b]	7.25[a]	6.75[b]	0.25	0.10
g/day	111.06[b]	149.50[b]	157.46[a]	15.50	0.04
Protein					
%	2.96[b]	3.30[a]	3.22[a]	0.13	0.02
g/day	55.73[b]	56.30[a]	65.06[a]	4.76	0.02
Total solids %	13.70[b]	14.54[a]	13.76[b]	0.38	0.03
Casein (% of protein)	81.60	83.50	84.00	1.32	0.45
Milk Energy value (kcal/kg)[2]	276.32[b]	285.17[a]	280.27[b]	2.77	0.04

[a, b] Means with different superscripts within the same raw are different ($P < 0.05$).
[1] ECM = 0.3246 * milk yield + (12.86 * fat yield) + (7.04 * protein yield).
[2] MEV = 203.8 + (8.36 * fat %) + (6.29 * CP %).

salt fed goats with no differences between the 2 dietary treatments or between the 3% Ca salt supplemented group and the control group.

Milk fat (%) was higher ($P < 0.05$) in milk from the 3% supplemented group goats with no differences between goats fed the 5% supplemented diet and the control group (Table 3). Meanwhile, fat yield (g/day) was maximum ($P < 0.05$) in milk from goats fed the 5% supplemented diet with no effect of the 3% supplementation level. Percentage of milk protein content was higher ($P< 0.05$) for the milk from the supplemented groups compared to that for the control goats with no differences due to Ca salt level in the diet. The same was true for the yield of protein content expressed as g/day. Like that of fat, total solids content (%) of milk was higher ($P < 0.05$) for milk from goats fed the 3% group, with no effect of the 5% supplemented diet.

Concentration of casein, as a percentage of protein content, was not affected by the dietary treatment (Table 3). In the same table, milk energy value for the treated does was increased ($P < 0.05$) in the 3% Ca salt supplemented group with no effect of the 5% level (Table 3).

Final body weight and feed intake (hay and concentrate) were not affected by dietary treatment (Table 4). Intake of metabolizable energy was increased ($P < 0.05$) with increased Ca salts level in the diet. On the other hand, feed to milk ratio, expressed as kg dry matter intake per kg of daily milk production, was lower ($P < 0.05$) for the 5% group with no differences between the 3% supplemented and the unsupplemented groups. No differences were also reported in weaning weights or blood plasma metabolites (cholesterol and triglycerides) with different levels of Ca salts in the diet (Table 4).

Intake from the TMR was not affected by Ca salts supplementation due to limitation of intake among groups (Table 4). Likewise, ad libitum intake of alfalfa hay was not affected by Ca salts inclusion.

Table 5 presents the composition of milk fatty acids. In comparison with the control, different levels of Ca salts supplementation did not change production of any of the short chain (C2-C10) and medium chain (C12-C14) fatty acids except for the C14:1, which was increased ($P < 0.05$) compared to the control and with no differences between the supplemented groups. As for the long chain fatty acids (C16-C22), the 3% supplemented diet increased ($P < 0.05$) the production of the C16:0 fatty acid with no difference between the 5% supplemented and the unsupplemented goats. C18:2 was increased compared to the control and without any difference between the 3% and 5% groups. The 5% Ca salt supplementation increased ($P < 0.05$) production of the C18:3 fatty acid compared to the control, while the 3% supplementation decreased ($P < 0.05$) it. Likewise, goats fed the 5% Ca salt diet had higher ($P < 0.05$)

Table 4. Body weights and blood metabolites of Shami goat fed different level of Ca salt in their ration.

	0%	3%	5%	SE	P value
No of goats	25	25	25		
Initial weight (kg)	49.70	50.30	49.0	2.6	
Final weight (kg)	51.8	53.1	53.80	3.1	0.85
Feed Intake (kg DM)	2.45	2.48	2.53	0.05	0.76
Ration	1.5	1.5	1.5		
Hay	0.95	0.98	1.03	0.05	0.61
ME intake (MJ/day)	23.38^{b}	24.81^{ab}	26.00^{a}	0.98	0.04
Feed: Milk[1]	1.32^{a}	1.23^{a}	1.11^{b}	0.06	0.04
Weaning weight (kg)	15.00	13.40	13.44	0.84	0.80
Single	15.74	13.49	13.83	1.50	0.85
Twin	14.28	13.23	13.05	0.61	0.85
Male	15.75	12.83	13.25	1.10	0.30
Female	14.26	13.90	13.63	1.00	0.30
Cholesterol (mmol/L)	2.10	2.19	2.28	0.30	0.51
Triglyceride (mmol/L)	0.33	0.37	0.41	0.09	0.33

$^{a, b}$ Means with different superscripts within the same raw are different ($P < 0.05$).
[1]Feed: Milk: Dry matter intake: daily milk production, kg/kg.

Table 5. Fatty acid composition (% of total) of milk fat from Shami goat fed different level of Ca salt in their ration.

	0%	3%	5%	SE	P value
C4:0	2.92	2.94	3.06	0.12	0.54
C6:0	3.32	3.44	3.46	0.15	0.32
C8:0	3.86	3.82	3.86	0.19	0.61
C10:0	10.96	10.72	10.40	0.36	0.29
C12:0	4.34	4.32	4.16	0.53	0.46
C14:0	10.20	10.22	10.26	0.48	0.15
C14:1	0.34^{b}	0.42^{a}	0.46^{a}	0.03	0.02
C16:0	25.62^{b}	26.76^{a}	25.00^{b}	0.52	0.04
C16:1	2.25	2.00	2.20	0.24	0.17
C18:0	6.20	5.96	6.10	0.48	0.34
C18:1	23.54	22.88	23.60	1.20	0.30
C18:2	2.32^{b}	3.63^{a}	4.22^{a}	0.40	0.03
C18:3	1.26^{b}	1.00^{c}	1.32^{a}	0.03	0.03
C20:0	0.20^{b}	0.20^{b}	0.24^{a}	0.02	0.04
C20:2	0.28	0.32	0.30	0.03	0.54
C20:3+4+5	0.94	0.92	0.96	0.04	0.62
C22:0	0.24^{a}	0.20^{b}	0.18^{b}	0.02	0.02
Total Saturated	67.86	68.58	66.72	3.90	0.84

$^{a, b}$ Means with different superscripts within the same raw are different ($P < 0.05$).

C20:0 with no difference between the control and the 3% group. However, Ca salts supplementation decreased ($P< 0.05$) the production of C22:0 compared to the control. No differences were observed for other fatty acids or for the composition of the total saturated fatty acids.

Discussion

Milk production of early lactating goats was increased by dietary addition of 3% Ca salt but linearly decreased with fat level of 6% and 9% (14), or not influenced by dietary fat treatments (1,4,5,8). Factors responsible for this difference between experiments involved fat source, FA composition of Ca salts, and dietary concentrate level (3; 15).

Sampelayo et al. (6) stated that when the ruminant diet is supplemented with a protected fat, the first effect that would normally occur is an increase in milk production. In their review, Chilliard et al. (7) stated that in early lactation, lipid supplementation tended to increase milk production of treated goat. The same was also reported for dairy cows (16). The effect has been closely related to a higher intake of net energy as observed in the 5% group (5). Rumen protected fat as Ca salt is efficiently digested and available for direct use by mammary gland, hence, increasing milk production (14). In addition, when ruminants are supplemented with fat, a greater efficiency is achieved in the use of metabolizable energy for milk production (6).

In goats, the energy balance of the animal is considered to be the most important factor determining milk composition (5). Fat supplementation to lactating goats sharply increased milk fat % and had a variable effect on protein content (7). The significantly higher milk fat % for the 3% group would mostly be a result of lower milk yield produced by this group, which increased the fat content. Higher fat content values of the treated groups in this study, even when not significantly different, is a reflection of net increase in fatty acid brought to the mammary gland due to the inclusion of fat source in the diet of these groups (1,3). Increased milk fat content of Ca salt treated does have been reported earlier (4,8). In the present case, the increased fat content only in the 3% group does not agree with Brown-Crowder et al. (3) and Teh et al. (14), who observed a linear increase in milk fat concentration with increased Ca salt level, and Andrade and Schmidely (17), who observed no response of milk fat % to dietary fat supplementation.

Again, results with fat supplementation to early lactating goats recorded variable effect on protein content (7). Opposite to our results, several studies reported no effect of different fat supplements on protein content (%) of early lactating goats (1,4,5,8,14,17), or dairy cows (15,18). Meanwhile, a review by Chilliard et al. (16) showed a negative effect of lipid supplementation on protein content in dairy cows.

Milk protein concentration, in general, appears less prone to fat induced depression in dairy goat versus cows (3). Changes in milk protein content as a result of fat addition to diets of dairy cows are largely associated with the casein fraction (5). In the same study, it was revealed that improvements in certain characteristics of milk obtained from goats fed fat supplemented diet should be considered in light of higher casein content of the milk. In this study, casein content was not affected by the level of fat addition. In addition, it is not feasible to discuss the results concerning casein because this aspect of fat source addition to the diet of lactating goat on casein content has not been extensively studied. To the best of our knowledge, only Sampelayo et al. (5) reported similar results of no effect of different fat levels on total casein proportion of goat milk. Brown-Crowder et al. (3) deduced excessive ruminally available N of early lactating does supplemented with fat. As has been mentioned, the energy balance of goats is considered to be the most important factor determining milk composition. It could be that increased protein content observed with treated groups in the present experiment is due to improved energy balance in goats of these groups and/or increased availability of rumen N, which, in turn, enhanced synthesis of protein in the mammary gland.

Changes in total solids content reflected changes in fat content (15). Higher total solid content for the milk of the 3% fat group is due to significantly higher fat percent of milk from this group (6).

To the best of our knowledge, there is no literature concerning the effect of fat supplementation on ECM of goats to compare our results with. However, energy corrected milk (ECM) is a correction of milk yield for its composition of fat and protein (Table 3). Therefore, lower value for the 3% group is mainly due to lower milk production by this group.

Milk energy value of does fed Ca salt fat was also increased (8). Likewise, Rapetti et al. (4) reported that the milk energy output of lactating goats was

increased by the addition of fat. This higher milk energy value observed in the present case for the 3% supplemented group is due to increased energy components, mainly fat and protein, in milk of this group. It was proposed that the increased energy intake in the form of fat brought about an increase in milk fat and energy production (5).

Although differences in the final body weight were not significant, it increased with increased supplemented fat in the diet. In ruminants, milk production is fundamentally determined by energy balance in the animal. The improved milk production observed in this study reveals that the supplementation gives rise to positive energy balance. Nevertheless, significant changes were not observed in the final body weight of the experimental goats after 60 days might be because of their poor ability to develop subcutaneous fat (6). However, Brown-Crowder et al. (3) reported similar results with elevated fat supplementation, while opposite results were reported by Baldi et al. (8) and Teh et al. (14).

Different forms of protected fat, in agreement with our results, had no effect on feed intake by lactating goats (3,4,5,14). Working with dairy cattle, Chouinard et al. (15) revealed that lacking of effect on feed intake was likely due to the absence of ruminal disturbances. Moreover, similar intake among groups indicated no palatability problems attributed to fat supplementation as mentioned by Sampelayo et al. (5). Metabolizable energy intake was higher for the 5% supplemented group due to higher ME concentration of the TMR fed to that group.

As mentioned earlier, supplementation of ruminant diets with a fat source will result in greater efficiency for milk production. The significantly lower feed:milk ratio observed with goats in the 5% group is associated with higher milk production by this group and reflects better efficiency of conversion of feed DM into milk. However, the lack of differences in efficiency of conversion of feed to milk between the control and 3% supplemented group is similar to what observed by Brown-Crowder et al. (3) and Teh et al. (14) fed Ca salts to lactating goats.

The lack of significant variation of serum cholesterol and triglycerides is in accordance with the opinion indicated that lactating goats were not influenced by diets differing in type and level of fat (2). This is not consistent with the results obtained by others where the effect of Ca salts on these parameters was investigated (4).

Milk fatty acid composition is linked to intrinsic (breed, genotype, and lactation) or extrinsic factors (19). Nutrition, therefore, constitute a natural way to modulate milk fatty acid composition (16). The amount and type of dietary fat are more important than any other dietary component (1,2). Bernard et al. (2) reported that feeding protected fat to goats increased milk fatty acids proportionally to their percentage in the lipid supplement.

Milk fat represents the combined effects of de novo synthesis and the uptake of fatty acids, and the decrease in the intramammary synthesis is due to depression of ruminal activity. As results obtained here showed no effect up to C14 fatty acids, ruminal activity was not affected by the level of fat addition (5). Mir et al. (1) reported that feeding Ca salts of fatty acids have partly circumvented the adverse effects of fats on rumen fermentation and digestibility. Moreover, Chilliard and Ferly (19) in their review reported that concentrations of short chain fatty acids (C4, C6, and C8) are unchanged by dietary supplementation.

In the mammary gland of ruminants, monounsaturated fatty acids increase either from direct uptake or from desaturation of saturated fatty acids via Δ^9 *desaturaese* enzyme, and C14:0, C16:0, C18:0 fatty acids are substrates for this enzyme in the mammary gland (7,17). Higher proportions of C14:1 might be a consequence of this mechanism.

The importance of changing fatty acid composition of milk from goats to human health is through its effects on specific saturated and unsaturated fatty acids. Saturated fatty acids of C12, C14, and C16 are considered to be cholesterol rising (14). Proportions of these fatty acids were not or slightly affected by different levels of Ca salts, which might explain the lack of difference observed in cholesterol values (Table 4).

Changes accompanied by C18:1, C18:2, and C18:3 are mainly due to their high proportions in the supplemented Ca salt. A similar conclusion was reported by Bernard et al. (2). However, saturated fatty acids of C16 and C18 had little effect on milk fatty acid profile (18). In the present study, the higher proportions of both C18:2 and C18:3 are responsible

for the lack of differences in C18:0 and C18:1. Chouinard et al. (15) and Chilliard and Ferly (19) indicate that C18:3 is often hydrogenated into C18:0 while hydrogenation of C18:2 gives rise to different isomers of C18:1. Moreover, high doses of C18:2 fatty acid fed to dairy cows were responsible for reducing the Δ^9 *desaturaese* responsible for the formation of monosaturated fatty acids (17). High levels of C18:2 in the Ca salt utilized in the present case could be responsible for the lack of difference in the monosaturated C18:1 fatty acid.

Furthermore, goat milk is considered to have certain nutritional advantages over cow milk. The significant increase in the total production of PUFA (C18:2 and C18:3) have been associated with a decrease in the risk of heart disease (5).

It is possible to conclude that the addition of Ca salts to the diets of lactating dairy goats in early lactation at the level of 3% has limited effect on milk production but improve the percentages of fat, protein, and total solids. Meanwhile, a level of 5% increases milk production. Both levels have limited effect on the final body weight, feed intake, kids weaning weight, or blood levels of cholesterol and triglycerides. Supplementation with Ca salts can modify milk fat properties for better nutritional means.

References

1. Mir, Z., Goonewardene, L. A., Okine, E., Jaegar, S., Scheer, H. D.: Effect of Feeding Canola Oil on Constituents, Conjugated Linoleic Acid (CLA) and Long Chain Fatty Acid in Goat Milk. Small. Rumin. Res., 1999; 33:137-143.
2. Bernard, L., Rouel, J., Leroux, C., Ferlay, A., Faulconnier, Y., Legrand, P., Chilliard, Y.: Mammary Lipid Metabolism and Milk Fatty Acid Secretion in Alpine Goats Fed Vegetable Lipids. J. Dairy. Sic., 2005; 88:1478-1489.
3. Brown-Crowder, E. I., Hart, S. P., Cameron, M., Sahlu, T., Goetsch, A. L.: Effects of Dietary Tallow Level on Performance of Alpine Does in Early Lactation. Small. Rumin. Res., 2001; 39:233-241.
4. Rapetti, L., Crovetto G. M., Galassi G., Sandrucci A., Succi, G., Tamburini, A., Battelli, G.: Effect of Maize, Rumen-Protected Fat and Whey Permeate on Energy Utilization and Milk Fat Composition in Lactating Goats. Ital. J. Anim. Sci., 2002; 1:43-53.
5. Sampelayo, M. R. S., Perez, L., Martin Alenso, J. J., Amigo, L., and Boza, J.: Effects of Concentrates with Different Contents of Protected Fat Rich in PUFAs on the Performance of Lactating Granadina Goats. Small. Rumin. Res., 2002; 43:141-148.
6. Sampelayo, M. R. S., Alonso, J. J. M., Perez, L., Extremera,F. G., Boza, J.: Dietary Supplements for Lactating Goats by Polyunsaturated Fatty Acid-Rich Protected Fat. Effects after Supplement Withdrawal. J. Dairy. Sci., 2004; 87:1796-1802.
7. Chilliard, Y., Ferlay, A., Rouel, J., Lamberet, G.: A Review of Nutrition and Physiological Factor Affecting Goat Milk Lipid Synthesis and Lipolysis. J. Dairy. Sci., 2003; 86:1751-1770.
8. Baldi, A., Cheli, F., Corino, C., Dell'Orto, V., Polidroi, F.: Effects of Feeding Calcium Salts of Long Chain Fatty Acids on Milk Yield, Milk Composition and Plasma Parameters of Lactating Goats. Small. Rumin. Res., 1992; 6:303-310.
9. AOAC.: In Official methods of analysis. 16th ed. Association of Official Analytical Chemists. Gaithersburg, MD, USA. 1997.
10. Van Soest, P.J., Robertson, J.B., Lewis, B.A.: Methods for Dietary Fiber, and Nonstarch Polysaccharides in Relation to Animal Nutrition. J. Dairy Sci., 1991; 74:3583-3597.
11. Richardson, G.H.: Standard Methods for the Examination of Dairy Products, 15th ed. American Public Health Association, Washington, DC. 1985.
12. SAS.: SAS user guide statistics. Version 7 edition. SAS Inst., Cary, NC, USA. 2000.
13. Steel, R. G. D. and Torrie, J. H.: Principles and procedures of statistics. 2nd ed. McGraw-Hill, USA. 1986.
14. Teh, T. H., Trung, L. T., Jia, Z. H., Gipson T. A.: Varying Amounts of Rumen Inert Fat for High Producing Goats in Early Lactation. J. Dairy Sci., 1994; 77: 253-258.
15. Chouinard, P. Y., Girard, V., Brisson, G. J.: Fatty Acid Profile and Physical Properties of Milk Fat From Cows Fed Calcium Salts of Fatty Acids with Varying Unsaturation. J. Dairy Sci., 1998; 81:471-481.
16. Chilliard, Y., Ferlay, A., Doreau, M.: Effect of Different types of Forage, Animal Fat or Marine Oils in Cow's Diet on milk Fat Secretion and Composition, Especially Conjugated Linoliec Acid (CLA) and Polyunsaturated Fatty Acids. Livest. Prod. Sci., 2001; 70:31-48.
17. Andrade, P. V., Schmidely, P.: Effect of Duodenal Infusion of *trans* 10,*cis* 12-CLA on Milk Performance and Milk Fatty Acid Profile in Dairy Goats fed High or Low Concentrate Diet in Combination with Rolled Canola Seed. Reprod. Nutr. Dev., 2006; 46:31-48.
18. Harvatine, K. J., Allen, M. S.: Effect of Fatty Acid Supplements on Milk Yield and Energy Balance of Lactating Dairy Cows. J. Dairy Sci. 2006; 89: 1081-1091.
19. Chilliard, Y., Ferlay, A.: Dietary Lipids and Forages Interactions on Cow and Goat Milk Fatty Acid Composition and Sensory Properties. Reprod. Nutr. Dev., 2004; 44:467-492.